Understanding Adolescents' Sugary Beverage Consumption: A Review and Application of the Theory of Planned Behavior

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ABSTRACT

Introduction: Weight problems not only affect adults, but youth as well. Excessive sugar-sweetened beverage (SSB) consumption is suggested to be a contributor to youth overweight and obesity and other cardiometabolic risk factors. Parents, although probably not readily admitted by adolescents, are known to influence youth's dietary beliefs and practices. Using theoretical models, like the Theory of Planned Behavior (TPB) that accounts for intention, attitudes, norms, and perceptions of control, to develop interventions can be more effective in changing health-risk behaviors versus those not grounded in theory. **Methods:** A systematic literature review and meta-analysis on how the TPB has been applied to youth's diet-related behaviors was conducted. Subsequently, a mixed methods investigation of adolescents' (n=100) and parents' (n=66) SSB consumption and exploratory analysis of parents' responses to adolescents' beverage choices was carried out. **Results:** From 34 articles, attitude was identified as having the strongest relationship with behavioral intention (mean r=0.52), and intention as the most common predictor of youth's diet-related behavior (mean r=0.38, both p<0.001). However, in the mixed methods analysis adolescents' subjective norm was the strongest predictor of intention to limit sugary beverage consumption to less than one cup per day (b=0.57, p=0.001). Intention was the strongest predictor of SSB intake in parents and adolescents (b=-47, p=0.01; b=-37, $p\leq$0.05). The TPB explained more variance in parents' SSB consumption than adolescents' (R^2=0.22 versus R^2=0.38, both $p\leq$0.001, respectively). At lower levels of intention to limit SSB consumption and higher levels of parental encouragement to consume SSBs, adolescents' predicted SSB intake was highest (p=0.059) suggesting that some adolescents may be influenced by their parent's reactions to their sugary beverage choices while others may not. **Conclusions:** Intention appears to be a strong construct influencing adolescents' diet-related behaviors, specifically SSB consumption, and this intention may be influenced by parents and other social factors. Future work can tap into adolescents' peer network and role models or authority figures to identify how these groups and individuals influence and moderate the intention to limit sugary beverage consumption.

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Attributions

Several colleagues aided in the writing and research behind one of my chapters and two appendices presented as part of this dissertation. A brief description of their contributions follows.

Chapter 2: A Systematic Literature Review and Meta-analysis: The Theory of Planned Behavior's Application to Understand and Predict Nutrition-related Behaviors in Youth.
Brenda M. Davy, PhD, RD, is currently an Associate Professor in the Human Nutrition, Foods and Exercise (HNFE) Department at Virginia Polytechnic Institute and State University. Dr. Davy developed the study's design. Andrea M. Dietrich, PhD, is a Professor in the Civil and Environmental Engineering Department of the College of Engineering Virginia Polytechnic Institute and State University. Julie C. Dunsmore, PhD, is an Associate Professor in Department of Psychology at Virginia Polytechnic Institute and State University. Paul A. Estabrooks, PhD is a professor in the HNFE Department at Virginia Polytechnic Institute and State University. Madlyn I. Frisard is an Assistant Professor in the HNFE Department at Virginia Polytechnic Institute and State University. Yiming Peng, PhD, is a Senior Biostatistician in Novartis, providing statistical support to Novartis Companion Diagnostics. Jyoti S. Savla, PhD is an Associate Professor of Human Development at Virginia Polytechnic Institute and State University. Xiang Zhang is currently a PhD Candidate at Virginia Polytechnic Institute and State University in the Department of Statistics. Dr. Savla provided guidance on the statistical analyses for the review. Dr. Peng, and Mr. Zhang assisted with all stages of the meta-analysis. All authors contributed to and reviewed the manuscript.

Appendix K. The Hydration Equation: Update on Water Balance and Cognitive Performance.
Brenda M. Davy, PhD, RD is currently an Associate Professor in the (HNFE) Department at Virginia Polytechnic Institute and State University. Dr. Brenda Davy served as a co-author and provided guidance on the manuscript's structure and content.

Appendix L. The Comparative Validity of Interactive Multimedia Questionnaires to Paper-Administered Questionnaires for Beverage Intake and Physical Activity: Pilot Study.
Brenda M. Davy, PhD, RD, is currently an Associate Professor in the (HNFE) Department at Virginia Polytechnic Institute and State University. Paul A. Estabrooks, PhD, is a professor in the HNFE Department at Virginia Polytechnic Institute and State University. Valisa E. Hedrick, PhD, RD, is an Assistant Professor in the HNFE Department at Virginia Polytechnic Institute and State University. Allyson Paone graduated from Virginia Polytechnic Institute and State University in 2012 and is currently studying to become a Physician Assistant. Jamie M. Zoellner, PhD, RD, is an Associate Professor in the HNFE Department at Virginia Polytechnic Institute and State University. All authors wrote the manuscript. Ms. Paone assisted with data collection. Drs. Davy, Estabrooks, Hedrick, and Zoellner designed the study and provided insight on data analysis and interpretation. Funding Disclosure: This work was in part supported by R01 CA154364-01

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Chapter 1: Introduction

Over 30% of American children and adolescents are considered either overweight or obese.[1,2] Despite efforts to address this national problem,[3,4] little headway has been made in achieving one of the Healthy People 2020's Leading Health Indicator targets: a youth obesity rate of 14.6%.[5] Consumption of sugar-sweetened beverages (SSBs), which include soda, lemonade, fruit drinks, sports drinks, energy drinks, sweetened tea, and beverages that have added caloric sweeteners,[4,6,7] have been linked to the development of overweight and obesity in youth.[8-14] Some of the highest consumers of SSBs are adolescents aged 12-19 years[15,16] with 77% of teens consuming SSBs on a given day.[17]

Excessive weight gain in children and adolescents may lead to adult obesity and cardiovascular risk.[18-20] In youth, overconsumption of added sugars in the form of SSB has been associated with risk factors for diabetes,[8,21,22] obesity, increased caloric consumption, BMI, waist circumference, inflammatory markers, and blood pressure, and low HDL concentrations,[6,10,23-26] among other cardiovascular disease risk factors.[27,28] Furthermore, sugary beverage consumption may displace nutrient-rich foods,[24,29,30] and thus nutrients (e.g. calcium, magnesium, potassium, zinc, iron, vitamin A, riboflavin, and folic acid) essential to adolescents' growth and development.[15,29,31,32] Decreasing or replacing SSB with healthier beverage options, like water, may be health protective in youth. [6,15,33-39]

During adolescence food may be a form of self-expression,[40,41] and maladaptive eating behaviors like meal skipping, supplementation, and dieting can become more prevalent.[41] While peers play an important role in adolescents' food choices,[40,41] parents remain the primary providers of food and support throughout this developmental life stage.[42] Adolescents who consistently have family meals are more likely to have better diet quality, successful academic performance, and less engagement in health-risk behaviors.[43,44] Parent attitudes and feeding practices have been associated with youth's eating behaviors, eating styles, food selection, and preferences,[45-50] and may influence youth's attitudes and dietary intake[45,51-53] specifically, high energy fluids.[54] Parents modeling overconsumption and fostering food environments that are controlling and promote restricting may cause dysregulation of a child's ability to acknowledge and honor hunger and satiety cues.[51,55] Moreover, parents create environments that either support the development of healthy eating behaviors and weight or promote obesity and disordered eating symptomology.[56] Thus, parents play a fundamental role influencing food behaviors and beliefs among adolescents.[57]

To address youth overweight and obesity effectively, theory-based frameworks may be more successful versus those not grounded in theory.[58-60] The Theory of Planned Behavior (TPB) is a social psychological theory in which distal factors are thought to work through more proximal variables to determine behavior action.[61-63] The TPB attempts to not only predict, but explain why a person may hold specific intentions, attitudes, norms, and perceptions of control related to a behavior.[61,62,64] Application of the information collected from the TPB can be used to develop culturally and contextually appropriate interventions[61,62,64] that may be more effective than those not based on theory.[60]

The purpose of the following investigations were to 1) systematically review how the TPB has been used to understand and predict youth's nutrition-related behavioral intentions and behaviors, and 2) assess adolescents' and parents' beverage choices using the TPB and examine the possible associations between parents' responses to adolescents' beverage choices and adolescents' beliefs about SSBs and their predicted SSB intake.

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Chapter 2: A Systematic Literature Review and Meta-analysis: The Theory of Planned Behavior's Application to Understand and Predict Nutrition-related Behaviors in Youth

Abstract

Introduction: Efforts to reduce unhealthy dietary intake behaviors in youth are urgently needed. Theory-based interventions can be effective in promoting behavior change; one promising model is the Theory of Planned Behavior (TPB). **Purpose:** To determine, using a systematic literature review, how the TPB has been applied to investigate dietary behaviors, and to evaluate which constructs are associated with dietary behavioral intentions and behaviors in youth. **Methods:** Publications were identified by searching electronic databases, contacting experts in the field, and examining an evolving Internet-based TPB-specific bibliography. Studies including participants aged 2-18 years, all TPB constructs discernable and measured with a description of how the variables were assessed and analyzed, were published in English and peer-reviewed journals, and focused on nutrition-related behaviors in youth were identified. Accompanying a descriptive statistical analysis was the calculation of effect sizes where possible, a two-stage meta-analysis, and a quality assessment using tenants from the Consolidated Standards of Reporting Trials (CONSORT) and Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statements. **Results:** Thirty-four articles, including three intervention studies, were reviewed. The TPB most often used to evaluate healthy eating and sugary snack and beverage consumption. Attitude had the strongest relationship with dietary behavioral intention (mean r=0.52), while intention was the most common predictor of behavior performance (mean r=0.38; both p<0.001). All three interventions revealed beneficial outcomes when using the TPB (e.g. η^2=0.51 and ds=0.91, 0.89, and 0.79); extending the TPB with implementation intentions may enhance its effectiveness (e.g. η^2=0.76). **Conclusions:** Overall, the TPB may be an effective framework to predict and understand child and adolescent nutrition-related behaviors, allowing for the development of tailored initiatives targeting poor dietary practices in youth. However, support from the literature is primarily from observational studies and a greater effort towards examining these relationships within intervention studies is needed.

Introduction

Childhood overweight and obesity have been associated with a myriad of health conditions,[1-4] bullying, depression,[5-8] low self-esteem, and negative body image[2,4] as well as overweight and obesity in adulthood which has well known comorbidities.[9] To address youth overweight and obesity theoretically-based frameworks may be more effective than those not grounded in theory.[10-12]

The Theory of Planned Behavior (TPB), an extension of the Theory of Reasoned Action (TRA),[13-15] is a social psychological theory that attempts to predict and understand why an individual may perform certain behaviors.[13,14,16] Behavioral intention is a product of distal constructs attitude, subjective norms (SN), and perceived behavioral control (PBC);[13-15,17,18] PBC and behavioral intention are thought to directly impact the targeted action.[13,14,17,18] Briefly, attitudes can be defined as the positive or negative evaluations of the behavior and its outcomes; SN is the degree to which an individual perceives others close to him/her and society in general values the behavior and how much the individual is willing to comply with such normative beliefs; PBC is defined as the perceived ease or difficulty of completing the behavior.[13,15,17] Attitude, SN, and PBC are all hypothesized to predict behavioral intentions, defined as what an individual plans to do, which in turn—and along with PBC—is thought to have a direct relationship with performing the behavior.[13,15,17] Attitude and PBC are the most consistent predictors of food choice intentions in young adults and adults.[19-21] Research supports the usefulness of the TPB proper in the prediction of intention and performance for a wide variety of health behaviors.[21-23]

Children and adolescents may not possess the cognitive maturity or development to rationally attribute their current dietary choices/behaviors to long-term health.[24] Further, knowledge may not influence behavior in youth.[25] The TPB, which can be modified or extended for specific populations and behaviors[13,26,27] and encompasses behaviors not under total volitional control,[13,17] has displayed acceptable behavior and intention prediction for numerous health behaviors in various groups.[21-23,28] Moreover, the TPB has been used in settings where intentions for change are low or nonexistent[28] and has extensive and clear methodological guidelines for instrument development.[13,16,29] Thus, the TPB can be an effective theoretical model to identify psychosocial factors related to youth's diet behaviors, allowing targeted interventions to be developed with the ultimate goal of preventing or changing poor nutrition-related practices.

This review will systematically evaluate how the TPB has been utilized in youth to explain nutrition-related behavioral intention and behavior, and evaluate the effectiveness of interventions using the TPB in targeting such behaviors.

Methodology

This review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[30,31] The identification stage entailed searching on-line databases (see **Figure 1**) with the keywords and combinations of the keywords: theory of planned behavior, theory of reasoned action, nutrition, children, adolescents, and diet. Where available limits and/or filters were applied (e.g. Age/Age Group: Child: birth-18 years and/or Adolescent (13-18 years); Index Term: Eating Behavior; Publication Type: Peer Reviewed Journal; Population Group: Humans). The search strategies for each of the other databases were adapted from the original PubMed search. Additionally, two experts in the field (i.e. Drs. Wendy Hardman and Ronald Plotnikoff) were contacted through email to inquire about additional studies that may be relevant to this review, and Dr. Icek Ajzen's website (http://people.umass.edu/aizen/tpbrefs.html), which contains a "living" TPB bibliography, was manually searched for additional articles. Searching was concluded in September 2014. A total of 8219 references were initially retrieved and after search filters/limits were applied, related citations sought, and duplicates removed, 103 citations were imported into the reference management software EndNote X6 for Macintosh.[32]

Abstracts of articles were reviewed to determine inclusion in the screening stage. To be eligible studies must have used the TPB to predict the intention to consume or consumption of a nutrient, food, food group, or meal and/or the Theory's predictive role in nutrition-related behaviors (e.g. weight loss, choosing healthier food options, or avoiding unhealthy ones), been written/available in English, and have participants with a mean age between 2-18 years or identify examining participants 2-19 years. (Note: one reference included participants aged 13-22 years; however, the mean age of participants was 16.2 years, thus it was included.) Additionally, all TPB variables (i.e. attitude, SN, PBC, and intention) must have been measured and the means by which TPB constructs were assessed and analyzed statistically (e.g. correlations, regressions, ANOVAs, t-tests, etc.) was a requisite for inclusion. If the application of the TPB was exclusively to predict non-nutrition-related behaviors, participants' mean age was >18 years, or significant modifications were made to the original TPB model in such a manner that original constructs were difficult to identify, studies were excluded (**Appendix A**). If all eligibility criteria were not apparent (e.g. mean age of participants) the full-text article was screened. Out of

103 imported records, 48 full-text publications were retrieved for eligibility evaluation (**Figure 1**).

After applying the above criteria, 34 articles remained for full review in stage three. During this stage the following data were extracted: author(s), year published, location of the study, study design, purpose, participant characteristics, nutrition behaviors/outcomes measured, method and description of diet intake assessment, and beta and correlation coefficients (or other available statistics) for any TPB or extended TPB constructs and nutrition-related parameters measured for intention and behavior, and any age, gender, BMI, or ethnic differences (**Appendix B**).

Statistical Analyses

When possible, effect sizes were calculated within studies using either means and pooled standard deviations, *F*-ratios, or *t*-statistics. A small, medium, and large effect was defined as d=0.30, 0.50, and 0.80; r=0.10, 0.30, and 0.50; and f^2=0.02, 0.15, and 0.35, respectively.[33,34] Comparison of correlation coefficients via the Fisher *r*-to-*z* transformation was conducted[35] for two studies, one that investigated females,[36] and the other males[37] utilizing participants from the same population, but with results reported separately.

A meta-analysis was applied on 24 studies using a syntax adapted from Field and Gillett [38] in SPSS 14. The Pearson's correlation coefficient, *r*, was used as the effect size. Specifically, we investigated the correlations between intention and the following constructs: attitude, SN, and PBC; and the correlations between behavior and the following constructs: attitude, SN, PBC, and intention (giving a total of seven pairs).

The meta-analysis was conducted in two stages. First, a basic meta-analysis on the seven correlation coefficients was performed. A random effects model was chosen because of the heterogeneity among the selected studies and to allow inferences to be generalizable beyond the included studies in the meta-analysis.[38] The mean and confidence interval (CI) for each correlation coefficient were calculated under Hedges & Vevea's random effects model[39] and reported. In the second stage moderators were included to provide an evaluation of the impact of elicitation (i.e. studies conducting and not conducting elicitation for TPB questionnaire development), bias risk (high risk vs. medium risk studies), and experimental design (cross-sectional vs. longitudinal) on each of the seven correlation coefficients. In the case where statistics were not reported in the original research, the study was excluded from the assessment, leaving a total of 21 articles included in the meta-analysis.

Bias Risk Assessment

Similar to Plotnikoff et al.,[40] bias was assessed with five questions adapted from the Consolidated Standards of Reporting Trials (CONSORT)[41] and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)[42] statements. Questions received a value of "0" when specific factors were not present or not explained clearly and a value of "1" when information was present. The scores were totaled for each study and could range from "0" to "5," with higher scores indicating a lower risk of bias.[40]

Results

Table 1 summarizes the non-intervention studies reviewed. Thirty-four articles were included, representing 26 original studies. There were 19 cross-sectional,[36,37,43-58] 14 longitudinal studies,[59-72] and three intervention studies.[67,71,72] Follow-up durations ranged from two weeks to six months. The youngest participants were eight years old[43] and the eldest was 22[52]. Most studies were conducted in those over age 11. Thirteen of the studies were performed in Europe,[43,48,49,53,57,58,63-65,67,68,72,73] 11 in the US,[36,37,44,45,47,51,54,61,66,69,74] three in Africa,[52,59,60] two each in Australia/New Zealand,[50,53] Iran[56,71] and Canada,[62,70] and one in Hong Kong.[46] The influence of gender,[45,46,49,54,61,63,64,69] age,[46,49,63,64] BMI,[46,49,51] ethnicity,[54,61] social class,[64,69] and acculturation[66] were explicitly stated as at least one objective in several trials. One study studied Native American youth[74] and three studies solely assessed either males[37] or females,[36,71] one of which was an intervention.[71]

Theory of Planned Behavior Questionnaire Development

Ten studies did not report conducting elicitation to develop questionnaire items.[43,46,47,50-52,65,71-73] Twenty-nine articles describe instrument pilot testing while six do not.[47,50,65,69,71,73] Two studies refer to prior work piloting the TPB measure,[57,58] and two studies piloted the measure, but not in the target population.[44,45] One study mentioned pretesting without providing further details.[43]

Nutrition Behaviors Measured

The most consistent nutrition behavior outcome assessed was "healthy eating;"[43,46,48,49,61,66,74] however, definitions of this behavior differed between studies. Sugary snack and drink consumption[52,58-60] and sugary beverage/soft drink intake[36,37,51,57,65] accounted for nine publications. Making healthy breakfast choices was an outcome in four studies[50,63,64,68] and two trials assessed fast food consumption.[55,56] Three studies measured low calorie versus high calorie snack consumption or snacking less[44,45,73] and four evaluated fruit or vegetable intake.[51,54,69,70] One study focused solely on the consumption of breakfast[53] and another study assessed children's intention to eat healthier, lose weight, and exercise more.[47]

Types of Nutrition Measures Used

To assess diet/nutrition behaviors the articles identified and included in this review reported using food records,[63,64] 24-hour recalls,[44,45,51] and one reported using a food diary.[68] The remaining studies reported using a food frequency questionnaire (FFQ).[57,58,61,65,66,69,73] In 13 studies it was unclear or not specified which type of which dietary evaluation tool was administered;[36,37,43,46,47,50,53,55,56,59,60,70,74] however, it can be inferred that a food screener or FFQ was used in six of these.[36,37,50,53,56,70] Studies evaluating the intention of a specified nutrition behavior (e.g. consumption of chips, fruit, and/or chocolate and sweets, fast foods, desserts, sugary drinks and snacks, and breakfast)[48,49,52,54] were considered not applicable in this assessment.

The Theory of Planned Behavior in Predicting Intention

When considering the predictors of intention, attitude was the most consistently reported with the highest beta coefficients in 13 studies (**Table 1**).[36,37,44,47,54,59-61,63,65,68,70,73] Eight studies found PBC to be the strongest predictor of intention[43,46,48,49,52,53,55,56] and four SNs.[50,62,64,69] Six articles [45,51,58,66,67,71] were not included in this analysis due to insufficient information provided or results were reported for specific subsamples addressed in other sections of this review.

The top panel of **Table 2** shows the results from both stages of the meta-analysis for the mean relationships between TPB constructs and nutrition-related behavioral intentions. Confidence intervals are presented for the seven mean correlation coefficients calculated. Some studies included in the review did not have all relevant data to include in the meta-analysis; thus, the "*k*" for moderators may not equate the total *k* presented. Overall, the strongest relationship was between intention and attitude (mean r=0.52), followed by PBC (mean r=0.46) and then SN (mean r=0.37; all p<0.001). Across attitude, SN, and PBC the relationships with intention were robust in regards to the use of elicitation, bias, and study design. One exception was that studies with increased bias risk (mean r=0.43) had a significantly higher SN-intention coefficient versus those at moderate risk (mean r=0.29, p<0.05). There were no statistically different correlations for the weeks between measurement moderator (all p>0.05, results not presented). No other statistically significant correlations were found from the moderator analysis for intention on the TPB's constructs.

Extended Theories of Planned Behavior in Predicting Intention

Fifteen articles incorporated additional factors to predict nutrition-related behaviors and/or intent (**Table 1**). Of the 15 publications measuring additional constructs along with the original TPB items, PBC[43,46,48,52,53,72] and attitude[59,65,73] remained the most significant predictors of intention despite the other variables being included. Three studies[50,56,62] identified SNs as being the most predictive of intention in extended models, and habit strength[57] and self-efficacy[74] were the most predictive of intention in two studies, even when the original TPB constructs were included.

Impact of Gender, Age, Acculturation, and BMI on Intention

Overall, in comparison to males, females were observed to have significantly greater intention,[43,46,49,61,66,73], attitude[48,49,61,66] SN,[48,61,66] and PBC.[48] When possible, effect sizes were calculated for these differences and ranged from small to medium (see **Table 1**). Few studies investigated and found differences between those of differing age, acculturation, and BMI on nutritional behavior intent and the findings are outlined in **Table 1** and **Appendix B**.

The Theory of Planned Behavior in Predicting Behavior

When examining models of the TPB alone, intention emerged as the most significant predictor of behavior in 18 studies[36,37,43,44,50,53,55,56,58-65,70,73] and PBC was the strongest predictor in two.[68,69] Six records were excluded from this analysis due to information not being available or not applicable or measures were specific for a subsample discussed elsewhere.[45,47,49,51,54,66]

The lower panel of **Table 2** shows the results from both stages of the meta-analysis for the TPB's relationship with behavior. A superscript "a" is used to indicate confidence intervals that contain zero from the moderator analysis. The strongest relationship overall was with intention (mean r=0.38) followed by PBC (mean r=0.35), attitude (mean r=0.33), and SN (mean r=0.26; all p<0.01; bottom panel of **Table 2**). Too few data points were available to examine the mean correlations of the attitude-behavior, SN-behavior, and PBC-behavior relationships with the "weeks between measurement" moderator. However, the p-value for the intention-behavior relationship when examining this moderator was not statistically significant (p=0.13).

Extended Theories of Planned Behavior in Predicting Behavior

Intention was the most significant predictor of behavior in seven[43,50,51,58,62,63,73] of the 11 studies investigating extended models of the TPB. Past behavior[56,59] and attitude[65,74] were the most predictive of behavior in two studies each; however, parenting practices had the same beta coefficient as attitude with a higher correlation coefficient (i.e. -0.24) in one of these trials (**Table 1**).[65] Three publications[46,48,52] were not included in this analysis due to the outcome being intention and not behavior.

Impact of BMI and Gender on Behavior

Intention in normal weight adolescents explained a significant amount of variance in fruit and vegetable consumption with SNs being identified as a significant contributor.[51] Similar results were observed for sugary beverages versus water consumption. No significant predictors of fruit and vegetable intake or consumption of more water versus sugary beverages were identified for those classified as overweight/obese.[51]

In relation to diet behaviors eight studies assessed gender differences in TPB constructs.[36,37,43,44,55,61,63,74] No discernable pattern can be observed from the reviewed studies; different diet behaviors had varying relationships with TPB constructs (**Table 1** and **Appendix B**). Differences between genders were not significant in four analyses.[43,55,61,63]

Variance Explained in Intention and Behavior by TPB Constructs

To provide a visual depiction and insight into some of the model's predictive ability, **Figure 2** A and B provide stem-and-leaf plots for the variances in intention and behavior in TPB-only models available from the studies within this review. The coefficients for intention appear to be normally distributed with a majority of values indicating an explained variance of 50-60%. Results for behavior differ with many of the coefficients indicating 6-19% of the variance being accounted for.

TPB Interventions and Outcomes

The three interventions identified in this review are described in **Table 3**. All interventions utilized randomization and two studies used a modified, validated food frequency questionnaire[71,72] and the remaining study, a seven-day food diary[67] for dietary assessment. The targeted nutrition behaviors/outcomes were changing unhealthy snacking behavior and intention,[67] increasing "healthy eating,"[71] and modifying intention to increase consumption of five servings of fruit and vegetables a day.[72] Two trials[67,71] incorporated interventions using the TPB with implementation intentions (IIs) (i.e. TPB+IIs versus TPB-only), and the other expanded the original TPB model to include attitude strength and role identity.[72] The shortest follow-up measures were obtained at three weeks[67] and the longest at three months.[71]

Generally, the TPB-only and TPB+IIs had positive influences on youth's diet-related intentions and behaviors. Interventions incorporating IIs displayed greater reductions in intention to consume unhealthy snacks[71] and beneficial effects on fruit and vegetable consumption versus TPB-only groups (both $p \leq 0.001$, $\eta^2 = 0.51$ and 0.76, respectively[67]). In comparison to a control group, the TPB intervention group from one study had significantly higher PBC (d=0.79), intention (d=0.91), attitude (d=0.89), and attitude strength (d=0.93) to eat healthy.[72]

Bias/Quality Assessment

Appendix C outlines results from the study bias risk assessment. No studies were classified as having a low risk of bias; 13 studies[44,45,57,59-61,66-69,71-73] were classified as moderate risk of bias and the majority of studies (*n*=21) were considered high risk of bias. Five studies reported validity of the dietary assessment tool used;[47,61,65,66,73] however, none of these reported the tool's reliability. Three studies reported reliability,[57,58,69] but no validity information on the dietary assessment tool.

Discussion

The purpose of this systematic review was to evaluate how the TPB has been used in youth to explain nutrition-related behavioral intention and behavior, and evaluate the effectiveness of interventions using the TPB in targeting such behaviors. We found that there are a considerable number of studies that have used the theory in samples of adolescents across a variety of nutrition outcomes. We also documented that the literature in this area is balanced between correlational and longitudinal designs, but despite the call to conduct more interventions using the TPB,[16,28] only three interventions were identified for this review.

Nutrition Outcomes Measured

"Healthy eating" or "eating healthy" was the most frequently studied nutrition-related behavior with consumption of sugary beverage/soft drink and sugary snack and drink consumption being more prevalent. While having open-ended categories like "healthy eating" may encompass more variables within dietary behavior, uniformity in defining such a category would be beneficial. Using a measure such as the Healthy Eating Index[75] would permit the comparison of results when using the TPB in youth. The use of individual food groups and foods in TPB research in youth can provide understanding of why certain nutrition-related behaviors are performed or intended to be performed. For example, exploring sugar-sweetened beverage and added sugar consumption in youth may hinder unhealthy weight gain and other health problems associated with excessive intake of such foods and beverages.[76-79] Similarly, using valid and reliable nutrition assessment instruments are imperative.[80-82] Furthermore, diet assessment presents unique challenges in children and adolescents,[81,83-85] thus, having uniform dietary assessment tools used in TPB research would facilitate analyses across studies. Unfortunately, the lack of validated diet assessment techniques was a weakness in the reviewed articles, leading to less precise conclusions.

The Theory of Planned Behavior and Extended Theories of Planned Behavior in Predicting Nutrition-Related Behavioral Intentions and Behavior

The variety of nutrition outcomes across the 34 studies makes specific conclusions about different consumption behaviors difficult, but the findings were robust across cross-sectional/longitudinal, levels of scientific bias, and presence or absence of elicitation development of measures. This later finding has implications for potentially reducing participant burden and suggests that researchers are able to accurately develop TBP construct measures that will have strong predictive validity for intention and behavior.

Also of note, is the strength of inter-relationships between TPB constructs and behavior. These findings are similar to research in adult populations,[21-23] where attitude emerged as the most frequently reported predictor and associated construct with behavioral intention; however, PBC was also consistently related to intention with a similar magnitude of relationship. Adolescents had higher SNs as compared to adults in one meta-analysis, when strictly examining diet behavior intention.[23] This differs from the present review where the meta-analysis revealed the weakest associations between this construct and intention. Social and media outlets may influence youth's behaviors[86-88] and possibly intentions, thus future research can investigate such associations to better understand youth's nutrition-related behavioral intentions. Social pressure, hypothesized to be encapsulated within SN,[13] may be difficult to measure and different types of norms could be included in the TPB.[22] Additionally, the SN construct can have multiple influences and thoroughly assessing them may strengthen the SN's predictive ability,[13,22] in youth.

The TPB has been criticized for not thoroughly explaining intention and behavior,[27] however, the Theory is open to adding constructs[13] and recommendations on including additional variables to the Theory have been described.[26] The current review found PBC and attitude to remain highly associated with intention in extended TPB model's and this provides support for two of the Theory's original constructs in understanding nutrition-related behavioral intentions in youth.

Intention materializing as the most significant predictor and the moderate effect sizes for the intention-behavior and PBC-behavior relationships are similar to a prior meta-analysis evaluating how cognitive theories explain physical activity engagement in adolescents.[40] Additionally these results are similar to a review on the relationship between cognitive variables and eating behaviors in youth,[89] as well as research focusing on the TPB in other study populations,[13,21-23] providing support for the acknowledged intention-behavior relationship.[13] The medium strength relationship between PBC and behavior might reflect the mean age of participants within the reviewed articles since as youth age and become more autonomous they may be in greater control of their food choices.[83,85,88] Even when additional variables were used to extend the TPB, intention remained the most consistent and significant predictor of behavior, similar to a previous meta-analysis.[23] Intention emerging as the most frequent predictor of behavior may indicate that children and adolescents' nutrition-related actions may be of a higher cognitive order versus affective and impulsive motivations.[86,87]

Variance Explained in Behavioral Intention and Behavior

The depiction of variance explained in intention and behavior shows a majority of multiple regression coefficients falling between 0.50 and 0.60 for intention and 0.09-0.16 for behavior, although the latter lacks normality (**Figure 2**A and B). Considering this evaluation is a simple frequency estimate, the findings cannot directly be comparable to previous research. Armitage and Conner found 39% of the variance explained in intention was accounted for by the TPB global constructs[22] and McEachan et al.'s analysis was related finding 44.3% of the variance explained.[23] In regards to behavior, these prior works found multiple regression coefficients of 0.27[22] and 0.19.[23] The present review found higher intention coefficients and lower behavior coefficients, and the total variance explained in intention was higher than that of behavior.

Interventions

Only three interventions were identified for the current review despite the call for application of the TPB to behavior change interventions.[16,28] The TPB is recognized to be effective in understanding and changing health-related intentions and behaviors[16,21,28] and, although limited, the reviewed studies suggest it can be effectively applied to examine dietary behaviors in youth. Implementation intentions, as utilized in other works,[90,91] were successfully employed to extend the TPB model in two interventions.[67,71] The limited number of interventions restricts generalizability; nonetheless, the studies were categorized as at a moderate risk for bias and all used randomization and reported small to large effect sizes. Overall, the trials provide support for using the TPB in youth to change diet-related behaviors and intentions; however, more work is needed using different populations, outcomes, and intervention strategies to determine its effectiveness.

Strengths, Limitations, and Future Directions

Strengths of this review include the use of the PRISMA guidelines[30,31] and a quality analysis using CONSORT[41] and STROBE[42] statements. In addition, this was the first systematic review exploring how the TPB has been utilized in predicting, understanding, and potentially changing youth's nutrition-related behaviors. However, the following limitations are recognized. The search strategy and exclusion of non-English published works may not have captured all available publications as might have not including unpublished works; however, this was addressed by contacting two experts within the field and searching a bibliography available on the Theory developer's website. One author was used to identify, review, and assess articles and this may have introduced selection and reporting biases; however, included article's abstracts were cross-checked by another author. Additionally, the studies identified differed in measures of dietary intake, outcomes assessed, and results reported, thus a meta-analysis on all reviewed articles was not possible. The number of publications that differentiated TPB outcomes on gender and BMI was limited as were the number of interventions identified. The moderator analysis was limited in the number of studies applicable for evaluation. Another limitation is that the potential for reporting bias exists within the studies included as only significant results were reported in some instances. Additionally, a majority of the records identified were categorized as at high risk for bias due to methodological and reporting shortcomings. Some moderators in the meta-analysis have more publications included than others (e.g. 10 studies with a high bias risk versus three with medium bias risk with intention and behavior (lower panel of **Table 2**) and this may have impacted the analysis.

Our systematic review of the literature also identified a number of areas of future research. For example, findings on the potential moderating influences of body weight status, age, and gender were assessed in only a minority of the studies included in the review. Further, the results were not consistent in the degree to which these factors influence TPB constructs or the magnitude of relationships between attitude, subjective norm, and perceived behavioral control with intention and behavior. Further research is needed that develop a priori plans to examine these moderators within experimental designs to determine if different approaches may be needed to improve consumption patterns in youth.

Conclusions

The present review investigated and identified ways in which the TPB has been applied to predicting, changing, or evaluating nutrition-related behaviors in children and adolescents, and which constructs or predictors arise most frequently as significant within the TPB models. Thirty-four publications were reviewed and analyses demonstrate that the TPB has been applied to investigate a variety of populations and nutrition-related intentions and behaviors with healthy eating and consumption of sugary snacks and beverages being the most prevalent. Unfortunately, few of the identified articles reported the validity and reliability of the dietary assessment tool and this needs attention in future TPB works focusing on youth’s diet-related intentions and behaviors. Attitude materialized as the strongest and the most frequently associated and significant predictor of intention and intention was the strongest and regularly distinguished construct most related to and predictor of nutrition-related behaviors. Despite observed differences between genders and those classified as normal weight or overweight/obese findings were inconsistent. Research is warranted to explore the differences in TPB constructs, intention, and behavior among youth of differing genders and BMI. All three interventions exhibited beneficial effects on diet behaviors and the TPB's underlying constructs with two of the studies extending the Theory to include IIs. These results suggest that the Theory is an effective means to address nutrition-related behaviors in youth and that its effectiveness may be enhanced with the use of IIs. Overall, the TPB may be useful in determining youth’s underlying attitudes, norms, and perceptions of control that can be employed in customized interventions and programs to address dietary behaviors.

Figure 1. Identification, screening, eligibility, and inclusion process based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[30,31]

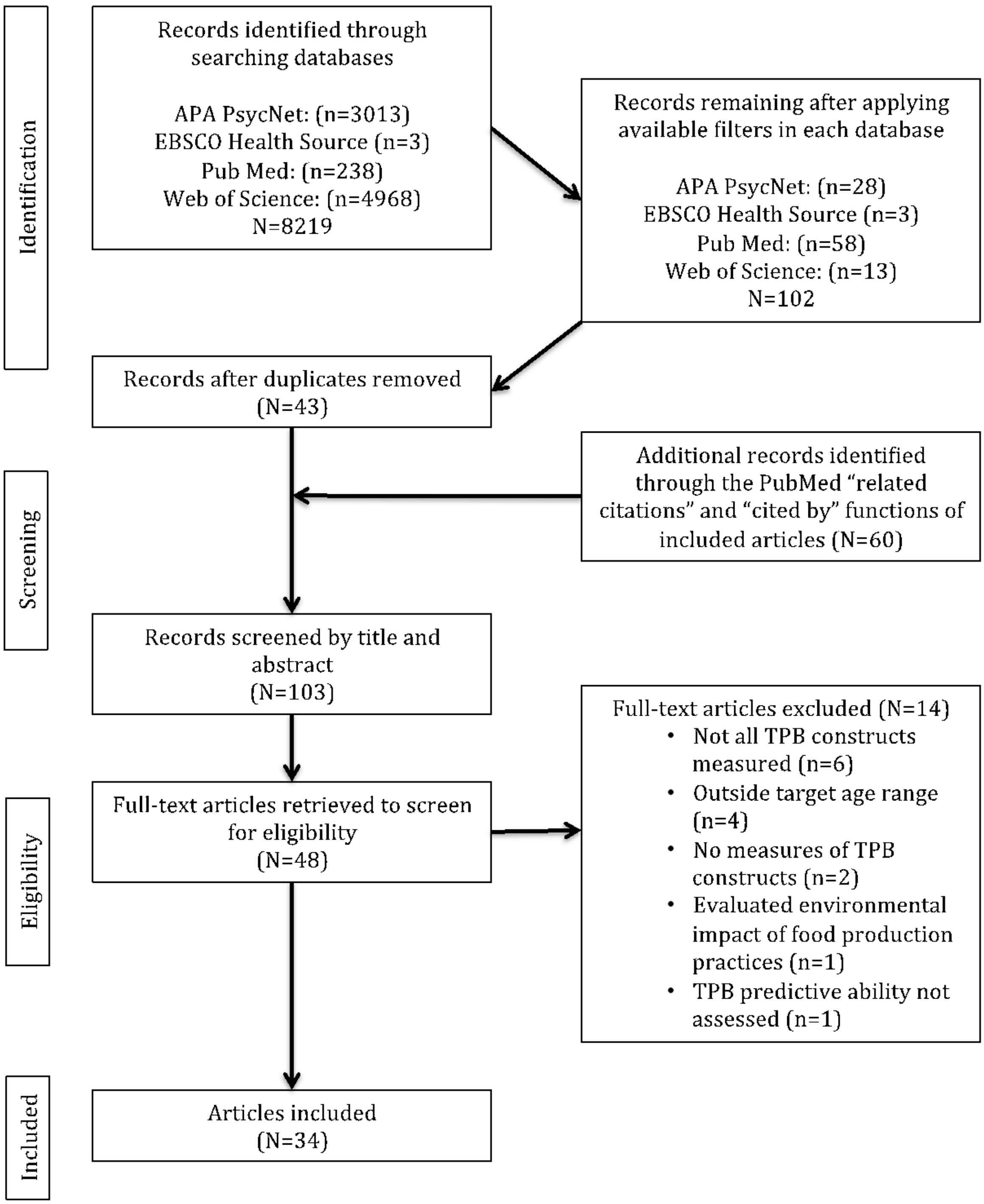

Figure 2. Stem-and-leaf- plot of variances explained (R^2) in intention (A) and behavior (B) by Theory of Planned Behavior (TPB)-only models from studies identified and included in this review.

A. R^2 Intention

```
Frequency    Stem &  Leaf

    2.00        1 .  19
    3.00        2 .  026
    4.00        3 .  1577
    4.00        4 .  2235
    8.00        5 .  00136888
    5.00        6 .  12478
    2.00        7 .  17
    2.00        8 .  14

Stem width:       .10
Each leaf:       1 case(s)
```

B. R^2 Behavior

```
Frequency    Stem &  Leaf

    4.00        0 .  6789
    6.00        1 .  125789
    1.00        2 .  8
    1.00        3 .  8
    4.00        4 .  0156
    2.00        5 .  68
    2.00        6 .  33

Stem width:       .10
Each leaf:       1 case(s)
```

Table 1. Summary of the Theory of Planned Behavior (TPB) non-intervention studies in youth.

Author (year) **Location** **Design** **Follow-up**	**Purpose** **Additional Constructs Measured**	**Participants**	**Behavior: Nutrition Outcome/Measure** **Dietary Assessment Instrument Used**	**Predictors of and Relationships with Intention** **β's, (*r*'s), OR's, *Mean* and CI's** **Age, gender, BMI, or Ethnic Differences**	**Predictors of and Relationships with Behavior** **β's and (*r*'s)** **Age, gender, BMI, or Ethnic Differences**
Astrom, 2004 Africa - Uganda Longitudinal - Prospective 3 months	Explore the effectiveness of the TPB plus past behaviors in predicting intended and self-perceived sugar intake in Ugandan adolescents Past BR (PB)	Age Range: 13-19 years *M* age 16.3 (±1.7) years 52% male N=372	Sugary snacks and drinks on daily basis and in future 1-item, self-perceived sugar intake measured at T2 asking about sugary snacks intake over the "past weeks"	**ATT: 0.53* (0.74*)** SN: 0.09 (NS) (0.60*) PBC: 0.24* (0.60*) EXTENDED TPB **ATT: 0.52* (0.74*)** SN: 0.07 (NS) (0.60*) PBC: 0.17* (0.60*) PB: 0.24* (0.47*)	**INT: 0.16* (0.21*)** ATT: (0.13*) SN: (0.1 NS) PBC: 0.07 (0.17*) EXTENDED TPB INT: 0.07 PBC: 0.05 **PB: 0.24* (0.30*)**
Astrom and Okullo, 2004 Africa - Uganda Longitudinal - Prospective 3 months	Determine the validity of the TPB in predicting intended and self-reported sugar consumption in Ugandan adolescents and if the predicted INT were correlated with self-reported BR at 3 months	Age Range: 13-19 years 52% male T1: N=1146, *M* age: 15.8 (±1.6) years T2: N=372, *M* age 16.3 (±1.7) years	Self-perceived sugar intake: sugary snacks and drinks 1-item, self-perceived sugar intake measured at T2 asking about sugary snacks intake over the "past weeks"	**ATT:** **T1=0.56**** **T2=0.32**** SN: T1=0.08 (NS) T2=-0.02 (NS) PBC: T1=0.22** T2=0.18*	**INT: 0.16*** PBC: 0.09 NS
Backman et al., 2002 USA - California Longitudinal - Prospective 1 month	Identify predictors of INT to eat healthful and actual healthy eating as defined by total energy intake (i.e. total kcals), % calories from fat (% kcal fat), and servings of fruit and vegetables in adolescents using the TPB and determine how gender and ethnicity influence the predictors.	Age Range: 14-19 years 44.1% male N=672	Eating a healthy diet over next month FFQ: 67- items	**ATT: 0.39**** (0.55)****** SN: 0.23**** (0.35)**** PBC: 0.28**** (0.45)**** Females had sig greater INT (*d*=0.34), more positive ATT (*d*=0.23), and greater SN (*d*=0.52) vs. males**	**INT:** Total kcals: -0.36**** (-0.14***) % kcal fat: -0.10** (-0.24****) Fruit and vegetable servings: 0.41**** (0.23****) PBC: NS and no values given No differences between genders
Bazillier et al., 2011 Europe - France Cross-sectional	Evaluate if an extended TPB can explain healthy eating INT and BR in children Knowledge Perceived parental norm Motivation to comply to parental norm Perceived friend's norm Motivation to comply to friend's norm	Age Range: 8-9 years 49% male N=1272	Healthy eating 1-item, self-report; breakfast consumed on morning of assessment used as proxy; fruits, dairy products, and bread items must have been checked to be considered "healthy"	**PBC: 0.40 (sig with no value given)** **M=0.46** **F=0.43** Knowledge was not sig predictor of INT Females had sig higher INT vs. males (no sig level provided; *d*=0.18; CI 0.13-0.22)	**INT** was only sig predictor (no other information provided) No differences in genders on TPB constructs Females had higher knowledge (*d*=0.16; CI 0.09, 0.23) and wanted to listen to their parents more than males** (*d*=0.16; CI 0.40, 0.20)
Beaulieu and Godin, 2011 Canada Longitudinal - Prospective 2 weeks	Identify BR determinants for high school students to stay for lunch using an extended TPB Descriptive norm	Age Range: 12-17 years *M* age =14.6±1.5 years 41.8% male N=153	Staying in school for lunch NA	ATT: OR=2.7* (1.06-6.85) **SN: Descriptive Norm OR=12.67*** (3.39-47.27)** PBC: OR=11.46**** (4.53-29.04) No sig gender or age differences	**INT** only sig predictor reported OR=16.22 (7.08-37.21)
Berg et al., 2000 Europe - Sweden Longitudinal - Prospective 2 weeks	Determine if the TPB and its underlying construct's influence youth's milk and high-fiber bread consumption for breakfast and if the TPB variables were associated with age and gender Descriptive norms (Des N) for mother and father Injunctive norms (Inj N), Motivation to comply, Behavioral beliefs and outcome beliefs, Habit Accessibility	Age Range: 11, 13, 15 years (5th, 7th, and 9th graders) 48% male N=1096	Milks with varying fat content (SM, LFM, MFM, FFM) and high-fiber bread (HFB) consumption for breakfast 7-day breakfast food record with type of food and not amount; number of days out of 7 that the target food was eaten	**ATT:** **HFB=1.4***** **Milks=1.9-2.4***** No sig gender or age differences	**INT** **HFB=1.0***** **Milks=2.8-3.6***** No sig gender or age differences
Branscum and Sharma, 2011 USA - Ohio Cross-sectional	Determine how well the TPB predicts consumption of calorie-dense, nutrient-poor snacks versus fruit and vegetable snacks in elementary-aged children	Are Range: 4th and 5th graders *M* age =10.4 (±0.79) years 41% male N=167	Low calorie (e.g. fruit, vegetables, pretzels, rice cakes, vanilla wafers, and graham crackers) and high calorie (e.g. potato chips, Doritos, Cheetos, candy bars, snack cakes, and cookies) snack food consumption 24-hour snack foods recall; method similar to USDA's AMPM for 24-hour recalls	**ATT: 0.41***** SN: 0.24*** PBC: 0.22**	**INT:** **Fruit and Vegetables: 0.26***** **High Calorie: -0.17***

Table 1. Summary of the Theory of Planned Behavior (TPB) non-intervention studies in youth.

Author (year) **Location** **Design** **Follow-up**	**Purpose** **Additional Constructs Measured**	**Participants**	**Behavior: Nutrition Outcome/Measure** **Dietary Assessment Instrument Used**	**Predictors of and Relationships with Intention** **β's, (*r*'s), OR's, *Mean* and CI's** **Age, gender, BMI, or Ethnic Differences**	**Predictors of and Relationships with Behavior** **β's and (*r*'s)** **Age, gender, BMI, or Ethnic Differences**
Branscum and Sharma, 2013 USA - Ohio Cross-sectional	Investigated how well the TPB predicts different snack food choices in school-aged boys and girls.	Same as Branscum and Sharma, 2011	Same as Branscum and Sharma, 2011	**ATT:** **Males=0.57***** Females=0..25** **SN:** Males=0.19* **Females=0.29**** PBC: Males=0.29** Females=0.27**	**INT** Fruit and Vegetables: **Males=0.27*** Females=0.27** **High Calorie:** Males=0.11 (NS) **Females=-0.29**** Males reported sig higher PBC vs. females*
Chan and Tsang, 2011 Asia - Hong Kong Cross-sectional	Assess how well the TPB and attitudes towards healthy eating advertisements influence adolescents INT to eat healthy and if gender, BMI, and age influence INTs. Perceptions and ATT towards healthy eating advertisements (ATT towards ad)	Age Range: 11-19 years (7th-11th graders) *M* age = 14.5yrs 49.6% male N=570	Healthy eating INT: avoiding candies, chips, desserts, and fast foods and eating three meals with adequate fruit and vegetable content daily 1-item, self reported INT to "engage in healthy eating in the coming two weeks."	ATT: 0.25***(0.54**) SN:0.04 (NS) (0.35**) **PBC: 0.47***(0.64**)** ATT towards ad: -0.03 (NS)(0.17**) Higher BMI participants had lower INT vs. those with lower BMI (*r*=-0.13**, *d*=0.26) Females had greater INT vs. males (*r*=0.09*, *d*=0.18)	NA
Conner et al., 2011 (same study as Berg et al., 2000) Europe - Sweden Longitudinal - Prospective 2 weeks	Extent to which the 2 factor TPB predicted healthy breakfast choices in adolescents and how, age, social class, and gender influence the relationship. Affective and instrumental attitude (Affective and Instru ATT) Descriptive and injunctive norm (Des N and Inj N) Perceived control and confidence (P cntrl and P confid)	Age Range: 11, 13, 15 years (5th, 7th, and 9th graders) 48% male N=832	Milks with varying fat content (SM, LFM, MFM, FFM) and high-fiber bread (HFB) consumption for breakfast 7-day breakfast food record with type of food and not amount; number of days out of 7 that the target food was eaten	**SN** **HFB:** Inj N: 0.15***(0.46***) **Des N: 0.23***(0.47***)** **LFM:** Inj N: 0.15***(0.63***) **Des N: 0.36***(0.70***)** HFB: As age increased Affective ATT became stronger predictor of INT LFM: As age increased Des N became stronger predictor of INT	**INT** **HFB: 0.25***(0.28***)** All constructs except PBC were related to BR **LFM: 0.68***(0.68***)** HFB and LFM: As age increased INT increased
Cottrell et al., 2012 USA - West Virginia Cross-sectional	Use the TPB to predict children's INT to eat healthier, exercise more, and lose weight over the next 6 months and to evaluate how parental perceptions of their child's and their own health and children's perceptions of their own health influence INTs to lose weight, exercise, and eat healthy.	Age Range: 10-14 years, *M* age =10.9 (±0.6) years N=342 parent-child dyads	Child's INT to lose weight, eat healthier, and exercise more over next 6 months Health Belief Questionnaire evaluating beliefs about health, exercise, and diet	**ATT:** LOSING WEIGHT: Parent's Own Perception=0.07* EATING HEALTHIER **Child's Own Perception=0.41***	NA
de Bruijn et al., 2005 Europe - The Netherlands Cross-sectional	Assess how well a conceptual model based on the TPB with distal factors explains snacking and bicycle use and identify the proximal and distal determinants of snacking and biking behavior in Dutch adolescents. The Theory of Triadic Influence: cultural environment, social environment, and biology/personality	*M* age = 14.8 (+-1.6) years 45.8% male N=3859	INT to consume less snacks FFQ: 4 items about number of times per week fried snacks, nuts and potato chips, pastries, chocolate, and cookies were consumed	**ATT: 0.36***(0.51[a])** SN: 0.13***(0.19[c]) PBC: 0.20**** (0.31[b]) Self-esteem: -0.07*** (-0.11[c]) Relations with parents: 0.03* (0.07[0]) Females more likely to have greater INT to restrict snacking (β=0.21***, *r*=0.29[c])	**INT: 0.25*** (0.42[b])** ATT: 0.19*** (0.40[b]) SN: -0.03 (0.05[0]) PBC: 0.15*** (0.30[b]) Self-esteem: -0.05** (-0.07[0]) Relations with parents: 0.03* (0.08[0]) Not living or living with both parents: -0.04* (-.08[0])

Table 1. Summary of the Theory of Planned Behavior (TPB) non-intervention studies in youth.

Author (year) Location Design Follow-up	Purpose Additional Constructs Measured	Participants	Behavior: Nutrition Outcome/Measure Dietary Assessment Instrument Used	Predictors of and Relationships with Intention β's, (*r*'s), OR's, *Mean* and CI's Age, gender, BMI, or Ethnic Differences	Predictors of and Relationships with Behavior β's and (*r*'s) Age, gender, BMI, or Ethnic Differences
de Bruijn et al., 2007 Europe - The Netherlands Longitudinal - Prospective 6 months	Identify individual and social-environmental factors associated with adolescent soft drink consumption using distal factors of personality and parenting factors and the TPB constructs. Parenting practices Big Five personality dimensions (i.e. Agreeableness, Extraversion, Conscientiousness, Emotional stability, and Openness to experience)	Age Range: 12-18yo *M*=15.2 (±1.9) years N=208	Soft-drink consumption FFQ: how many days per week and how much each time "sugar-containing soft drinks" were consumed	**ATT: 0.32***(0.38**)** SN: 0.22***(0.23**) PBC: 0.16*(0.19**) Extended TPB constructs did not have sig *r* values on INT	**INT: -0.20**** EXTENDED TPB INT: -0.12 (NS) (-0.20**) **ATT: -0.24** (-0.23**)** SN: 0.20** (0.03 (NS)) PBC: -0.04 (NS) (-0.16*) **Parenting practices: -0.24*** (-0.26**)** Agreeableness: 0.16* (0.07 (NS))
Dennison and Shepherd, 1995 Europe - UK Cross-sectional	Determine the appropriateness and effectiveness of using the TPB to predict adolescents' food choice INT and BR. Dietary restraint Descriptive norm (i.e. friend's BR) Self-identification of being a "healthy eater"	Are Range: 11-12 and 14-15 years 52% male N=675	Food choice: eating chips, fruit, and/or chocolate and sweets (CS) at lunch time as identified during elicitation 2-items for each food: INT to eat "X" food 1) tomorrow, and 2) over the next week	<u>CS:</u> **PBC1 (i.e. ease or difficulty): -0.24***** PBC2 (i.e. can have amount preferred): 0.16** <u>Fruit:</u> PBC1: -0.12*** **PBC2: 0.20***** <u>Chips:</u> **PBC1: -0.24***** PBC2: 0.07* F had more positive ATT (*d*=0.52), greater SN (*d*=0.27), and found it easier to eat fruit and not CS (*d*=0.24) or chips (*d*=0.31) vs. males (all **).	NA
Diaz et al., 2009 (same study as Backman 2002) USA - California Longitudinal - Prospective 1 month	Secondary analysis of Backman et al's., data from 2002 for acculturation (Accult) and gender effects on the TPB as related to healthy diet intake in Latino adolescents.	Age Range: 14-19 years Hispanic/Latino 41% male N=265	Same as Backman et al., 2002	Females had stronger INT, more positive ATT, and stronger SN to eat healthier vs. males (all***). Sig greater INT to eat healthfully in less Accult vs. high Accult** Females had sig more positive ATT, stronger SN, and greater INT to eat healthy vs. males (all ***)	NR
Fila and Smith, 2006 USA - Minnesota Cross-sectional	Use the TPB to identify ATT that promote or create barriers to healthful eating, identify who or what promotes healthful diet BR, and examine to what extent youth perceive control over their diet behavior. Self-efficacy (SE) Barriers	Age Range: 9-18 years Native Americans *M* age ≅ 12.5 (±2.5) years 41.7% male N=139	Healthy eating: "eating different types of foods from all food groups like bread, grains, cereals, fruit, vegetables, milk, and meat while limiting sugary and fatty foods Unclear: used responses to questions on dietary intake of fruit, vegetables, soft drinks, and fast foods, along with 11 additional BR questions using the Likert scale	ATT: (0.45**) SN: (0.39**) PBC: (-0.01 (NS)) Barriers: (-0.14 (NS)) **SE: (0.56**)** M **SE: (0.68**)** F **SN: (0.41**)** **SE: (0.41**)**	INT: (0.05 (NS)) **ATT: 0.52*** (0.44**)** SN: 0.11** (0.34**) PBC: (0.35**) SE: -0.23** (-0.12 (NS)) Barriers: 0.12* (0.46**) Males **SN: 0.13** (0.46**)** Females **ATT: 0.54** (0.46**)**
Grønhøj et al., 2012 (used Chan's from above) Europe - Denmark Cross-sectional	Determine the predictive power of INT to eat healthier in Danish adolescents using the TPB and if gender, age, and BMI influence the INT to adopt healthy eating patterns.	Age Range: 11-16 years (6-10th grade) *M* age =13 years (no SD reported) 47.6% male N=410	(Measure was adapted from Chan and Tsang, 2011) Healthy eating INT: avoiding candies, chips, desserts, and fast foods and eating three meals with adequate fruit and vegetable content daily 1-item, self reported INT to "engage in healthy eating in the coming two weeks."	ATT: 0.30*** (0.54***) SN: 0.06 (NS) (0.26***) **PBC: 0.37*** (0.51***)** Females had greater INT (*r*=0.26) and stronger ATT (*r*=0.20) vs. males***	NA

Table 1. Summary of the Theory of Planned Behavior (TPB) non-intervention studies in youth.

Author (year) Location Design Follow-up	Purpose Additional Constructs Measured	Participants	Behavior: Nutrition Outcome/Measure Dietary Assessment Instrument Used	Predictors of and Relationships with Intention β's, (*r*'s), OR's, *Mean* and CI's Age, gender, BMI, or Ethnic Differences	Predictors of and Relationships with Behavior β's and (*r*'s) Age, gender, BMI, or Ethnic Differences
Gummeson et al., 1997 Europe - Sweden Longitudinal - Prospective 1 month	Use of the TPB to evaluate the determinants of Swedish children's INT and actual consumption of breakfast choices . PBC measured with two items: perceived difficulty and control	Age Range: 10-16 years (grades 4, 7, and 10) N = 182	Healthy vs. unhealthy breakfast options (e.g. low-fat versus high-fat milk yogurts and milks, fiber content of breads and cereals, and use of margarine/butter spreads with varying fat content). 4-day breakfast food diary; number of days healthy choices were made minus the number of days unhealthy choices made	**ATT:** **Milk: 0.89**** **Cultured Milk: 0.77***** **Yogurt: 0.57**** **Bread: 0.70***** **Cereal: 0.77***** **Spread: 0.81***** SN: only sig for milk 0.08* and cultured milk 0.36** PBC: Control for cultured milk: 0.27*	**INT[d]** **Milk: 0.17*** Cultured Milk: 0.14* Yogurt: 0.18* **Bread: 0.44**** **Cereal: 0.28*** Spread: 0.08 (NS) PBC - Difficulty[c] Milk:: -0.14* **Cultured Milk: -0.23*** **Yogurt: -0.20***
Hewitt and Stephens, 2007 Australia - New Zealand Cross-sectional	Assess predictive power of the TPB variables and child feeding practices on children's INT to eat healthy foods and to test if INT are related to BR. Behaviorial beliefs (BB) Parent's perceived responsibility (PR) Parent's concern about child's weight (PCw) Parent's restriction of child's intake (PRi)	Age Range: 10-13 years *M* age = 11.4 (no SD reported) 45.6% male N = 261	Consumption of healthy (i.e. fruit and vegetables) and unhealthy foods (i.e. hamburgers, fish and chips, pizza, fried chicken, carbonated drinks, chocolate, sweets, and crisps) over past week Unclear: self-report on a scale of 1-7 on how many days over past week were foods of categories eaten	ATT: 0.25*** (0.52**) **SN: 0.29*** (0.55**)** PBC: 0.22*** (0.49**) BB: 0.21*** Sig differences between genders on reported TPB constructs (all **)	EXTENDED TPB: **INT: 0.42*** (0.63**)** ATT: 0.01 (0.37**) SN: 0.12 (0.45**) PBC: 0.21*** (0.63**) BB: 0.09 (0.44**) PR: 0.03 (NS)(0.08(NS)) PCw: 0.02 (NS)(0.08(NS)) PRi: 0.04 (NS)(0.14*)
Ickes and Sharma, 2011 USA Cross-sectional	Determine the extent to which INT predicted 2 nutritional BR related to obesity in normal weight (nw) and overweight/obese (ow/ob) adolescents.	Age Range: 12-17 years (7-8th graders) *M* age: 13.18 (±0.76) years 44.3% male N = 318	INT to consume ≥5 servings fruit and vegetables a day or decreased amount of SSB per day 24-hr recall for number of fruit and vegetable servings and glasses of water and SSB consumed	<u>Fruit and Vegetables:</u> All participants: SN and PBC reported as sig predictors of INT with no coefficients or *p* values given. nw: NS ow/ob: PBC identified as sig predictor of INT with no coefficients or *p* value given. <u>SSB vs. Water:</u> All participants: NS nw: PBC reported as sig predictor for INT (no coefficient provided) ow/ob: NS	<u>Fruit and Vegetables:</u> All participants: SN: 0.17** **PBC: 0.23**** **nw:** INT: 0.15* ATT: NR **SN: 0.19**** PBC: NR ow/ob: no constructs were significant <u>SSB vs. Water:</u> All participants: **INT: -0.14*** **nw:** **INT: -0.18**** ATT: -0.08 (NS) SN: -0.14* PBC: 0.03 (NS) ow/ob: no constructs were significant INT: -0.02 (NS) PBC: 0.37 (NS)
Kassem et al., , 2003 USA - California Cross-sectional	Use the TPB to identify factors influencing regular soft drink consumption in female adolescents (i.e. predicting INT to drink soda).	Age Range: 13-18 years No males N=707	Regular soda consumption (i.e. cola or non cola) over past 12 months Unclear/FFQ: 1-item, consumption of < 1 glass, bottle, or can per month, 1 glass per week or less, 2-6 glasses per week, 1 glass per day, and 1, 2, 3, or more than 3 glasses per day.	**ATT: 0.58**** (0.76)** SN: 0.14**** (0.42) PBC: 0.24**** (0.57)	**INT: 0.51**** (0.53****)** PBC: 0.03 (NS) (0.32****)
Kassem and Lee, 2004 USA - California Cross-sectional	Use the TPB to identify factors influencing regular soft drink consumption in male adolescents (i.e. predicting INT to drink soda).	Age Range: 13-18 years All male N = 564	Same as Kassem et al., , 2003	**ATT: 0.52*** (0.72***)** SN: 0.19*** (0.42***) PBC:0.28*** (0.54***)	**INT: 0.38****(0.39****)** PBC: 0.02 (NS) (0.22****)

Table 1. Summary of the Theory of Planned Behavior (TPB) non-intervention studies in youth.

Author (year) **Location** **Design** **Follow-up**	**Purpose** **Additional Constructs Measured**	**Participants**	**Behavior: Nutrition Outcome/Measure** **Dietary Assessment Instrument Used**	**Predictors of and Relationships with Intention** **β's, (*r*'s), OR's, *Mean* and CI's** **Age, gender, BMI, or Ethnic Differences**	**Predictors of and Relationships with Behavior** **β's and (*r*'s)** **Age, gender, BMI, or Ethnic Differences**
Kida and Astrom, 1998 Africa - Tanzania Cross-sectional	Use of TPB to evaluate adolescents INT to avoid daily intake of sugared snacks and drinks in the future. Past BR (PB) Perceived risk (PR) of tooth decay	Age Range: 13-22 years *M* age: 16.2 (±1.4) years 53.5% male N=312	INT to avoid sugary snacks and drinks in future and past sugar intake: <u>INT:</u> sum of 2-items; how likely and unlikely to avoid sugared drinks and snacks each day in the future <u>Past sugar intake:</u> 1-item, self-report on daily consumption of sugared drinks and snacks (e.g. chocolate/sweets, sugared tea/coffee, cake/biscuits, and soda) over the past 6 months	ATT: 0.15** (0.53***) SN: 0.26** (0.60***) **PBC:0.46** (0.67***)** PB: NA (-0.08 (NS)) PR: 0.10* (0.26***) No gender differences in TPB constructs	NA
Lien et al., 2002 USA - Minnesota Longitudinal - Prospective 6 months	Evaluate how well the TPB predicts fruit and vegetable intake in adolescents and if the constructs of the model were confirmed and affected by SES and gender.	Age Range: 7th graders 52.2% male N = 1406	Fruit and vegetable intake FFQ: 6 questions on frequency of consumption of fruit Juice, fruit, green salad, potatoes, carrots, and other vegetables	All participants: ATT: 0.13[f](0.3*) **SN: 0.34[f](0.4*)** PBC: 0.33[f](0.40*) Genders ATT: M: 0.07[f]; F: 0.18[f] **SN:** M: 0.37[f]; **F: 0.34**[f] **PBC:** **M: 0.37**[f]; F: 0.27[f]	All Participants: INT: 0.11[f] **PBC: 0.20[f]** Genders: INT M: 0.16[f] F: 0.06[f] **PBC** **M: 0.19**[f] **F: 0.22**[f]
Mullan et al., 2013 Europe (UK) and Australia Cross-sectional	Assess if the TPB and addition of risk awareness can predict breakfast consumption in a sample of adolescents from Australia (Aus) and the UK Absolute risk (AR) Relative risk (RR) Risk severity (RS)	Age range: 11-18 years *M* age: 14 (±1.1) years Aus: 36% and UK: 20% male N=605 (335: Aus, 270: UK)	Breakfast consumption (i.e. eating a meal with 2 hours of waking) 1-item, self report on how many times over past 4 weeks had breakfast been consumed	ATT: 0.27*** (0.52**) SN: 0.18*** (0.4**) **PBC: 0.35*** (0.58**)** PBC strongest in UK sample EXTENDED TPB: ATT: 0.24*** (0.52**) SN: 0.15*** (0.4**) **PBC: 0.33*** (0.58**)** AR: 0.09* (0.40**) RR: 0.05 (NS) (0.35**) RS: -0.01 (NS) (0.11**)	**INT: 0.70*** (0.75**)** ATT: (0.44**) SN: (0.29**) PBC: 0.07*(0.48**) AR: (0.31**) RR: (0.29**) RS: (0.85*) PBC only sig in UK sample EXTENDED TPB: ATT: 0.24*** (0.52**) SN: 0.15*** (0.4**) **PBC: 0.33*** (0.58**)**
Murnaghan et al., 2010 Canada Longitudinal - Prospective 1 month	Evaluate the TPB's effectiveness in predicting adolescents' physical activity, fruit and vegetable intake, and being smoke-free over a 1 month period and assess associations between BR normative, and control beliefs and the global TPB constructs	Age Range: 12-16 years (7-9th graders) 49% male N=183	5 servings of fruit and vegetables per day 1-item, self-report: "During the past 30 days I ate at least 5 servings of fruit and vegetables on (0-30) days."	**ATT: 0.34* (0.59***)** SN: 0.27* (0.53***) PBC: 0.30* (0.54***)	**INT: 0.57* (0.61***)** ATT: 0.19* (0.54***) SN 0.15* (after passing through INT) (0.33***) PBC: 0.07 (0.24* after passing through INT) (0.38***)
Pawlak and Malinauskas, 2008 USA - North Carolina Cross-sectional	Identify how well the TPB and its underlying behavioral beliefs predict 9th graders' INT to consume 2.5 servings of vegetables per day and if findings were consistent across genders and ethnicities.	Age Range: 9th graders *M* age = 14.7 (±0.82) years 34.4% male N=157	INT to consume 2.5 servings of vegetables per day NA	**ATT: 0.43***** SN: 0.37*** PBC: 0.16* No gender differences on TPB constructs. PBC only sig in Caucasian females and not African American females or all males.	NA
Seo et al., 2011 Korea Cross-sectional	Examine the factors influencing fast food consumption using the TPB in adolescents.	Age Range: "Middle School students" 52.5% male N = 354	Fast food consumption (i.e. intake of hamburgers, pizza, fried chicken, doughnuts, and French fries) Unclear/FFQ: number of days when fast foods were used often, place of fast food consumption, and people with whom used fast food	ATT: 0.05 (0.46**) SN: 0.15** (0.42**) **PBC: 0.56*** (0.66**)**	**INT: 0.61***(0.74**)** ATT: (0.38**) SN: (0.35**) PBC: 0.19*** (0.59**) No sig gender differences.

Table 1. Summary of the Theory of Planned Behavior (TPB) non-intervention studies in youth.

Author (year) **Location** **Design** **Follow-up**	**Purpose** **Additional Constructs Measured**	**Participants**	**Behavior: Nutrition Outcome/Measure** **Dietary Assessment Instrument Used**	**Predictors of and Relationships with Intention** **β's, (*r*'s), OR's, *Mean* and CI's** **Age, gender, BMI, or Ethnic Differences**	**Predictors of and Relationships with Behavior** **β's and (*r*'s)** **Age, gender, BMI, or Ethnic Differences**
Sharifirad et al., 2013 Iran Cross-sectional	Analyze the predictive ability of the TPB and TPB and actual behavior control and past behavior in Iranian adolescents in regards to fast food consumption. Actual behavior control (ABC) Past behavior (PB)	Age Range: 15-18 years *M* age: 16.3 (±0.8) years 53.2% male Total of 18 classes (9 M and 9 F) N=521	Fast food consumption (i.e. sandwiches, Berger-piroshky, hot dogs, snacks, pizza, chicken nuggets, and fried chicken) Unclear/FFQ: how many times each food listed above consumed over the past week	**ATT: 0.31*** (0.40**)** SN: 0.29*** (0.38**) PBC: -0.10 (-0.21**) M had higher SN scores vs. F* EXTENDED TPB: ATT: 0.25*** **SN: 0.27***** PBC: -0.10* ABC: -0.09* (-0.09*) PB: 0.24*** (0.36**)	**INT: 0.24** (0.24**)** ATT: 0.15**(0.19**) SN: 0.18***(0.21**) PBC: -0.01 (NS) (-0.05 (NS)) EXTENDED TPB: INT: 0.09* ATT: 0.15** SN: 0.18*** PBC: NR and NS ABC: NR and NS (-0.05 (NS)) **PB: 0.42*** (0.45**)**
Tak et al., 2011 Europe - The Netherlands Cross-sectional	Investigate the associations between home environment factors, habit strength, and the TPB with soft drink consumption in youth and if the TPB and habit strength mediates the association between home environment and soft drink intake. Availability Accessibility Parental modeling Parental rules Habit strength	Age Range: 12-13 and 14-15 years *M* age: 14.1 (±1.2) years 54% male N=1361	Sugar-sweetened soft drink consumption (i.e. "carbonated beverages, other non-carbonated sugar-sweetened drinks [water-based beverages that contain sugar] and sports drinks") FFQ: 2 questions: 1) How many days per week do you usually drink sugar-sweetened (not diet or light) drinks?, and 2) How many glasses, cans, and/or bottles on average per day?	ATT: (0.58***) SN: (0.39***) PBC: (0.43***) **Habit Strength: (0.61***)**	INT: (0.54***) ATT: (0.48***) SN: (0.31***) PBC: (0.3***) **Habit Strength: (0.64***)**
van der Horst et al., 2008 Europe - The Netherlands Cross-sectional	Examine the associations between cognitions (i.e. the TPB constructs) and soft drink and snack consumption in youth and if the effect of environmental factors on these BR are mediated by cognitions. School food availability Food stores in school neighborhood Parental norm (PN) Parent modeling (PM) Friend modeling (FM)	Age Range: 12-13 and 14-15 years *M* age: 14.1 (±1.2) Soft drinks: 52.9% male Snacks: 53.6% male N = 1174 for soft drinks N = 1139 for snacks	Sugar-sweetened soft drink (same definition as Tak et al., 2011) and snack consumption (i.e. sweet being candy, bars, chocolate, cake, and biscuits and savory being fast-food, pizza, fries, chips, and nuts) Unclear/FFQ: 2 questions sugary drinks (same as Tak et al., 2011) and 2 questions for each type of snack: "How many days a week do you usually eat X?" and "On average, how many times a day do you eat X?"	NR	Data only for soft-drink consumption[g] **INT: 0.42***** ATT: 0.32*** PN: 0.20*** PM: 0.29*** FM: 0.19*** PBC: 0.04 (NS)

**p*≤0.05
***p*≤0.01
****p*≤0.001
*****p*≤0.0001
[a]large effect
[b]medium effect
[c]small effect
[d]Overall healthy options were chosen more regularly with greater INT
[e]Negative β indicates less healthy options were chosen with greater difficulty
[f]Sig at critical ratio>1.96
[g]All unstandardized beta coefficients
[0]no effect
Abbreviations: AMPM=Automated Multiple Pass Method, ATT=Attitude, β=regression coefficient (beta), BMI=Body mass index, BR=Behavior, CI=Confidence Intervals, FFQ=Food Frequency Questionnaire, INT=Intention, *M* age=Mean age, NA=Not Applicable, NR=Not Reported, NS=Not significant, OR=Odds ratio, PBC=Perceived Behavioral Control, *r*=correlation coefficient, sig=significance, SN=Subjective Norm, SSB=Sugar-Sweetened Beverages, T1=Time 1, T2=Time 2, TPB=Theory of Planned Behavior, USDA=United State Department of Agriculture

Table 2. Meta-analysis results. Top panel displays the mean correlation coefficients (*r*) for TPB constructs with nutrition-related behavioral intention. The bottom panel displays the mean correlation coefficients (*r*) for TPB constructs with nutrition-related behavior.

Construct Correlated with Intention	Number of Studies (*k*)	Overall Mean *r*	95% CI	Mean *r* w/ Elicit (*k*)	Mean *r* w/o Elicit (*k*)	*p*	Mean *r* High Bias Risk (*k*)	Mean *r* Medium Bias Risk (*k*)	*p*	Mean *r* SD: Cross-sectional (*k*)	Mean *r* SD: Longit (*k*)	*p*
Attitude	21	0.519***	(0.446, 0.586)	0.544 (12)	0.502 (7)	0.586	0.527 (13)	0.535 (6)	0.921	0.556 (12)	0.489 (6)	0.425
Subjective Norm	21	0.374***	(0.320, 0.425)	0.358 (12)	0.377 (7)	0.889	0.425 (13)	0.290 (6)	0.039*	0.403 (12)	0.359 (6)	0.392
PBC	21	0.458***	(0.367, 0.540)	0.452 (12)	0.483 (7)	0.756	0.463 (13)	0.467 (6)	0.984	0.457 (12)	0.462 (6)	0.961

Construct Correlated with Behavior	*k*	Overall Mean *r*	95% CI	Mean *r* w/ Elicit (*k*)	Mean *r* w/o Elicit (*k*)	*p*	Mean *r* High Bias Risk (*k*)	Mean *r* Medium Bias Risk (*k*)	*p*	Mean *r* SD: Cross-sectional	Mean *r* SD: Longit (*k*)	*p*

										(*k*)		
Intention	17	0.383***	(0.193, 0.545)	0.517 (9)	0.335 (4)	0.364	0.474 (10)	0.440 (3)	0.854	0.493 (9)	0.401[a] (4)	0.613
Attitude	11	0.331**	(0.123, 0.511)	0.373 (6)	0.267 (4)	0.605	0.314 (7)	0.383 (3)	0.744	0.388 (7)	0.205[a] (3)	0.278
Subjective Norm	11	0.258***	(0.165, 0.346)	0.277 (6)	0.217 (4)	0.448	0.285 (7)	0.220 (3)	0.506	0.290 (7)	0.194 (3)	0.251
PBC	13	0.353***	(0.183, 0.502)	0.339 (8)	0.288 (4)	0.746	0.325 (9)	0.321 (3)	0.971	0.362 (9)	0.196[a] (3)	0.328

*$p<0.05$

**$p<0.01$

***$p<0.001$

[a]CI contains 0

Abbreviations: PBC=Perceived behavioral control, *k*=Number of studies included in analyses, CI=Confidence interval, Elicit=Elicitation, SD=Study design, Longit=Longitudinal

Table 3. Summary of the Theory of Planned Behavior (TPB) interventions in youth.

Author (year) Location Final N	Purpose	Participants	Design	Intervention(s)	Outcomes
Gratton et al., 2007 England/UK N = 198	Establish the effectiveness of a volitional-based intervention using TPB+implementation intentions (IIs) versus a motivational-based TPB intervention in increasing youth's intent to consume and consumption of 5 servings of fruit and vegetables a day.	One school Age Range: 11-16 years *M* age =13.1 (±1.32) years 48.5% male	Randomized controlled trial over 3-week period with 2 waves of data collection (i.e. weeks 1 and 3), which included a 7-day food diary and pilot-tested and validated TPB questionnaire.	**TPB+IIs (n=103):** asked to form IIs on consuming 5 servings of fruit and vegetables for next 7 days and encouraged to put into action over next week. **TPB-only (n=53):** aimed to increase fruit and vegetables to 5 servings via recognizing and overcoming motivational barriers and developing new salient beliefs with a "health education activity sheet." **Active Control (n=43):** ask to develop IIs for how, where, when to complete homework for next week.	Increased fruit and vegetable intake and more advantageous changes in TPB variables were seen between TPB+IIs and Active Control group ($F_{(5,140)}$=5.91***, η2=0.17). No significant differences between Active Control and TPB-only ($F_{(5,140)}$=1.03, η2=0.06) or TPB+IIs and TPB-only ($F_{(5,140)}$=2.54*[a], η2=0.08). TPB+IIs had significant beneficial effect on fruit and vegetable intake (*t*=7.7***, η2=0.76), INT (*t*=5.4***, η2=0.53), SN (*t*=5.3***, η2=0.52), and PBC (*t*=3.5***, η2=0.35). TPB-only had significant positive effect on fruit and vegetable intake (*t*=3.7***, η2=0.51), and would have been significant if α remained ≤.05[a] for SN (*t*=2.3*, η2=0.32), and ATT (*t*=2.2*, η2=0.31). **Overall:** Interventions utilizing the TPB can be effective in producing beneficial behaviors in regards to fruit and vegetable consumption.
Shahanjarini et al., 2013 Iran N=739	Determine if a TPB+implementation intentions (IIs) intervention was more effective than a TPB-only intervention in changing snacking BR and INT to consume unhealthy snacks, defined as snacks having high calories and low nutrient value like chocolates, chips, puffed cheese snacks, sweets and candies, and soda (all identified from previous qualitative study).	29 classes from multiple middle schools Age Range: 12-15 years *M* age: TPB=14.1 (±0.79) TPB+IIs=14.2 (±0.73) Control=13.8 (±0.80) All female Randomization done so that one class from each school was assigned to each of the 3 groups (except 2 schools with 2 participating classes and one with 4 classes).	3-group cluster randomized controlled trial with outcomes measured at baseline ("pretest"), 10 days postintervention ("posttest"), and 3 month follow-up via a modified, previously validated FFQ (ICC=0.77) and a TPB questionnaire.	**TPB-only (n=225):** involved a lecture, group discussion, and booklet forum using informing and motivating elements. **TPB+II (n=212):** same as TPB-only with addition of IIs element. **Control (n=302)** Sessions were 1-2 weeks apart and lasted for 90 minutes each giving a total contact time of 4.5 hours).	**POSTINTERVENTION (10 days after)** Both experimental groups decreased INT to eat unhealthy snacks more than control***. TPB+IIs (pretest *M*=3.49±1.07; posttest *M*=2.99±0.69) did so more than TPB-only group (pretest *M*=3.51±0.73; posttest *M*=3.14±0.65). Effect size (*d*) for decreasing INT to eat unhealthy snacks was medium for TPB+IIs (0.54) and small for TPB-only (0.4). Both interventions changed consumption of unhealthy snacks with TPB-only (adjusted *M* intervention effect estimate = -2.66 SE=0.95, 95% CI -4.52, -0.79*, *d*=0.35 [i.e. small]) reporting a lower decrease in unhealthy snacks versus TPB+II (adjusted *M* intervention effect estimate = -4.00 SE=0.94, 95% CI -5.84, -2.16** *d*=0.52 [i.e. medium]) although not significant. TPB+IIs had a decreased consumption of healthy snacks (adjusted *M* intervention effect estimate = -2.86 SE=0.84, 95% CI -4.50, -1.22**) compared to TPB only (-1.09 SE=0.84, 95% CI -2.73, 0.55) and control groups with a small effect (note: ES was small and disappeared at 3 months). **3 MONTH FOLLOW-UP** Only TPB+IIs intervention effects on INT (adjusted *M* intervention effect estimate = -0.25, 95% CI -0.40, -0.10*) and unhealthy snack consumption (-2.09 SE=1.05, 95% CI -4.14, -0.04*) remained statistically significant with ES diminishing during this time. Decrease in healthy snacks was no longer significant in TPB+IIs group (adjusted *M* intervention effect estimate 0.01 SE=0.90, 95% CI -0.85, 0.87). **Overall:** TPB-based interventions produce favorable changes in intent to consume and actual consumption of unhealthy snacks.

Table 3. Summary of the Theory of Planned Behavior (TPB) interventions in youth.

Author (year) **Location** **Final N**	**Purpose**	**Participants**	**Design**	**Intervention(s)**	**Outcomes**
Tsorbatzoudis, 2005 Greece N = 335 At 2 month Follow-up: N = 111	How well a TPB with ATT strength (ATS) and role identity (RI) intervention increases healthy eating in adolescents.	5 schools from city in Northern Greece: Age Range: "High school" *M* age: 14.9 (±0.7) years 53.4% male 3 schools assigned to the intervention 2 schools assigned to the control 2 classes from each of the 5 participating schools were randomly selected for follow-up measure	Longitudinal trial with measures, including a TPB questionnaire developed according to Ajen's guidelines[29] and a valid and reliable FFQ, collected at baseline (T1), postintervention (i.e. 12 weeks from start of intervention [T2]), and 2 months following the intervention ("follow-up").	**TPB with ATS and RI:** 12 weeks of lectures and posters (approximately 32-38 lessons provided to students) and physical education teacher instruction. **Lectures:** 3, 45-minute lectures using information, persuasion, and goal-setting were delivered to reduce negative ATTs and develop favorable "self-efficacy" and norms; lecture materials and written instructions for subsequent study were provided to students and discussions to resolve any confusions about the messages provided were conducted following each lecture. **Posters:** in each class 2 posters per month were displayed next to the blackboard for viewing before, during, and after class; posters either highlighted the benefits of and encouraged healthy eating and others focused on the risks associated with unhealthy eating; a poster was also displayed on the gymnasium announcement board. Physical Education instructors were trained to relay tips on being active, eating healthfully, among other building strategies to students during class time.	Correlations of TPB measures on INT to eat a healthy were: ATT: T1=(0.44**), T2=(0.43**); SN: T1=(0.27**), T2=(0.23**); PBC: T1=(0.55**), T2=(0.44**). **POSTINTERVENTION** After adjustment for initial differences, as compared to the control group, the intervention group had more positive INT and ATT to eat healthy ($F_{(1,311)}$=14.49***, *d*=0.91; *M*=13.85 SE 0.37 versus 11.82 SE=0.37 and $F_{(1,311)}$=10.51***, *d*=0.89, *M*=27.63 SE=0.34 versus 26.03 SE=0.34, respectively). PBC and ATS were also significantly higher in the intervention group after adjusting for initial differences ($F_{(1,311)}$=7.79***, *d*=0.79, *M*=15.32 SE=0.3 versus 14.08 SE=0.30 and $F_{(1,314)}$=11.92***, *d*=0.93, *M*=17.67 SE=0.48 versus 15.28 SE=0.48, respectively). Significant differences between groups in energy intake after controlling for initial measures ($F_{(1,311)}$=9.07, p<.001, *d*=0.85) with the intervention having lower mean intake (7872.2kj SE=178.3 [about 1881kcal SE=43] versus 8616.4kj SE= 161.2 [about 2060kcal SE=39]). No differences between groups in RI or SN. **FOLLOW-UP** No significant differences after controlling for potential initial differences with energy intake remaining lower in the intervention group, although not significantly different ($F_{(1,105)}$=16 (NS)). **Overall:** A TPB-based intervention can be effective in changing ATT towards healthy eating; however, additional constructs may need consideration for long-term effects.

*p≤0.05
**p≤0.01
***p≤0.001

[a] *p* -value adjusted via Bonferoni technique to .01 for multiple testing using one-way, between-subjects MANOVA
Abbreviations: ATT=Attitude, BR=Behavior, IIs=Implementation intentions, INT=Intention, M=Mean, NS=Not Significant, SN=Subjective Norm, PBC=Perceived Behavioral Control

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Chapter 3: A Mixed Methods Analysis of Beverage Choices in Adolescents and Their Parents Using the Theory of Planned Behavior and Parent Response to Beverage Choice Questionnaire

Abstract

Introduction: Added sugar intake in the form of sugar-sweetened beverages (SSBs) has been considered a contributor to weight gain and cardiometabolic dysfunction in adults and youth. Adolescents are some of the highest consumers of added sugars, taking in ~16% of their total calories from added sugars with ~40% of these calories coming from SSBs. Thus, efforts are needed to understand why adolescents choose such beverages. The Theory of Planned Behavior (TPB) may be a means to help identify areas where intervention efforts be directed. Youth's food preferences and self-regulation of dietary intake can be influenced by parents. The Parent Response to Beverage Choice Questionnaire (Par-B-Q), an instrument adapted from the Coping with Children's Negative Emotions Scale (CCNES), can explore parents' responses to their child's SSB and non-SSB choices in and out of the home. **Methods:** The current investigation utilized four record-assisted 24-hour dietary recalls and a TPB questionnaire targeting SSB in 100 adolescents. Consenting parents completed the beverage intake questionnaire, a TPB questionnaire, and Par-B-Q. **Results:** Adolescents consumed an average of ~118 kcals from SSBs daily. The TPB explained 34% of the variance in adolescents' and parents' intention to limit SSBs to less than one cup per day. Parents' perceived behavioral control (b=1.35, p=0.002) and adolescents' subjective norms (b=0.57, p=0.001) were the strongest predictors of intention, and intention was the strongest predictor of SSB consumption in both adolescents and parents (b=-37, $p \leq 0.05$, b=-49, p=0.01). The TPB explained more variance in parent SSB consumption (R^2=0.38) than observed in adolescents (R^2=0.22). Parents did more discouraging of SSBs and encouraging of non-SSBs overall and the majority of parents (n=42, 65%) spoke to the children about beverage choices "sometimes." Water (n=46, 71%) and was the most reported permitted beverage energy drinks (n=40, 62%) were the beverage that parents did not like their child to purchase or drink most. The moderating role of adolescents' intention to limit SSBs trended towards significance when examining the relationship between parents' reactions encouraging SSBs and adolescents' predicted SSB consumption (p=0.059); no other moderators were statistically significant. **Conclusions:** The TPB explained a small, but statistically significant amount of variance in adolescents' SSB consumption. When addressing adolescent SSB intake, people in addition to parents may influence their intentions and ultimately SSB consumption. Future work evaluating adolescents' sugary beverage intake using the TPB can highlight peers and other role models as possible influences.

Introduction

Adolescence is a time characterized by dramatic changes psychologically, socially, and physiologically.[1] Despite adolescents' attempts to become autonomous,[2] with greater freedom and responsibility, parents remain primary sources of nourishment physically and emotionally by providing food, economic support, and empathy.[1,3] More specifically, during adolescence there is greater consumption of energy-dense foods and conventional eating patterns can be shunned,[2,4,5] potentially resulting in overweight and obesity.

Unfortunately, about one-third of US youth are considered overweight or obese,[6,7] and excessive weight gain in youth may track into adulthood and contribute to cardiovascular risk.[8,9] Bullying, depression, and disordered eating have been associated with obesity in youth.[10-13] Furthermore, relationships have been observed with obesity and low self-esteem and negative body image,[14,15] and teasing may contribute to greater weight gain in overweight adolescents.[13] The development of overweight and obesity in youth may result from overconsumption of added sugars, specifically sugar-sweetened beverages (SSBs).[16-19] Sugar-sweetened beverages are beverages that contain added caloric sweeteners and include soda, energy drinks, sweet tea, sports drinks, and fruit drinks.[20-22] Ervin and colleagues found that 2-18 year olds consume about 16% of total energy from added sugars with approximately 41% of these calories coming from SSB.[23] However, the Scientific Report of the 2015 Dietary Guidelines Advisory Committee has recommendations for limiting added sugar intake, which includes SSBs, to a maximum of 10% of daily calories.[24] In adolescents, excessive SSB intake has been associated with increased risk of diabetes[25-27] and cardiovascular disease risk.[21,28-31] Additionally, inadequate dietary intake established in adolescence can have long-term effects on health.[32]

Youth aged 2-19 years of age are known to consume an average of approximately 155 kcal, or about 12 fl.oz. of cola, per day from SSB,[33] an amount in excess of the American Heart Association's recommendation of 450 kcal per week from added sugars.[34] While consumption of soda, previously the highest contributor to SSB intake in adolescents,[22,33,35] has recently decreased,[33,36] 100% fruit juice,[37] sweetened coffee and tea,[33] and sports and energy drink[33,36,38] consumption has increased during this same time. Sports and energy drink consumption has increased threefold since 1988[22,36,38] and continues to rise, especially in adolescents.[33] Sports drinks have also been associated with increases in youth's BMI.[39] Yet the American Academy of Pediatrics recommends that sports and energy drinks not be consumed regularly by adolescents, [40] due to how these beverages can contribute to excessive caloric intake in youth's diets.[41]

Parents are known to help mold youth's attitudes and beliefs about food and eating practices.[42] Indeed, modeling overconsumption and parent feeding practices that are controlling or restrictive in nature are suggested to have detrimental effects on children's BMI[43] and food regulatory behaviors and preferences.[44,45] Thus, parents may play a crucial role influencing food beliefs and behaviors in adolescents.[46]

Theory-based models for predicting and conceptualizing health behaviors may be more successful when attempting to examine health behavior change compared to those not grounded in theory.[47-49] The Theory of Planned Behavior (TPB),[50] that posits to predict and explain behavior, is one psychosocial theory that can be promising when addressing adolescent overweight and obesity. According to the TPB, behavioral action occurs from the influence attitude, subjective norm, and perceived behavioral control (PBC) have on intention, the most proximal determinant of behavior.[50] The Theory has been successful in predicting and understanding many health-related behaviors,[51-53] and the information gained from application of the TPB can help create customized, relevant, and possibly more effective interventions[52] producing outcomes supportive of health.

Purpose

The purpose of this investigation was to evaluate the TPB's effectiveness in understanding and predicting adolescents' SSB consumption, identify which constructs are the most important when evaluating SSB consumption in adolescents, and determine if and how adolescents' beverage choices are influenced by parents' reactions to their beverage choices. It is hypothesized that 1) all TPB constructs will be significantly correlated to adolescents' intention, 2) attitude will be the strongest predictor of adolescents' behavioral intention, 3) behavioral intention will be the strongest predictor of adolescents' behavior (i.e. SSB intake), 4) adolescents and parents will have different TPB constructs emerge as the most predictive of intention to limit SSB intake, and 5) parental responses to adolescents' beverage choices will moderate the relationship between adolescents' attitude and intention and SSB consumption.

Methods

One hundred and two adolescents aged 12-18 years were recruited for participation in this investigation. Consistent with the methods used in the National Health and Nutrition Examination Survey (NHANES),[54] individuals in this age range can report their dietary intake independently, without the need of proxy reporters (i.e. parents). When three days or more of dietary information is obtained per participant a sample of this size can provide adequate precision.[55] Study procedures and questionnaires were pilot tested with three adolescents and modifications were made according to their feedback. Interested participants were included once parental permission was obtained and if they met the specified age criteria; could read, write, and speak English; and were willing to comply with study procedures. Adolescents were targeted in the proposed investigation due to their obesity prevalence rate[6,7] and known high added sugar and SSB consumption,[23,33,36] which may increase cardiometabolic[28,56] and obesity risk[57-59] later in life.[8,9,60] Parents accompanying children were also invited to participate.

Adolescent participants were randomized to one of two visit sequences, and completed four laboratory sessions within a one to three week period (**Figure 3**). Randomization was done to prevent an order effect in dietary outcome variables. Over the entire study duration, adolescents completed four 24-hour dietary recalls (24HR), the TPB questionnaire at two separate visits, a health history questionnaire, and had their height and weight measured. Consenting parents completed a health history questionnaire, the beverage intake questionnaire (BEVQ-15)[61], the TPB tool[62,63], the Parent Response to Beverage Choice Questionnaire (Par-B-Q), and had their height and weight measured. For both adolescents and parents, height was measured and recorded in centimeters without shoes using a wall mounted stadiometer (Seca 216, Hamburg, Germany), and body weight was measured in light clothing without shoes, to the nearest 0.2 kg using a digital scale (Scale-Tronix, Wheaton, IL). Body mass index (BMI) [kg/m^2] and BMI-for-age percentile were calculated for each adolescent,[64] and BMI was calculated for each parent. Institutional review board approval was obtained prior to data collection (**Appendices D and E**).

Adolescent and Parent Beverage Intake Assessment

Adolescents had a record-assisted 24HR administered at each study session. Adolescents' dietary intake is known to vary from day-to-day;[65,66] thus, four 24HRs were collected since this has been identified as optimal for examining usual intake of most nutrients and foods in youth.[67,68] Recalls were obtained on non-consecutive days using the automated multiple pass method (AMPM), similar to procedures used in NHANES.[54] The AMPM provides a more accurate diet recall with decreased subject burden,[69] when administered by a trained individual. Participants were provided with a food-recording booklet that was to be used the day prior to each study session, and would serve as a reference when being administered the 24HRs. Participants were told they can record as much data as they felt necessary, but were asked to provide the time, location, and list of foods and beverages consumed minus portion sizes and descriptions,[70] although some participants did record that data. Lab sessions were scheduled to collect data from weekdays and weekend days since added sugar intake in children and adolescents is known to be higher on Fridays and Saturdays versus other days of the week.[68] Recalls were entered and analyzed using nutritional analysis software (Nutrition Data System for Research [NDS-R 2013], University of Minnesota, Minneapolis, MN). The average water fluid ounces (fl.oz.), SSB fl.oz. and kcals, and total beverage fl.oz., and kcals consumed were calculated from the four 24HRs.

Parents completed the Beverage Intake Questionnaire (BEVQ-15; **Appendix F**) at their visit, which typically was the adolescents' first session. The BEVQ-15 is a quantitative food frequency questionnaire providing an estimate of habitual beverage intake across 15 beverage categories that evaluates total beverage and SSB intake (i.e. grams and kcals).[61,71] This tool is valid and reliable in adults[61,71] and is sensitive to detect changes in beverage intake patterns over time.[72] It includes individual items for soda, diet soda, 100% fruit juice, sports and energy drinks, coffee and tea with added cream and sweetener, and coffee and tea without added cream and/or sweetener, among others.

Parent and Adolescent Theory of Planned Behavior Questionnaires

Parents and their children were administered different TPB questionnaires (**Appendices G** and **H**). The behavior outcome was "less than one cup of sugar-sweetened drinks each day." Adolescents were administered the TPB questionnaire two times (time 1=TPB 1, time 2=TPB 2), with anywhere from three to 14 days between measures, to assess test-re-test reliability. The TPB questionnaire previously used in adults[63] was modified for adolescents to relate to their language and cognitive capacity since during the pilot-testing participants expressed confusion with some of the wording contained within items. For example, the seven-point semantic differential scale used in the adult TPB tool was reduced to five responses omitting the "slightly…" categories from each question and changing the "quite…" responses to "sort-of…" and the word “value” was replaced with “care about” in subjective norm items. Internal consistency was evaluated for each of the TPB constructs at both time 1 and time 2. Attitude was measured with six categories of responses (e.g. enjoyable-unenjoyable, healthy-unhealthy, unsatisfying-satisfying, wise-unwise, boring-exciting, and harmful-beneficial) to the prompt ‘For you, drinking less than 1 cup of SSB each day would be….’ Cronbach alphas (α) for attitude on TPB 1 and 2 increased to 0.64 and 0.67, respectively, after deletion of the third belief measure. Three items each were used to assess subjective norm (e.g. ‘Most people who are important to you want you to drink less than 1 cup of sugary drinks each day.’; α TPB 1=0.55, TPB 2=0.70) and PBC (e.g. ‘You have complete personal control over limiting your sugary drinks to less than 1 cup each day, <u>if you really wanted to.</u>’; α TPB 1=0.64, α TPB 2=0.62 after deletion of barrier three), and four items for intention (e.g. 'How motivated are you to limit your sugary drinks to less than 1 cup each day?'; α TPB 1=0.81, α TPB 2=0.88 after removing motivation item 2).

The parents' TPB questionnaire was developed in accordance with Ajzen's recommendations,[73] and elicited key messages for attitudes, subjective norms, and PBC, and behavioral intention constructs in relation to drinking "less than one sugar-sweetened drink each day."[74] According to preliminary testing the primary TPB constructs explained an acceptable variance (R^2=0.38, p<.05) in SSB consumption and had moderate to high internal consistency (Cronbach αs ranging from 0.51 with PBC to 0.93 with intentions[74]).

Parent Response to Beverage Choice Questionnaire (Par-B-Q)

The Par-B-Q (**Appendix I**) was adapted from the Coping with Children's Negative Emotions Scale (CCNES).[75] The CCNES contains six subscales demonstrating various responses to hypothetical troublesome circumstances parents may experience with their child/children; it is a self-reported measure of parents' reactivity to their child's emotions during bothersome situations.[75]

For this study's purposes the questionnaire was tailored to parents' responses to their child drinking the following beverages "at home" or "outside the home" since children and adolescents consume more SSBs at home versus out of the home:[23,33] coffee-type, sports or energy drinks, regular soda, juice drinks (all considered SSBs), diet soda, and 100% fruit juice (both considered non-SSBs). The Par-B-Q retains five of the original CCNES subscales, explained in **Table 4**. Responses for each respective beverage and subscale ranged from one (i.e. "Very Unlikely") to seven (i.e. "Very Likely"). Mean scores for subscales suggesting encouragement of SSB consumption (i.e. Expressive Encouragement and Minimization Reaction) and subscales suggestive of discouraging SSB intake (i.e. Distress Reaction, Punitive Reaction, Problem Focused Reaction) were calculated for SSBs and non-SSBs in and outside of the home. Cronbach alphas were acceptable (i.e. $\alpha > 0.70$)[76] for all constructs measuring discouraging SSB and non-SSB in and out of the home, while constructs measuring encouraging SSB and non-SSB intake in and out of the home were lower (αs ranged from 0.18-0.63). Responses from the Par-B-Q were primarily used to answer the question: are parents' responses to adolescents' beverage choices more discouraging of SSBs or encouraging of non-SSBs at home/out of the home?

The Par-B-Q's last section contained open-ended questions for the parents to complete. The first question was "How often do you talk with your child about beverage choices she/he makes?' with responses of "Often," "Sometimes," and "Never." Other questions pertained to the beverages parents allowed or did not allow their child to drink or purchase, why they discussed beverage choices with their children, and what was important to discuss with their child/children about in regards to beverage choices. Qualitative analyses were conducted with an inductive approach.[77,78] Briefly, themes were identified through open coding and grouping categories and frequency of responses were recorded in Microsoft Excel. Attempts were made to preserve the quality of data while reducing its length (i.e. condensation). [78] *Major themes* were considered similar responses from ≥50% of parent participants, while *minor themes* were considered similar responses from 25-49% of parent participants [79]

Statistical Analyses

Descriptive statistics including means, standard deviations, standard errors of the mean, and frequencies were used to summarize all responses for continuous variables. Simple and bivariate correlations, paired and independent sample *t*-tests, frequencies, and analysis of variance (ANOVA) were used to assess associations among variables, and group differences (e.g., sequence, gender, weight status). Sequential multiple regression, as described in Zoellner et al.,[63] was conducted to assess the TPB questionnaire's utility in predicting adolescents' and parents' SSB consumption. Four separate steps were generated to predict SSB intake using intention in the first, adding PBC in the second, then adding attitude and subjective norm in the third, and gender, age, and BMI percentile (BMI for parents) in the fourth. Gender was dummy coded. The resulting correlation, regression, and multiple regression coefficients and confidence intervals are presented. Adjusted R^2 is also reported due to the acknowledged limitations of using R^2 (i.e. overestimation of population variance) in TPB research.[80]

A moderator analysis was conducted to determine if adolescents' attitude and intention moderated the relationship between parents' responses to adolescents' beverage choices in and out of the home (e.g. encouraging/discouraging SSB/non-SSB consumption in the home, out of the home, and overall [i.e. combination of responses in or out of the home]) and adolescents' SSB consumption. The SPSS macro "PROCESS" (available at http://www.processmacro.org/download.html)[81] was used to conduct the moderator analysis in SPSS.[82] Briefly, the PROCESS macro centers the moderator and predictor variables, creates an interaction term, and then runs a forced entry regression providing R^2 for the model overall, *b*-values for each predictor and their standard errors adjusted for heteroscedasticity, *t*-statistic with significance, 95% confidence intervals for *b*, and simple slopes among other coefficients and data to be used for interpretation. If the interaction term is statistically significant it can be said that moderation is present and a simple slopes analysis follows. The simple slopes analysis involves fitting regression equations for the predictor and outcome at high, low, and average levels of the moderator (i.e. the PROCESS macro uses one standard deviation above [the "high" level] and below [the "low" level] the mean for the potential moderator variable[81,82]) to assess the conditional effect a predictor has on an outcome. Adolescents' attitude towards SSBs and intention to limit sugary beverage intake to less than one cup per day were chosen as moderators because these constructs were found to be the most consistently associated with adolescents' dietary intentions and behaviors, respectively (see **Chapter 2** and reference #105 from this **Chapter).** Bootstrapping was used in the multiple regression and moderator analysis to overcome the violation of regression assumptions preventing the invalidation of significance tests, confidence intervals, and generalizability of models overall.[82] An *a priori* significance level of $p \leq 0.05$ was chosen and all statistical analyses were carried out using PASW Statistics (version 22, SPSS Inc., Chicago, IL, 2013).

Results

Demographics and Beverage Intake of Adolescents and Parents

One hundred-twenty individuals completed an online screening form and 18 did not respond to communications for scheduling the first study session. Fifty-five adolescents were randomized to sequence one and 47 to sequence two; two participants from sequence one discontinued participation after the initial session, leaving 53 sequence one adolescents for data analyses.

Adolescent participants were primarily white (93%) and of normal weight (75%) with just over half being male (52%) (**Table 5**). Twenty adolescents each reported their last completed grade as

7th and 8th, 15 each reported 6th and 11th, 13 reported 10th, 11 reported 9th, and two reported 12th as their last grade completed. **Table 5** outlines adolescents' intake of major beverage categories (i.e. water, SSBs, and total beverages). There were no significant differences between sequences in gender, age, BMI-for-age classification, mean TPB scores, and water, SSB, and total beverage intake. There were significant differences between genders on mean attitude, subjective norm, and intention scores, and SSB and total beverage intake with females having higher mean scores on the TPB constructs and lower SSB and total beverage fl.oz. and kcals versus males (all $p<.05$). On average, male adolescents consumed 57 fl.oz. (SE=3) of total beverages per day, 31 fl.oz. (SE=3) of water, and 12 fl.oz. (SE=1) of SSBs. Females drank, on average, 43 fl.oz. (SE=2) of total beverages, 26 fl.oz. (SE=3) of water, and 6 fl.oz. (SE=0.0) of SSBs daily. Significant differences were observed between adolescents of differing BMI classifications for total beverage fl.oz. consumption ($F(3,96)=3.69$, $p=0.01$) with underweight participants drinking more than normal ($p=0.02$) and overweight ($p=0.03$) adolescents, respectively.

A total of 66 parents consented to participate in the study. The majority of parents were female (86%), white (97%), married (88%), highly educated (97%) (**Table 5**), and reported a household income of ≥$55,000 (n=52, 80%). Just under half of parents were considered of normal weight (45%) and BMI ranged from 16.00-52.9 kg/m^2 (mean±SE=26.1±0.8). Parents' mean consumption from each of the main beverage categories is outlined in **Table 5**. No differences were significant when examining parent BMI category and mean responses on the Par-B-Q and main beverage categories from the BEVQ-15; however, normal weight and obese parents differed in their responses to perceptions of control on the TPB questionnaire ($F(3,61)=5.00$, $p=0.004$) with obese individuals having less perceptions of control versus their normal weight counterparts (mean difference=-.710, p=0.003). All other TPB constructs were not significantly different between BMI categories.

Predicting Sugary Beverage Consumption in Adolescents and Parents: the Theory of Planned Behavior

The intercorrelations between sugary beverage intake and TPB constructs of adolescents and parents are displayed in **Table 6**. Test-re-test reliability of the TPB in adolescents was acceptable with Pearson correlation coefficients ranging from moderate to strong (all $p<0.001$; bolded values on diagonal in the upper panel of **Table 6**). As hypothesized, all TPB constructs were significantly correlated with adolescents' intentions. Intention had the strongest relationship with SSB consumption in both adolescents and parents (both $p<0.001$). In adolescents, subjective norm ($p<0.001$) had the highest correlation with behavioral intention, while in adults PBC had the highest correlation with intention. In both adolescents and parents attitude had the lowest correlation with behavioral intention (both $p<0.05$).

Thirty-four percent of the variance in adolescents' (adjusted R^2=.32, $F(3,96)$=16.81, $p<0.001$) and parents' (adjusted R^2=.31, $F(3,62)$=10.57, $p<0.001$) intention to limit sugary beverage consumption to less than one cup per day could be accounted for by the TPB's three main constructs (i.e. attitude, subjective norms, and PBC). As hypothesized, different TPB constructs emerged as the most predictive of intention to limit SSBs to less than one cup per day. In parents, PBC was the strongest and only significant predictor of behavioral intention (b±SE=1.35±0.36, 95% bias corrected and accelerated CI [95% BCa]=0.67, 2.07, $p\leq0.001$), while different from hypothesized, subjective norm was the strongest predictor in adolescents (b±SE=0.57±0.11, 95%

BCa=0.35, 0.72, $p \leq 0.001$). Also, a significant predictor in adolescents was PBC ($b \pm SE=0.39 \pm 0.11$, 95% BCa=0.18, 0.62, $p=0.002$).

The multiple linear regression results for TPB constructs with SSB kcal consumption in adolescents and parents are presented in **Table 7**. The Durbin-Watson test statistics of 2.03 and 1.86 for adolescent and parent models, respectively suggests the assumption of independent errors is met,[82] and average variance inflation factors of 1.26 and 1.36 suggests the regression models for adolescents and parents, respectively is not biased.[82] Each of the models overall were statistically significant (**Table 7**). Parent R^2 and adjusted R^2 values were higher than those observed for adolescents at all steps of the regression model (**Table 7**); more variance in SSB consumption could be accounted for by the TPB in parents versus adolescents. In both adolescents and parents intention was a significant predictor of SSB consumption, although stronger in parents (**Table 7**; adolescents: $b=-37$, $p \leq 0.05$; parents: $b=-49$, $p \leq 0.01$). For every one-point increase in adolescents' and parents' intention to limit sugary beverages, SSB consumption is predicted to decrease by 37 and 49 kcals, respectively. In adolescents gender was a significant predictor of intention to limit sugary beverages to less than one cup every day ($b=-49$, $p \leq 0.05$); females consumed 49 kcals less of SSB than their male counterparts.

Parent Response to Adolescents' Beverage Choices

The means and SEs for encouraging and discouraging SSBs and non-SSBs in and out of the home and overall are depicted in **Table 8**. Overall parents did significantly more discouraging of SSBs and encouraging of non-SSBs (both $p \leq 0.01$). When considering environment, parents' responses suggest they did more encouraging of non-SSBs ($M=2.95$) versus discouraging of SSBs ($M=2.49$) out of the home ($t(65)=-2.69$, $p=0.009$). However, at home parents' reactions are more discouraging of SSBs (M=3.17) compared to encouraging non-SSBs (M=2.95; $t(65)=3.69$, $p<0.001$).

Qualitative Results

All categories of responses for the open-ended questions of the Par-B-Q are listed in **Appendix J**. Sixty-five percent of parents (n=42) stated they speak with their child "sometimes," ~32% (n=21) stated "often," and ~3% (n=2) "never" speak to their child about beverage choices. One major and one minor theme emerged from parent responses to why they spoke with their child about beverage choices: they believed "health was impacted by choices" (55% of responses), and they wanted to "have a positive influence on beverage choices" (35% of responses). Parents thought it was important to speak with children about "how choices can impact their [i.e. the child's] health" (45% of responses), "how sugary drinks are not good/too much sugar is not good" (38% of responses), to "encourage water/water is important for health" (34% of responses), and "moderation" (28% of responses). Beverages parents permitted their child to drink or purchase included water (71% of responses), 100% fruit juice (63% of responses), soda on special occasions (58% of responses), milk (48% of responses), sports drinks (including low-calorie sports drinks, 31% of responses), and sweet tea/lemonade (26% of responses). Beverages that parents do not like their child to drink or purchase included energy drinks (62% of responses), soda (46% of responses), coffee (32% of responses), caffeinated drinks (29% of responses), SSBs/sweet tea (28% of responses), and artificially sweetened drinks/diet soda (25% of responses).

Moderator Analysis

Two adolescent participants discontinued participation in the study after the initial visit and the associated parent data was not included in the moderator analysis, leaving 64 parent participants with useable responses for the moderator analysis. Out of 24 possible moderators two models were statistically significant (**Table 7**): the interactions between adolescent intention and parental encouragement of sugary beverage intake 1) inside and outside the home (t=-2.37, p=0.02), and 2) outside the home (t=-4.04, $p \leq 0.001$). Contrary to hypotheses no parental response to adolescents' beverage choice in or out of the home had a significant interaction with adolescents' attitude toward SSBs.

The conditional effect of parent responses that are suggestive of encouraging adolescents' SSB intake in and out of the home combined [i.e. overall] on adolescent SSB consumption at low, average [i.e. mean], and high values of adolescent intention to limit SSB intake (i.e. the simple slopes) is depicted in **Figure 4**. When parents' responses encouraging SSBs are high and adolescents' intention to limit sugary beverages is low, adolescents' predicted SSB kcal intake is highest (i.e. 214 kcals; p=0.059). Similar patterns emerged when assessing parents' reactions encouraging sugary beverage consumption outside of the home at high, average, and low levels of adolescents' intention to limit SSBs.

Discussion

Adolescent and Parent Beverage Intake

Male and female adolescents drank less than established upper limits for SSBs[62,83] and this might be explained by recent research indicating that youth's SSB consumption has been declining.[33,37,84] Parents' SSB consumption exceeded recommendations of less than eight ounces per day;[83] however, it is less than recent findings.[33,36] The sample reporting a high income and education attainment may also be the reason of the current results. Nonetheless, these findings are promising due to the known negative health implications associated with excessive SSB consumption in adults[29,85-87] and youth.[17,28,29,31,56]

Individual's water requirements can vary due to many factors,[88-91] and the national average intake of water per day for those two years of age and older is ~31 fl.oz. (3.9 cups).[92]The average water intake in our sample of adolescents and parents fell below the national average and is below recommendations,[88] as is total beverage consumption. Water intake has been associated with less energy consumption[93] and prevention of overweight in youth[94] and adults.[95-100] Cognitive performance may be compromised with inadequate hydration (see **Appendix K**),[90] and our results display an area where improvements in beverage intake are necessary and future interventions be directed. Continuing to target reducing SSB intake and increasing water consumption, as stressed in the Scientific Report of the 2015 Dietary Guidelines Advisory Committee,[24] can assist with weight management and ultimately promote health and well-being in youth and adults.[95-100]

Effectiveness of the Theory of Planned Behavior

Research supports the usefulness of the TPB in the prediction of intention and behavior for a wide variety of health behaviors.[51-53] For example, Armitage and Conner found that on average the TPB constructs accounted for 39% of the explained variance in intentions and 27% in behaviors in their review of 161 articles.[51] A more recent meta-analysis of 206 publications on the TPB's predictive ability for various health behaviors found that the model accounted for

44.3% of the variance in behavioral intention and 19.3% of the variance in behavior.[53] The present results differ in that less variance can be accounted for in both adolescents' and parents' intention to consume SSBs. Additionally, R^2 values for behavior in adolescents and parents are higher than McEachan and colleague's work.[53] However, our results are similar to one study assessing soft drink consumption in adolescents.[101] In our sample, the TPB explained more variance in parents' SSB consumption versus adolescents, and past work examining dietary behaviors of adults and adolescents had similar findings (e.g. R^2 adults=0.27 vs. R^2 adolescents=0.10).[53] Additionally, the explained variance in behavioral intention is similar between adolescents and parents as seen in prior work.[53] It has been suggested that adolescents' health behaviors may include two processes (i.e. “heuristic” and evaluative) and a theoretical model incorporating both operations may be more effective in predicting adolescents' health behaviors versus a traditional expectancy-value model, such as the TPB.[102] The present results may be indicative of the need to account for these additional processes. Future research attempting to understand adolescents' SSB consumption can include incorporating this “dual-processing perspective,”[102] which may provide further reasoning to why adolescents choose specific beverages over others.

Perceived behavioral control in parents and subjective norm in adolescents had the strongest association with behavioral intention and this is dissimilar to previous analyses for adults,[51,53] but similar for adolescents,[53] although one study found a significant positive relationship between adolescents' soft drink intake and parental norm.[103] Godin and Kok found PBC to have the second highest average correlations (r=0.32) with intention when specifically considering eating behaviors, and the lowest with subjective norms (r=0.16).[52] More recently, among the relationships between all TPB constructs and intention, reviews have found the highest coefficients with the attitude-intention association (*r* values of 0.49 and 0.57, respectively) and lowest with the subjective norms-intention relationship (*r* values 0.34 and 0.40, respectively).[51,53] However, upon further evaluation one meta-analysis revealed that, when strictly examining diet behaviors, adolescents' subjective norm-intention correlation was higher than that seen in adults (r=0.53 versus 0.36).[53]

In the TPB, intention signifies the amount of effort someone is willing to put in to perform a behavior and relates directly to behavior action.[50] Intentions can change over time; thus, the closer intention is measured to behavioral action, the more likely it can predict behavior.[104] Adolescents' and parents' behavioral intention was the strongest predictor of SSB consumption, and this may be because SSB intake (i.e. behavior) was measured at the same time as intention. Previous works show similar patterns in adults[51-53] and adolescents.[53] Intention being identified as one of the most consistent variables associated with youth's dietary behavior suggests, like previous work,[105] that youth's choices may be less cognitive and more affective; however, investigating the underlying beliefs is crucial to make more definitive conclusions. As age increases processing of stimuli changes from being emotional-based to more rational/evaluative[106] and adolescents may be in the midst of this transition. However, our results contrast a review that had different cognitive constructs emerge as the strongest predictors of diet behaviors in youth as compared to research in adults, suggesting the need to customize interventions to the population being examined.[105] More research is needed to understand which approach would be best when exploring adolescents' SSB consumption. The results may also suggest that intention helps adolescents limit their SSBs since the contribution of energy intake from SSBs in the present sample is lower than previously observed.[33,36,84]

Overall the results suggest that adolescents and parents may differ in their beliefs about limiting SSBs; in adolescents the influence of others is imperative, and in adults the ease or difficulty of behavioral performance is important. When developing interventions, highlighting interpersonal connections and involving others important to adolescents may be of benefit for health outcomes.

Parent Responses to Adolescents' Beverage Choices and Moderation Analysis

Parents,[107] specifically mother's,[108-110]although fathers may play an important role,[110-113] influence youth's dietary intake[46] and parents in our sample doing more discouraging of SSBs overall appears to be influencing adolescents' SSB consumption. However, the present sample of adolescents may not necessarily be representative of all youth's behaviors, especially with our sample having less adolescents identified as being obese compared to VA population data.[114] The most recent literature suggests that SSB intake in adolescents has been decreasing[33,36,84] and our sample may indicate that the decline is continuing or the current sample may have healthier beverage choices.

The qualitative results from the Par-B-Q suggest that parents may be aware of the perceived health benefits of water consumption[95,98] and seek to have a positive influence on their child's health. This may be further exemplified by energy drinks being the most frequently identified beverage parents do not like their child to drink or purchase. Parents stating that they permit their children to drink or buy soda on special occasions (58% of responses) and 46% of parents reporting that they do not like their child to purchase soda may be confusing to adolescents; parent attitudes can impact youth's eating behaviors[115] and having inconsistencies may have negative effects[116] like disinhibited eating,[45] potentially resulting in weight gain.

While parental discouragement of SSBs appears to have a positive influence on adolescents' beverage consumption in the present sample, focusing on foods to avoid versus foods to consume may have detrimental effects on adolescents nutrition-related behaviors;[117] unhealthy weight-control behaviors, restricting diet intake, and using food as a coping tool are known behaviors some adolescents engage in when feeling pressure.[117-119] Thus, parents in our sample modeling SSB consumption and responding to adolescents' beverage choices in a manner discouraging SSBs in the home may have opposite effects on adolescents' beverage choices. However, due to the cross-sectional study design direct causation is not possible. More work is necessary to thoroughly understand the most effective strategies for parents to promote healthier dietary habits among their children.

The moderation analysis suggests that when adolescents' intentions to limit SSBs are low, parents' encouragement to consume SSBs matters (and is associated with increased SSB consumption by adolescents), but that when adolescents' intentions to limit SSBs are moderate or high, parents' encouragement may not affect adolescents' SSB intake. Some adolescents in our sample may have the autonomy typically sought during this developmental stage of life[2,65] and this may be the reason for the difference observed in predicted SSB consumption at moderate and high levels of intention versus low levels of intention. Our results are similar to previous works suggesting that parents may influence some adolescents' SSB intake,[107,109] and it has been suggested that positive modeling may be the best approach to promote healthy diet choices in youth.[115] The results also suggest that adolescents' motivation to limit SSBs may have influences beyond their parents. Peers have been shown to influence children's soft drink intake[120] and future work can investigate how much of an impact adolescents' peer network, older family members, those in authority (e.g. religious leaders, captains on sports teams, and coaches), and other role models have on SSB intake using the TPB.

Strengths and Limitations

Despite randomization, the varied age distribution, and high retention rate of the current investigation some limitations are acknowledged. First, this is a cross-sectional study, so causation cannot be determined. Second, in adolescents there is not one method of diet evaluation that is considered superior to another,[66] and obtaining accurate dietary intake data can be challenging due to youth's day-to-day variability in food intake, poor ability to estimate portion sizes, and decreased recall ability.[66,70,121] However, the present analysis used four record-assisted 24HRs which have been suggested to better estimate food intake at the individual level[65,121] and provide satisfactory nutrient and food data representative of regular consumption patterns.[67,68,122] Third, the sample of adolescents and parents were from the Blacksburg, VA area; thus, results may not generalize to others of different ethnicity or socioeconomic status. Approximately 15% and 12% of VA's adolescents are considered overweight and obese respectively, and our sample having 7% of participants being identified as obese is below the state average.[114]Fourth, while the Cronbach α has received criticism,[123] it is widely accepted for assessing the internal reliability of questionnaires and surveys used in research. Cronbach αs for some Par-B-Q constructs measuring parent responses encouraging SSBs and non-SSBs consumption in and out of the home were low; responses from the questionnaire should be taken with caution as should the moderation analysis, which partly relied on the responses from the Par-B-Q. Moreover, the Par-B-Q has not been validated, although it was adapted from a previously validated scale measuring how parents react to children's negative emotions.[75] Despite the limitations with the Par-B-Q, the present study attempted to account for multiple ways (e.g. modeling with the BEVQ-15[61] and psychosocial factors with the TPB) parents may influence adolescents' behaviors. Fifth, Ajzen highlights the importance of conducting formative research when developing a TPB questionnaire[73] and our sample of adolescents may hold different salient beliefs than those identified for development of the administered TPB tool,[63] which may be the reason for a lower amount of variance explained than that seen in parents.

Conclusions

In conclusion, adolescents' SSB and water intake was lower than found previously in national samples.[33,36,84,92] Subjective norm in adolescents and PBC in parents had the highest correlations with behavioral intention, and intention in both adolescents and parents had the highest relationship with SSB consumption. Intention was the strongest predictor of adolescents' and parents' SSB consumption, while only in adolescents did gender emerge as another significant predictor. The TPB accounted for ~34% of the variance in adolescents' and parents' intention to limit their sugary beverage intake to less than one cup per day. In adolescents and parents, after accounting for gender, age, and BMI percentile (BMI in parents), the TPB explained 22% and 38% of the variance in SSB consumption, respectively. At lower levels of adolescents' intention to limit SSBs and parents' encouragement of SSBs, adolescents' predicted SSB intake was highest suggesting that some adolescents are influenced by their parents' when making SSB choices. However, the low Cronbach αs for the Par-B-Q suggests the tool needs modifications to better assess parents' reactions to their children's beverage choices. Those closest to adolescents', including their parents, and motivation are areas where future efforts can be directed when attempting to modify adolescents' SSB intake.

Figure 3. Study Procedures: Mixed Methods Analysis of Beverage Choices in Adolescents and Their Parents using the Theory of Planned Behavior (TPB) and Parent Response to Beverage Questionnaire (Par-B-Q).

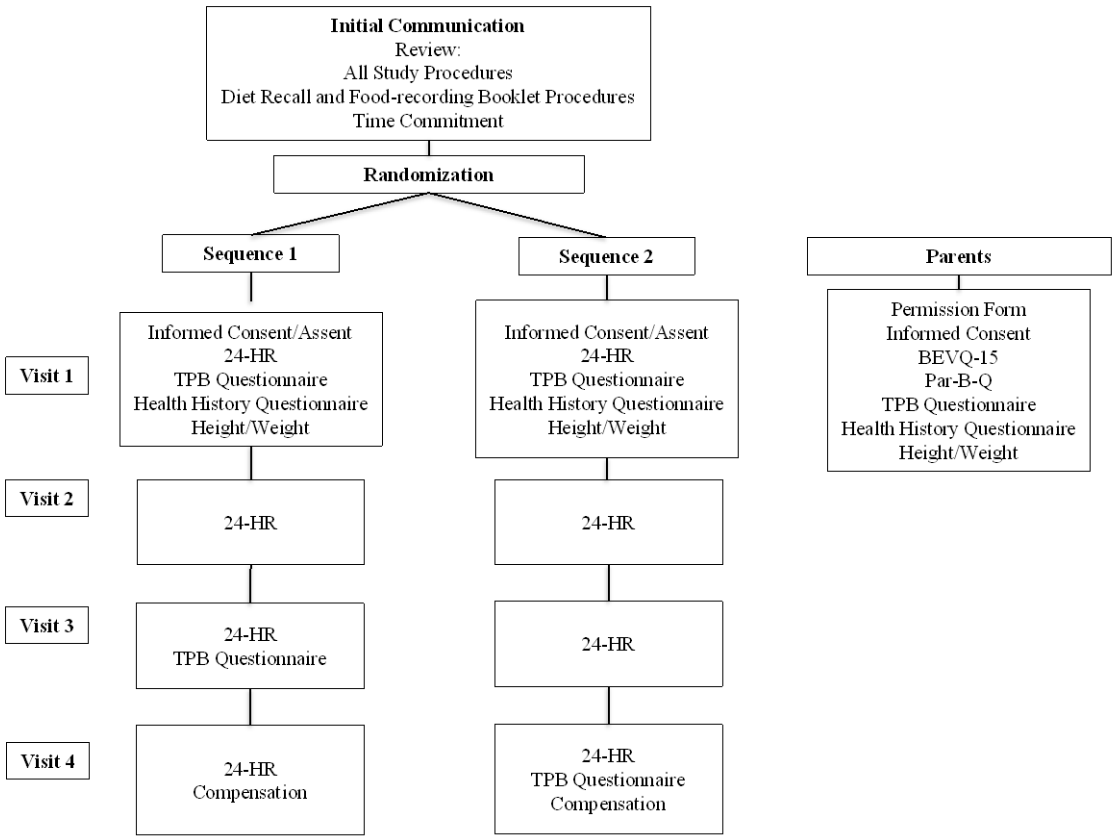
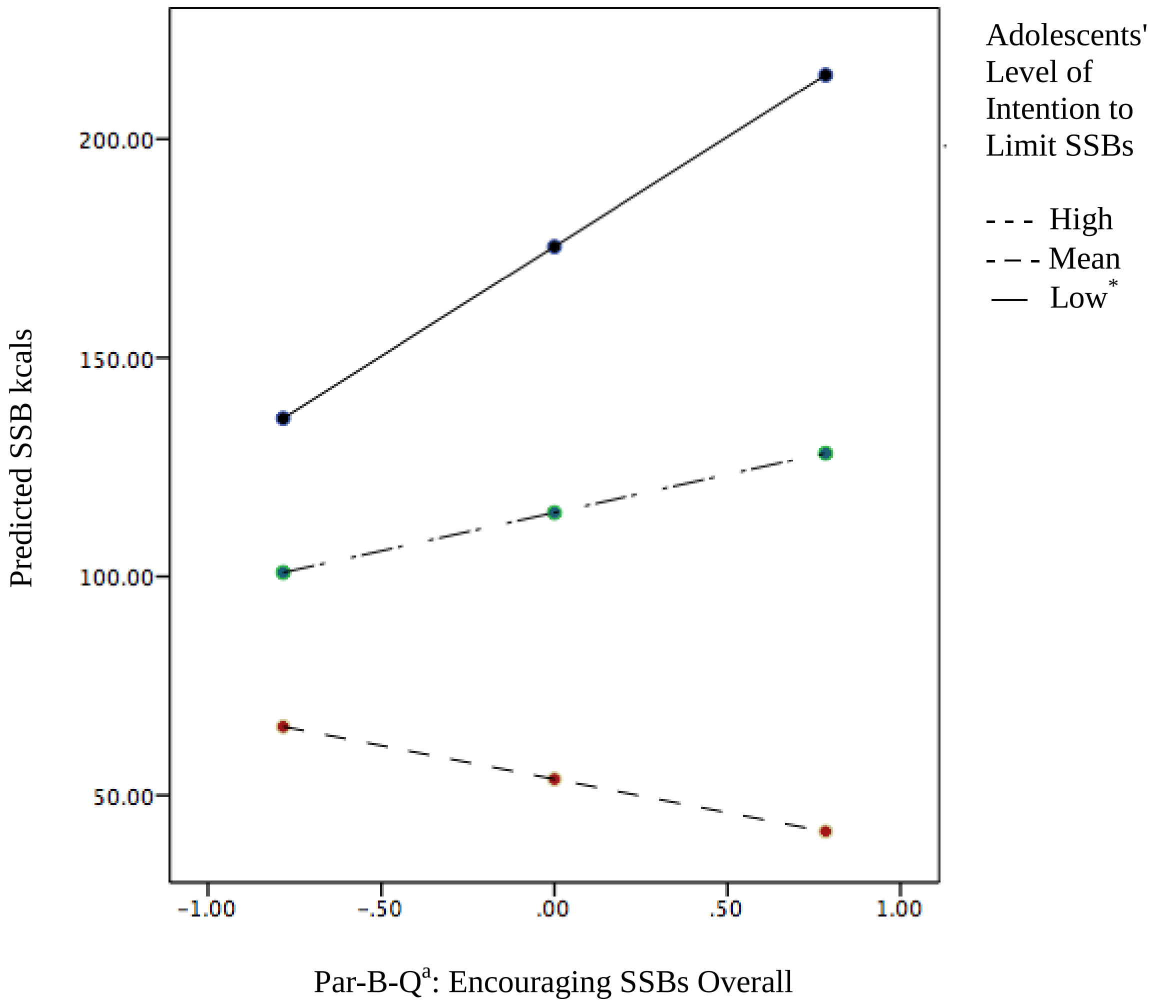


Figure 4. Simple slopes for conditional effect of parent responses encouraging sugar-sweetened beverage (SSBs) in and out of the home combined (i.e. overall) on predicted SSB consumption (kcals) at low (-1 standard deviation [SD]), average (i.e. mean), and high values (+1 SD) of adolescents' intention to limit SSBs.



[a]Parent Response to Beverage Choice Questionnaire
*p=0.059

Table 4. Subscales of responses on the Parent Response to Beverage Choice Questionnaire retained from the Coping with Children's Negative Emotions Scale.[75]

Subscale	Meaning (example statement)
Distress Reaction (DR)	Items reflect the degree to which parents experience distress when children express negative emotions ("get angry or upset with my child")
Punitive Reaction (PR)	Degree to which parents respond with punitive reactions that decrease their exposure or need to deal with the negative emotions of their children ("take it away or restrict him/her from drinking it")
Expressive Encouragement (EE)	Degree to which parents encourage their children to express negative emotions or the degree to which they validate the child's negative states ("encourage him/her to continue drinking or to drink more of it")
Problem-Focused Reactions (PFR)	Degree to which parents help the child solve the problem that caused the child's distress ("offer a different drink or ask why he/she chose that drink")
Minimization Reactions (MR)	Degree to which parents minimize the seriousness of the situation or devalue the child's problem or distressful reaction ("do nothing")

Adapted from Fabes, Eisenberg, and Bernzweig, 1990 (Reference #75).

Table 5. Demographics and mean beverage intake of adolescent and parent participants from a Mixed Methods Analysis of Beverage Choices in Adolescents and Parents using the Theory of Planned Behavior and Parent Response to Beverage Choice Questionnaire.

Characteristic	**Adolescents**	**Parents**
Total, *n* (%)	100	66
Male	52 (52)	9 (14)
Female	48 (48)	57 (86)
Age, years		
Mean age±standard error	14±0.2	46±0.7
Race/ethnicity, *n* (%)		
White	93 (93)	64 (97)
Black	2 (2)	0
Asian	2 (2)	1 (1.5)
Hispanic	0	2 (3)
More than one race	2 (2)	0
Not sure	0	1 (1.5)
Other	1(1)	0
BMI status, *n* (%)		
Underweight	3 (3) [a]	4 (6)[b]
Normal weight	75 (75) [a]	29 (45) [b]
Overweight	15 (15) [a]	18 (28) [b]
Obese	7 (7) [a]	14 (21.5) [b]
Beverage Category[c]		

Water, fl. oz. (SE)	28 (2)	32 (2)
Sugar-sweetened beverage,[d] fl. oz. (SE)	9 (2)	12.29 (2)
Sugar-sweetened beverage,[d] kcal (SE)	118 (11)	118 (16)
Total beverage, fl. oz. (SE)	50 (2)	63 (3)
Total beverage, kcal (SE)	291 (21)	285 (27)

[a]Adolescent BMI-for-age categories: Underweight: <5th percentile, Normal weight: 5th percentile to the 85th percentile, Overweight: 85th to less than 95th percentile, Obese: Equal to or greater than the 95th percentile.

[b]Parent BMI=body mass index; calculated as kg/m^2. Underweight: <18.5, Normal weight: 18.5-24.9, Overweight: 25-29.9, Obese≥30.

[c]Adolescent beverage intake was determined using the average of four interviewer-administered 24-hour recalls; parent beverage intake was determined using the beverage intake questionnaire (BEVQ-15).[69]

[d]Sugar-sweetened beverages include regular soft drinks, juice drinks, sweet tea, coffee/tea with cream and/or sugar, mixed alcoholic drinks, meal replacement drinks, and energy drinks.[69]

Table 6. Intercorrelations (*r* values), means (*M*), and bootstrapped standard errors (SE) for adolescent (A, *n*=100) and parent (B, *n*=65) Theory of Planned Behavior constructs. Paired samples correlations for the first and second TPB administrations in adolescents are bolded values on the diagonal (A).

A.

Variables	1	2	3	4	5	6	7	*M*	SE
1. Behavior (SSB[a] kcals)	---	-0.36***	-0.01	-0.30***	-0.11	0.16	0.03	117.55	11.65
2. Intention		**0.79*****	0.32***	0.52***	0.21*	0.06	-0.02	3.45	0.08
3. PBC[b]			**0.39*****	0.09	0.18*	0.19*	-0.01	4.48	0.06
4. Subjective norm				**0.60*****	0.34***	-0.07	-0.09	3.59	0.07
5. Attitude					**0.59*****	0.16	0.06	3.44	0.06
6. Age (years)						---	0.05	14.39	0.18
7. BMI-for-age Percentile							---	58.95	2.79

B.

Variables	1	2	3	4	5	7	8	*M*	SE
1. Behavior (SSB[a] kcals)	---	-0.58***	-0.27*	-0.04	-0.03	0.05	0.20	117.89	15.43

2. Intention		---	0.55^{***}	0.25^{*}	0.21^{*}	0.01	-0.15	5.69	0.22
3. PBC[b]			---	0.24^{*}	0.14	0.25^{*}	-0.30^{**}	6.52	0.08
4. Subjective norm				---	0.106	0.22^{*}	-0.06	4.56	0.15
5. Attitude					---	0.05	-0.08	4.85	0.16
7. Age (years)						---	0.011	46.05	0.72
8. Body Mass Index (kg/m^2)							---	26.06	0.77

[a]Sugar-sweetened beverage

[b]Perceived behavioral control

$^{*}p \leq 0.05$

$^{**}p \leq 0.01$

$^{***}p \leq 0.001$

Table 7. Linear models for predictors of sugar-sweetened beverage (SSB) consumption from the Theory of Planned Behavior (TPB) constructs in adolescents (panel A) and parents (panel B) with 95% bias corrected and accelerated confidence intervals (95% BCa) and statistically significant interactions from the moderator analysis of the Parent Response to Beverage Choice Questionnaire on adolescent TPB constructs and SSB intake (panel C). Confidence intervals and standard errors for linear models are based on 1000 bootstrap samples.

A. Adolescents					
Predictor Variable	**R^2 (Adj R^2)**	**Final Model *b* (95% CI)**	**Final Model *SE* B**	**Final Model β**	***F***
Step 1 Intention	0.13	-37*	16	-0.27	14.65***
	(0.12)	(-70, -7)			
Step 2 PBC[a]	0.14	16	20	0.09	7.99***
	(0.12)	(-24, 57)			
Step 3 Subjective norms	0.16	-15	20	-0.10	4.43**
	(0.12)	(-52, 28)			
Step 3 Attitude	0.16	-3	18	-0.01	4.43**
	(0.12)	(-36, 35)			
Step 4 Gender	0.22	-49*	22	-0.22	3.77***
	(0.16)	(-90, -10)			

Step 4 Age	0.22	9	6	-.15	3.77***
	(0.16)	(-4, 21)			
Step 4 BMI[b] percentile	0.22	0	0	0.02	3.77***
	(0.16)	(-1, 1)			
B. Parents					
Predictor Variable	**R^2 (Adj R^2)**	**Final Model *b* (95% CI)**	**Final Model *SE* B**	**Final Model β**	***F***
Step 1 Intention	0.33	-49**	14	-0.63	31.43***
	(0.32)	(-75, -17)			
Step 2 PBC[a]	0.34	17	31	0.08	15.72**
	(0.32)	(-47, 68)			
Step 3 Subjective norms	0.36	-7	12	0.06	8.25**
	(0.31)	(-14, 30)			
Step 3 Attitude	0.36	11	10	0.10	8.25**
	(0.31)	(-11, 31)			
Step 4 Gender	0.38	-41	56	-0.11	5.03***
	(0.31)	(-154, 60)			
Step 4 Age	0.38	-1	2	-0.02	5.03***
	(0.31)	(-6, 7)			

Step 4 BMI[b]	0.38	3	4	0.13	5.03***
	(0.31)	(-4, 7)			
C. Moderation Analysis	R^2	***b*** **(95% CI)**	***SE* B**	***F***	
Interaction: Parent encouragement of SSBs overall X adolescent intention	0.34	-43*	18	10.98***	---
		(-80, -7)			
Interaction: Parent encouragement of SSBs outside the home X adolescent intention	0.40	-55***	14	14.22***	---
		(-83, -28)			

[a]PBC: Perceived behavioral control

[b]Body mass index

*$p \leq 0.05$

**$p \leq 0.01$

***$p \leq 0.001$

Table 8. Means and standard errors of parent response to beverage choice questionnaire (Par-B-Q) subscales for sugar-sweetened beverages (A) and non-sugar-sweetened beverages (B) in and out of the home.

A. Par-B-Q Subscale for Sugar-sweetened Beverages	*M*[a]	SE
At Home		
Encouraging intake	2.26	0.09
Discouraging intake	3.17	0.13
Out of Home		
Encouraging intake	2.62	0.10
Discouraging intake	2.49	0.13
Overall encouraging intake	2.58	0.10
Overall discouraging intake	3.19	0.13
B. Par-B-Q Subscale for Non-Sugar-sweetened Beverages	*M*	SE
At Home		
Encouraging intake	2.53	0.11
Discouraging intake	2.40	0.12
Out of Home		
Encouraging intake	2.95	0.10
Discouraging intake	2.06	0.13
Overall encouraging intake	2.95	0.10
Overall discouraging intake	2.39	0.15

[a]Responses to the Par-B-Q are scaled from "1"= very unlikely to "7"=very likely.

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Chapter 4: Conclusions and Future Directions

Excessive weight gain is not only a problem for adults, but also children and adolescents with more than 10 million youth being categorized as obese.[1] Being overweight or obese as a youth may heighten the risk of obesity and cardiovascular complications in adulthood.[2-4] One contributor to excessive weight gain in youth is thought to be sugar-sweetened beverages (SSBs),[5-11] and adolescents are some of the highest consumers.[12,13] Although peers are known to influence adolescents' food choices,[14,15] parents remain primary providers of food in the home,[16] an environment where the majority of SSB consumption occurs.[17,18]

Using theoretical models to address weight problems in youth may be more successful than those without a theoretical foundation.[19-21] The Theory of Planned Behavior (TPB) is one model that has been effective in understanding and predicting a variety of health behaviors.[22,23] A systematic literature review and meta-analysis was conducted to explore how the TPB has been applied to youth's nutrition-related behaviors. Healthy eating and sugary snack and beverage consumption were the most frequently referenced behaviors from 34 articles reviewed, three of which were interventions. The strongest relationship was between attitude and nutrition-related behavioral intention, and behavior intention was the most common predictor of behavior action. Two studies specifically using the TPB to understand male and female adolescent soft drink consumption found the attitude-intention and intention-behavior relationships to be the strongest.[24,25] Overall the results suggest that the TPB may be an effective model to understand and predict youth's diet-related behaviors; however, many studies were cross-sectional and observational highlighting the need for interventions to confirm the relationships identified.

Parents play a role in establishing youth's eating attitudes[26-30] and behaviors,[26,27,31-35] specifically high energy fluid consumption.[36] Considering this information and the literature review findings, a mixed methods analysis of adolescents' and parents' beverage choices using the TPB was conducted. Additionally, parents' responses to adolescents' beverage choices were examined and assessed for moderating the relationship between adolescents' attitude and intention and SSB intake. Adolescents consumed less energy from SSBs than previously reported.[18,37,38] The TPB explained a minimal significant amount of variance in adolescents' SSB intake with intention being identified as the strongest predictor of behavior; similarly in parents intention was the strongest predictor of SSB consumption, although the TPB accounted for more variance compared to adolescents. Subjective norm in adolescents and perceived behavioral control (PBC) in parents were the strongest predictors of intention to limit sugary beverage consumption to less than one cup per day. Adolescents' intention moderated the relationship between parents' responses encouraging SSB consumption and adolescents' SSB intake; at lower levels of intention and high levels of parental encouragement, SSB consumption was predicted to be the highest (p=0.059) suggesting that some adolescents are influenced by their parents' reactions to drinking sugary beverages. Overall, the results suggest that adolescents' SSB intake may be explained by their intention and social factors including parents.

Many avenues for future work exist within the context of the present findings. Assessing adolescents' beverage intake may be more feasible with a rapid, self-administered food frequency questionnaire (FFQ). Validating the beverage intake questionnaire (BEVQ-15)[39] in adolescents could prove useful since no comparable tool presently exists. Food frequency questionnaires are less intrusive and demanding, requiring less time and effort; thus, may be appealing for investigators and adolescent participants.[14,40] Having the BEVQ-15 as a reliable, valid, and rapid self-administered assessment tool could assist healthcare professionals in identifying dietary behaviors that could be targeted for change. If specifically using SSB consumption as a proxy for added sugar (AS) intake in youth, the AS intake biomarker, $\delta^{13}C$,[41] can be promising if found valid in adolescents. Dietary biomarkers can potentially increase the accuracy of dietary intake data in clinical and research arenas.[42-45]

The importance of formative research has been emphasized when constructing a TPB questionnaire[46] and since elicitation was not conducted in the present qualitative analysis, doing so may provide more understanding of adolescent SSB intake than presently reported. With the growing use and advances in technology, computerized dietary assessment tools have been successfully created and used (see **Appendix L**)[47-55] showing promise for decreasing participant and investigator burden. Creating digital versions of an adolescent BEVQ-15 and TPB questionnaire may allow investigators to attract and reach more participants while minimizing participant burden and the resources needed for data collection, entry, and analysis.[56-59] While mothers have been identified as influencing youth's diet habits and beliefs, fathers may also play a role.[60-63] Only nine fathers participated in the qualitative study and efforts to involve fathers in future research may provide better understanding of where resources can be directed when examining adolescent SSB consumption. Finally, confronting health-risk behaviors, such as adolescents' excessive SSB consumption, [12,13] with collaboration across multiple disciplines, like human development, psychology, economics, social work, as well as human nutrition, may be more effective than remaining in respective disciplinary "silos."[64,65]

Intention is thought to encompass the influences of motivation to perform a behavior.[66] In light of the present findings, future interventions can utilize interactive and digital methods, like social media platforms, social networks, and group problem-based challenges or contests, targeting adolescents' motivations to limit sugary beverage intake. For example, with online gaming communities messages promoting non-sugary beverages may help create awareness and more acceptance of healthier beverage options among adolescent players. In the sporting arena, coaches, older players, and teammates can be used as vehicles to support consumption of hydrating, non-SSBs on team webpages, through group text messages, and other available platforms like Instagram, Pinterest, reddit, and Imgur. Taking such an approach could generate interventions adolescents can easily apply in their daily lives to promote health and well-being and develop lifelong health-risk behavior resilience that can be passed on to future generations.

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65. Wuchty S, Jones BF, Uzzi B. The increasing dominance of teams in production of knowledge. *Science.* May 18 2007;316(5827):1036-1039.

66. Ajzen I. The theory of planned behavior. *Organ Behav Hum Decis Process.* December 1991;50(2):179-211.

Appendix A. List of full-text articles excluded with reasons.

Not all TPB[a] constructs measured:

1. Baker CW, Little TD, Brownell KD. Predicting adolescent eating and activity behaviors: the role of social norms and personal agency. *Health Psychol.* Mar 2003;22(2):189-198.
2. Folta SC, Bell R, Economos C, Landers S, Goldberg JP. Psychosocial factors associated with young elementary school children's intentions to consume legumes: a test of the theory of reasoned action. *Am J Health Promot.* Sep-Oct 2006;21(1):13-15.
3. Groth SW, Morrison-Beedy D. Obesity risk in urban adolescent girls: nutritional intentions and health behavior correlates. *J N Y State Nurses Assoc.* 2011;42(1-2):15-20; quiz 26-18.
4. Messina F, Saba A, Vollono C, Leclercq C, Piccinelli R. Beliefs and attitudes towards the consumption of sugar-free products in a sample of Italian adolescents. *Eur J Clin Nutr.* Mar 2004;58(3):420-428.
5. Mesters I, Oostveen T. Why do adolescents eat low nutrient snacks between meals? An analysis of behavioral determinants with the Fishbein and Ajzen model. *Nutr Health.* 1994;10(1):33-47.
6. Rivis A, Sheeran P, Armitage CJ. Intention versus identification as determinants of adolescents' health behaviours: evidence and correlates. *Psychol Health.* Sep 2011;26(9):1128-1142.

Outside target age:

1. Dunn KI, Mohr P, Wilson CJ, Wittert GA. Determinants of fast-food consumption. An application of the Theory of Planned Behaviour. *Appetite.* Oct 2011;57(2):349-357.
2. Dunn KI, Mohr PB, Wilson CJ, Wittert GA. Beliefs about fast food in Australia: A qualitative analysis. *Appetite.* Sep 2008;51(2):331-

334.

3. Grogan SC, Bell R, Conner M. Eating sweet snacks: gender differences in attitudes and behaviour. *Appetite.* Feb 1997;28(1):19-31.
4. Masalu JR, Astrom AN. The use of the theory of planned behavior to explore beliefs about sugar restriction. *Am J Health Behav.* Jan-Feb 2003;27(1):15-24.

No measures of TPB[a] constructs:

1. Beaulieu D, Godin G. Development of an intervention programme to encourage high school students to stay in school for lunch instead of eating at nearby fast-food restaurants. *Eval Program Plann.* Aug 2012;35(3):382-389.
2. Rhoades DR, Kridli SA, Penprase B. Understanding overweight adolescents' beliefs using the theory of planned behaviour. *Int J Nurs Pract.* Dec 2011;17(6):562-570.

Evaluated environmental impact of food production practices and not nutrition behavior:

1. Bissonnette MM, Contento IR. Adolescents' perspectives and food choice behaviors in terms of the environmental impacts of food production practices: application of a psychosocial model. *J Nutr Educ.* Mar-Apr 2001;33(2):72-82..

TPB[a] predictive ability not assessed:

1. Shahanjarini AK, Rashidian A, Majdzadeh R, Omidvar N, Shojaeezadeh D. The role of sociocognitive mediators in the beliefs-intentions relationship: Snacking behavior. *Soc Behav Pers.* 2010;38(5):711-720.

[a]TPB=Theory of Planned Behavior

Appendix B. Detailed summaries of the Theory of Planned Behavior (TPB) non-intervention studies in children and adolescents.

Author (year) **Location** **Design** **Follow-up**	**Purpose** **Additional Constructs Measured**	**Participants**	**Behavior: Nutrition Outcome/Measure** **Dietary Assessment Instrument Used** **Validity/Reliability**	**Variance explained Intention (i.e. INT from ATT, SN, PBC) R2 (*r*)**	**Predictors of and Relationships with INT β's, (*r*'s), OR's, *Mean* and CI's** **Age, gender, BMI, or Ethnic Differences**	**Variance Explained Behavior (i.e. BR from ATT, SN, PBC) R2 (*r*)**	**Predictors of and Relationships with Behavior β's and (*r*'s)** **Age, gender, BMI, or Ethnic Differences**
Astrom, 2004 Africa - Uganda Longitudinal - Prospective 3 months	Explore the effectiveness of the TPB plus past behaviors in predicting intended and self-perceived sugar intake in Ugandan adolescents Past BR (PB)	Age Range: 13-19 years *M* age 16.3 (±1.7) years 52% male N=372	Sugary snacks and drinks on daily basis and in future 1-item, self-perceived sugar intake measured at T2 asking about sugary snacks intake over the "past weeks" NR	0.58 EXTENDED TPB 0.63	**ATT: 0.53* (0.74*)** SN: 0.09 (NS) (0.60*) PBC: 0.24* (0.60*) EXTENDED TPB **ATT: 0.52* (0.74*)** SN: 0.07 (NS) (0.60*) PBC: 0.17* (0.60*) PB: 0.24* (0.47*)	0.05 EXTENDED TPB 0.09	**INT: 0.16* (0.21*)** ATT: (0.13*) SN: (0.1 NS) PBC: 0.07 (0.17*) EXTENDED TPB INT: 0.07 PBC: 0.05 **PB: 0.24* (0.30*)**
Astrom and Okullo, 2004 Africa - Uganda Longitudinal - Prospective 3 months	Determine the validity of the TPB in predicting intended and self-reported sugar consumption in Ugandan adolescents and if the predicted INT were correlated with self-reported BR at 3 months	Age Range: 13-19 years 52% male T1: N=1146, *M* age: 15.8 (±1.6) years T2: N=372, *M* age 16.3 (±1.7) years	Self-perceived sugar intake: sugary snacks and drinks 1-item, self-perceived sugar intake measured at T2 asking about sugary snacks intake over the "past weeks" NR	T1=0.58**** T2=0.19**** (ΔR2)	**ATT:** **T1=0.56**** **T2=0.32**** SN: T1=0.08 (NS) T2=-0.02 (NS) PBC: T1=0.22** T2=0.18*	0.05 (ΔR2)****	**INT: 0.16*** PBC: 0.09 NS
Backman et al., 2002 USA - California Longitudinal - Prospective 1 month	Identify predictors of INT to eat healthful and actual healthy eating as defined by total energy intake (i.e. total kcals), % calories from fat (% kcal fat), and servings of fruit and vegetables in adolescents using the TPB and determine how gender and ethnicity influence the predictors.	Age Range: 14-19 years 44.1% male N=672	Eating a healthy diet over next month: "eating 2-3 pieces of fruit daily; consumption of 2-3 cups of raw or cooked vegetables daily; eating low-fat or fat-free dairy products daily; adding little fat (e.g. salad dressings, butter, oils, or lard) to food; small servings of meat, poultry, and fish, and limiting intake of fried food, snack foods, and fast food." Adapted from an Academy of Nutrition and Dietetics' Nutrition Entrepreneurs Dietetic Practice Group's 1996 publication. FFQ: 67- items Validity; Reliability NR	0.42 (0.65****)	**ATT: 0.39**** (0.55)****** SN: 0.23**** (0.35)**** PBC: 0.28**** (0.45)**** F had sig greater INT (*d*=0.34), more positive ATT (*d*=0.23), and greater SN (*d*=0.52) vs. M**	0.17 (0.41****)	**INT:** Total kcals: -0.36**** (-0.14***) % kcal fat: -0.10** (-0.24****) Fruit and vegetable servings: 0.41**** (0.23****) PBC: NS and no values given No differences between genders
Bazillier et al., 2011 Europe - France Cross-sectional	Evaluate if an extended TPB can explain healthy eating INT and BR in children Knowledge Perceived parental norm Motivation to comply to parental norm Perceived friend's norm Motivation to comply to friend's norm	Age Range: 8-9 years 49% male N=1272	Healthy eating 1-item, self-report; breakfast consumed on morning of assessment used as proxy; fruits, dairy products, and bread items must have been checked to be considered "healthy" NR	EXTENDED TPB: 0.35*** M: 0.38 F: 0.31	**PBC: 0.40 (sig with no value given)** **M=0.46** **F=0.43** Knowledge was not sig predictor of INT F had sig higher INT vs. M (no sig level provided; *d*=0.18; CI 0.13-0.22) See Appendices for other construct's coefficients.	0.05 (for extended TPB model; no value given)	**INT** was only sig predictor (no other info provided) No differences in genders on TPB constructs F had higher knowledge (*d*=0.16; CI 0.09, 0.23) and wanted to listen to their parents more than M** (*d*=0.16; CI 0.40, 0.20)
Beaulieu and Godin, 2011 Canada Longitudinal - Prospective 2 weeks	Identify BR determinants for high school students to stay for lunch using an extended TPB Descriptive norm	Age Range: 12-17 years *M* age =14.6±1.5 years 41.8% male N=153	Staying in school for lunch NA NA	0.58	ATT: OR=2.7* (1.06-6.85) **SN: Descriptive Norm OR=12.67*** (3.39-47.27)** PBC: OR=11.46**** (4.53-29.04) No sig gender or age differences	0.41	**INT** only sig predictor reported OR=16.22 (7.08-37.21)
Berg et al., 2000 Europe - Sweden Longitudinal - Prospective 2 weeks	Determine if the TPB and its underlying construct's influence youth's milk and high-fiber bread consumption for breakfast and if the TPB variables were associated with age and gender Descriptive norms(Des N) for mother and father Injunctive norms (Inj N), Motivation to comply, Behavioral beliefs and outcome beliefs, Habit Accessibility	Age Range: 11, 13, 15 years (5th, 7th, and 9th graders) 48% male N=1096	Milks with varying fat content (SM, LFM, MFM, FFM) and high-fiber bread (HFB) consumption for breakfast 7-day breakfast food record with type of food and not amount; number of days out of 7 that the target food was eaten NR	% correctly classified (from ATT, Inj N, Des N, and PBC): HFB: 70 SM: 94 LFM: 84 MFM: 81 FFM: 83	**ATT:** **HFB=1.4***** **Milks=1.9-2.4***** No sig gender or age differences	% correctly classified (from INT and PBC): HFB:61 SM: 98 LFM: 82 MFM: 79 FFM: 85	**INT** **HFB=1.0***** **Milks=2.8-3.6***** No sig gender or age differences
Branscum and Sharma, 2011 USA - Ohio Cross-sectional	Determine how well the TPB predicts consumption of calorie-dense, nutrient-poor snacks versus fruit and vegetable snacks in elementary-aged children	Are Range: 4th and 5th graders *M* age =10.4 (±0.79) years 41% male N=167	Low calorie (e.g. fruit, vegetables, pretzels, rice cakes, vanilla wafers, and graham crackers) and high calorie (e.g. potato chips, Doritos, Cheetos, candy bars, snack cakes, and cookies) snack food consumption 24-hour snack foods recall; method similar to USDA's AMPM for 24-hour recalls NR	NR	**ATT: 0.41***** SN: 0.24*** PBC: 0.22**	Fruit and Vegetables: 0.09*** High Calorie: 0.11***	**INT:** **Fruit and Vegetables: 0.26***** **High Calorie: -0.17***

Appendix B. Detailed summaries of the Theory of Planned Behavior (TPB) non-intervention studies in children and adolescents.

Author (year) **Location** **Design** **Follow-up**	**Purpose** **Additional Constructs Measured**	**Participants**	**Behavior: Nutrition Outcome/Measure** **Dietary Assessment Instrument Used** **Validity/Reliability**	**Variance explained Intention (i.e. INT from ATT, SN, PBC) R2 (*r*)**	**Predictors of and Relationships with INT β's, (*r*'s), OR's, *Mean* and CI's** **Age, gender, BMI, or Ethnic Differences**	**Variance Explained Behavior (i.e. BR from ATT, SN, PBC) R2 (*r*)**	**Predictors of and Relationships with Behavior β's and (*r*'s)** **Age, gender, BMI, or Ethnic Differences**
Branscum and Sharma, 2013 USA - Ohio Cross-sectional	Investigated how well the TPB predicts different snack food choices in school-aged boys and girls.	Are Range: 4th and 5th graders *M* age =10.4 (±0.79) years 41% male N=167	Low calorie (e.g. fruit, vegetables, pretzels, rice cakes, vanilla wafers, and graham crackers) and high calorie (e.g. potato chips, Doritos, Cheetos, candy bars, snack cakes, and cookies) snack food consumption 24-hour snack foods recall; method similar to USDA's AMPM for 24-hour recalls NR	M=0.56* F=0.39*	**ATT:** **M=0.57***** F=0..25** **SN:** M=0.19* **F=0.29**** PBC: M=0.29** F=0.27**	Fruit and Vegetables: M=0.06* F=0.06** High Calorie: M=NS F=0.07**	**INT** Fruit and Vegetables: **M=0.27*** F=0.27** **High Calorie:** M=0.11 (NS) **F=-0.29**** M reported sig higher PBC vs. F*
Chan and Tsang, 2011 Asia - Hong Kong Cross-sectional	Assess how well the TPB and attitudes towards healthy eating advertisements influence adolescents INT to eat healthy and if gender, BMI, and age influence INTs. Perceptions and ATT towards healthy eating advertisements (ATT towards ad)	Age Range: 11-19 years (7th-11th graders) *M* age = 14.5yrs 49.6% male N=570	Healthy eating INT: avoiding candies, chips, desserts, and fast foods and eating three meals with adequate fruit and vegetable content daily 1-item, self reported INT to "engage in healthy eating in the coming two weeks." NR	0.45**	ATT: 0.25***(0.54**) SN:0.04 (NS) (0.35**) **PBC: 0.47***(0.64**)** ATT towards ad: -0.03 (NS)(0.17**) Higher BMI participants had lower INT vs. those with lower BMI (*r*=-0.13**, *d*=0.26) F had greater INT vs. M (*r*=0.09*, *d*=0.18)	NA	NA
Conner et al., 2011 (same study as Berg et al., 2000) Europe - Sweden Longitudinal - Prospective 2 weeks	Extent to which the 2 factor TPB predicted healthy breakfast choices in adolescents and how, age, social class, and gender influence the relationship. Affective and instrumental attitude (Affective and Instru ATT) Descriptive and injunctive norm (Des N and Inj N) Perceived control and confidence (P cntrl and P confid)	Age Range: 11, 13, 15 years (5th, 7th, and 9th graders) 48% male N=832	Milks with varying fat content (SM, LFM, MFM, FFM) and high-fiber bread (HFB) consumption for breakfast 7-day breakfast food record with type of food and not amount; number of days out of 7 that the target food was eaten NR	HFB: 0.37*** LFM: 0.67***	**SN** **HFB:** Inj N: 0.15***(0.46***) **Des N: 0.23***(0.47***)** **LFM:** Inj N: 0.15***(0.63***) **Des N: 0.36***(0.70***)** HFB: As age increased Affective ATT became stronger predictor of INT LFM: As age increased Des N became stronger predictor of INT	HFB: 0.08*** LFM: 0.46***	**INT** **HFB: 0.25***(0.28***)** All constructs except PBC were related to BR **LFM: 0.68***(0.68***)** HFB and LFM: As age increased INT increased
Cottrell et al., 2012 USA - West Virginia Cross-sectional	Use the TPB to predict children's INT to eat healthier, exercise more, and lose weight over the next 6 months and to evaluate how parental perceptions of their child's and their own health and children's perceptions of their own health influence INTs to lose weight, exercise, and eat healthy.	Age Range: 10-14 years, *M* age =10.9 (±0.6) years N=342 parent-child dyads	Child's INT to lose weight, eat healthier, and exercise more over next 6 months Health Belief Questionnaire evaluating beliefs about health, exercise, and diet Validity in adults; Reliability NR	NR	**ATT:** LOSING WEIGHT: Parent's Own Perception=0.07* EATING HEALTHIER **Child's Own Perception=0.41***	NA	NA
de Bruijn et al., 2005 Europe - The Netherlands Cross-sectional	Assess how well a conceptual model based on the TPB with distal factors explains snacking and bicycle use and identify the proximal and distal determinants of snacking and biking behavior in Dutch adolescents. The Theory of Triadic Influence: cultural environment, social environment, and biology/personality	*M* age = 14.8 (+-1.6) years 45.8% male N=3859	INT to consume less snacks FFQ: 4 items about number of times per week fried snacks, nuts and potato chips, pastries, chocolate, and cookies were consumed Validity; Reliability NR (i.e. no data available)	Extended TPB: 0.34	**ATT: 0.36***(0.51[a])** SN: 0.13***(0.19[c]) PBC: 0.20**** (0.31[b]) Self-esteem: -0.07*** (-0.11[c]) Relations with parents: 0.03* (0.07[0]) F more likely to have greater INT to restrict snacking (β=0.21***, *r*=0.29[c]) [a]=large effect [b]=medium effect [c]=small effect [0]=no effect	0.19	**INT: 0.25*** (0.42[b])** ATT: 0.19*** (0.40[b]) SN: -0.03 (0.05[0]) PBC: 0.15*** (0.30[b]) Self-esteem: -0.05** (-0.07[0]) Relations with parents: 0.03* (0.08[0]) Not living or living with both parents: -0.04* (-.08[0]) [a]=large effect [b]=medium effect [c]=small effect [0]=no effect
de Bruijn et al., 2007 Europe - The Netherlands Longitudinal - Prospective 6 months	Identify individual and social-environmental factors associated with adolescent soft drink consumption using distal factors of personality and parenting factors and the TPB constructs. Parenting practices Big Five personality dimensions (i.e. Agreeableness, Extraversion, Conscientiousness, Emotional stability, and Openness to experience)	Age Range: 12-18yo *M*=15.2 (±1.9) years N=208	Soft-drink consumption FFQ: how many days per week and how much each time "sugar-containing soft drinks" were consumed Validity; Reliability NR	NR	**ATT: 0.32***(0.38**)** SN: 0.22***(0.23**) PBC: 0.16*(0.19**) Extended TPB constructs did not have sig *r* values on INT	EXTENDED TPB 0.14 (f^2=0.16 - medium ES)	**INT: -0.20**** EXTENDED TPB INT: -0.12 (NS) (-0.20**) **ATT: -0.24** (-0.23**)** SN: 0.20** (0.03 (NS)) PBC: -0.04 (NS) (-0.16*) **Parenting practices: -0.24*** (-0.26**)** Agreeableness: 0.16* (0.07 (NS))

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Author (year) Location Design Follow-up	Purpose Additional Constructs Measured	Participants	Behavior: Nutrition Outcome/Measure Dietary Assessment Instrument Used Validity/Reliability	Variance explained Intention (i.e. INT from ATT, SN, PBC) R2 (*r*)	Predictors of and Relationships with INT β's, (*r*'s), OR's, *Mean* and CI's Age, gender, BMI, or Ethnic Differences	Variance Explained Behavior (i.e. BR from ATT, SN, PBC) R2 (*r*)	Predictors of and Relationships with Behavior β's and (*r*'s) Age, gender, BMI, or Ethnic Differences
Dennison and Shepherd, 1995 Europe - UK Cross-sectional	Determine the appropriateness and effectiveness of using the TPB to predict adolescents' food choice INT and BR. Dietary restraint Descriptive norm (i.e. friend's BR) Self-identification of being a "healthy eater"	Are Range: 11-12 and 14-15 years 52% male N=675	Food choice: eating chips, fruit, and/or chocolate and sweets (CS) at lunch time as identified during elicitation 2-items for each food: INT to eat "X" food 1) tomorrow, and 2) over the next week NA	CS:0.2 Fruit: 0.19 Chips: 0.22	CS: **PBC1 (i.e. ease or difficulty): -0.24***** PBC2 (i.e. can have amount preferred): 0.16** Fruit: PBC1: -0.12*** **PBC2: 0.20***** Chips: **PBC1: -0.24***** PBC2: 0.07* F had more positive ATT (*d*=0.52), greater SN (*d*=0.27), and found it easier to eat fruit and not CS (*d*=0.24) or chips (*d*=0.31) vs. males (all **).	NA	NA
Diaz et al., 2009 (same study as Backman 2002) USA - California Longitudinal - Prospective 1 month	Secondary analysis of Backman et al's., data from 2002 for acculturation (Accult) and gender effects on the TPB as related to healthy diet intake in Latino adolescents.	Age Range: 14-19 years Hispanic/Latino 41% male N=265	Eating a healthy diet over next month: "eating 2-3 pieces of fruit daily; consumption of 2-3 cups of raw or cooked vegetables daily; eating low-fat or fat-free dairy products daily; adding little fat (e.g. salad dressings, butter, oils, or lard) to food; small servings of meat poultry, and fish, and limiting intake of fried food, snack foods, and fast food." Adapted from an Academy of Nutrition and Dietetics' Nutrition Entrepreneurs Dietetic Practice Group's 1996 publication. FFQ: 67- items Validity; Reliability NR	0.433 (without Accult, gender, grade level, and interaction of Accult and gender)	F had stronger INT, more positive ATT, and stronger SN to eat healthier vs. M (all***). Sig greater INT to eat healthfully in less Accult vs. high Accult** F had sig more positive ATT, stronger SN, and greater INT to eat healthy vs. M (all ***)	NR	NR
Fila and Smith, 2006 USA - Minnesota Cross-sectional	Use the TPB to identify ATT that promote or create barriers to healthful eating, identify who or what promotes healthful diet BR, and examine to what extent youth perceive control over their diet behavior. Self-efficacy (SE) Barriers	Age Range: 9-18 years Native Americans *M* age ≅ 12.5 (±2.5) years 41.7% male N=139	Healthy eating: "eating different types of foods from all food groups like bread, grains, cereals, fruit, vegetables, milk, and meat while limiting sugary and fatty foods Unclear: used responses to questions on dietary intake of fruit, vegetables, soft drinks, and fast foods, along with 11 additional BR questions using the Likert scale NR	NR	ATT: (0.45**) SN: (0.39**) PBC: (-0.01 (NS)) Barriers: (-0.14 (NS)) **SE: (0.56**)** M **SE: (0.68**)** F **SN: (0.41**)** **SE: (0.41**)**	EXTENDED TPB: 0.36 (no PBC)	INT: (0.05 (NS)) **ATT: 0.52*** (0.44**)** SN: 0.11** (0.34**) PBC: (0.35**) SE: -0.23** (-0.12 (NS)) Barriers: 0.12* (0.46**) M **SN: 0.13** (0.46**)** F **ATT: 0.54** (0.46**)**
Grønhøj et al., 2012 (used Chan's from above) Europe - Denmark Cross-sectional	Determine the predictive power of INT to eat healthier in Danish adolescents using the TPB and if gender, age, and BMI influence the INT to adopt healthy eating patterns.	Age Range: 11-16 years (6-10th grade) *M* age =13 years (no SD reported) 47.6% male N=410	(Measure was adapted from Chan and Tsang, 2011) Healthy eating INT: avoiding candies, chips, desserts, and fast foods and eating three meals with adequate fruit and vegetable content daily 1-item, self reported INT to "engage in healthy eating in the coming two weeks." NR	0.37* (.33 increase from 1st step of MR with demos only as predictors)	ATT: 0.30*** (0.54***) SN: 0.06 (NS) (0.26***) **PBC: 0.37*** (0.51***)** F had greater INT (*r*=0.26) and stronger ATT (*r*=0.20) vs. M***	NA	NA
Gummeson et al., 1997 Europe - Sweden Longitudinal - Prospective 1 month	Use of the TPB to evaluate the determinants of Swedish children's INT and actual consumption of breakfast choices . PBC measured with two items: perceived difficulty and control	Age Range: 10-16 years (grades 4, 7, and 10) N = 182	Healthy vs. unhealthy breakfast options (e.g. low-fat versus high-fat milk yogurts and milks, fiber content of breads and cereals, and use of margarine/butter spreads with varying fat content). 4-day breakfast food diary; number of days healthy choices were made minus the number of days unhealthy choices made NR	Milk: 0.81** Cultured Milk: 0.84*** Yogurt: 0.50** Bread: 0.56*** Cereal: 0.62*** Spread: 0.71***	**ATT:** **Milk: 0.89**** **Cultured Milk: 0.77***** **Yogurt: 0.57**** **Bread: 0.70***** **Cereal: 0.77***** **Spread: 0.81***** SN: only sig for milk 0.08* and cultured milk 0.36** PBC: Control for cultured milk: 0.27*	Milk: 0.12* Cultured Milk: 0.38* Yogurt: 0.21 (NS) Bread: 0.18*** Cereal: 0.16 (NS) Spread: 0.02 (NS)	**INT**[a] **Milk: 0.17*** Cultured Milk: 0.14* Yogurt: 0.18* **Bread: 0.44**** **Cereal: 0.28*** Spread: 0.08 (NS) PBC - Difficulty[b] Milk:: -0.14* **Cultured Milk: -0.23*** **Yogurt: -0.20*** [a]Overall healthy options were chosen more regularly with greater INT [b]Negative β indicates less healthy options were chosen with greater difficulty
Hewitt and Stephens, 2007 Australia - New Zealand Cross-sectional	Assess predictive power of the TPB variables and child feeding practices on children's INT to eat healthy foods and to test if INT are related to BR. Behaviorial beliefs (BB) Parent's perceived responsibility (PR) Parent's concern about child's weight (PCw) Parent's restriction of child's intake (PRi)	Age Range: 10-13 years *M* age = 11.4 (no SD reported) 45.6% male N = 261	Consumption of healthy (i.e. fruit and vegetables) and unhealthy foods (i.e. hamburgers, fish and chips, pizza, fried chicken, carbonated drinks, chocolate, sweets, and crisps) over past week Unclear: self-report on a scale of 1-7 on how many days over past week were foods of categories eaten NR	0.51***	ATT: 0.25*** (0.52**) **SN: 0.29*** (0.55**)** PBC: 0.22*** (0.49**) BB: 0.21*** Sig differences between genders on reported TPB constructs (all **)	0.45*** EXTENDED TPB: 0.31 (NS)	EXTENDED TPB: **INT: 0.42*** (0.63**)** ATT: 0.01 (0.37**) SN: 0.12 (0.45**) PBC: 0.21*** (0.63**) BB: 0.09 (0.44**) PR: 0.03 (NS)(0.08(NS)) PCw: 0.02 (NS)(0.08(NS)) PRi: 0.04 (NS)(0.14*)

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Author (year) Location Design Follow-up	Purpose Additional Constructs Measured	Participants	Behavior: Nutrition Outcome/Measure Dietary Assessment Instrument Used Validity/Reliability	Variance explained Intention (i.e. INT from ATT, SN, PBC) R2 (*r*)	Predictors of and Relationships with INT β's, (*r*'s), OR's, *Mean* and CI's Age, gender, BMI, or Ethnic Differences	Variance Explained Behavior (i.e. BR from ATT, SN, PBC) R2 (*r*)	Predictors of and Relationships with Behavior β's and (*r*'s) Age, gender, BMI, or Ethnic Differences
Ickes and Sharma, 2011 USA Cross-sectional	Determine the extent to which INT predicted 2 nutritional BR related to obesity in normal weight (nw) and overweight/obese (ow/ob) adolescents.	Age Range: 12-17 years (7-8th graders) *M* age: 13.18 (±0.76) years 44.3% male N = 318	INT to consume ≥5 servings fruit and vegetables a day or decreased amount of SSB per day 24-hr recall for number of fruit and vegetable servings and glasses of water and SSB consumed Validity and reliability unclear (TPB tool reported as being tested for face and content validity pilot tested and 4 questions on tool asked about dietary intake; no psychometric properties provided).	Fruit and Vegetables: All participants: 0.11*** (R2 only for SN and PBC) nw: NS ow/ob: 0.19* (R2 only for PBC) SSB vs. Water: All participants: NS nw: 0.02* (R2 only for PBC)	Fruit and Vegetables: All participants: SN and PBC reported as sig predictors of INT with no coefficients or *p* values given. nw: NS ow/ob: PBC identified as sig predictor of INT with no coefficients or *p* value given. SSB vs. Water: All participants: NS nw: PBC reported as sig predictor for INT (no coefficient provided) ow/ob: NS	Fruit and Vegetables: All participants: NS nw: 0.02* (R2 only for INT) ow/ob: NS SSB vs. Water: All participants: 0.02* nw: 0.03** (R2 only for INT) ow/ob: NS	Fruit and Vegetables: All participants: SN: 0.17** **PBC: 0.23**** **nw:** INT: 0.15* ATT: NR **SN: 0.19**** PBC: NR ow/ob: no constructs were significant SSB vs. Water: All participants: **INT: -0.14*** **nw:** **INT: -0.18**** ATT: -0.08 (NS) SN: -0.14* PBC: 0.03 (NS) ow/ob: no constructs were significant INT: -0.02 (NS) PBC: 0.37 (NS)
Kassem et al., , 2003 USA - California Cross-sectional	Use the TPB to identify factors influencing regular soft drink consumption in female adolescents (i.e. predicting INT to drink soda).	Age Range: 13-18 years No males N=707	Regular soda consumption (i.e. cola or non cola) over past 12 months Unclear/FFQ: 1-item, consumption of < 1 glass, bottle, or can per month, 1 glass per week or less, 2-6 glasses per week, 1 glass per day, and 1, 2, 3, or more than 3 glasses per day. NR	0.64****	**ATT: 0.58**** (0.76)** SN: 0.14**** (0.42) PBC: 0.24**** (0.57)	0.28****	**INT: 0.51**** (0.53****)** PBC: 0.03 (NS) (0.32****)
Kassem and Lee, 2004 USA - California Cross-sectional	Use the TPB to identify factors influencing regular soft drink consumption in male adolescents (i.e. predicting INT to drink soda).	Age Range: 13-18 years All male N = 564	Regular soda consumption (i.e. cola or non cola) over past 12 months Unclear/FFQ: 1-item, consumption of < 1 glass, bottle, or can per month, 1 glass per week or less, 2-6 glasses per week, 1 glass per day, and 1, 2, 3, or more than 3 glasses per day. NR	0.61***	**ATT: 0.52*** (0.72***)** SN: 0.19*** (0.42***) PBC:0.28*** (0.54***)	0.15***(0.39)	**INT: 0.38****(0.39****)** PBC: 0.02 (NS) (0.22****)
Kida and Astrom, 1998 Africa - Tanzania Cross-sectional	Use of TPB to evaluate adolescents INT to avoid daily intake of sugared snacks and drinks in the future. Past BR (PB) Perceived risk (PR) of tooth decay	Age Range: 13-22 years *M* age: 16.2 (±1.4) years 53.5% male N=312	INT to avoid sugary snacks and drinks in future and past sugar intake: INT: sum of 2-items; how likely and unlikely to avoid sugared drinks and snacks each day in the future Past sugar intake: 1-item, self-report on daily consumption of sugared drinks and snacks (e.g. chocolate/sweets, sugared tea/coffee, cake/biscuits, and soda) over the past 6 months NR	0.53** EXTENDED TPB (without PB): 0.54**	ATT: 0.15** (0.53***) SN: 0.26** (0.60***) **PBC:0.46** (0.67***)** PB: NA (-0.08 (NS)) PR: 0.10* (0.26***) No gender differences in TPB constructs	NA	NA
Lien et al., 2002 USA - Minnesota Longitudinal - Prospective 6 months	Evaluate how well the TPB predicts fruit and vegetable intake in adolescents and if the constructs of the model were confirmed and affected by SES and gender.	Age Range: 7th graders 52.2% male N = 1406	Fruit and vegetable intake FFQ: 6 questions on frequency of consumption of fruit Juice, fruit, green salad, potatoes, carrots, and other vegetables Validity NR; Reliability	0.31[a] M:0.35 F: 0.28 [a]Sig at CR>1.96	All participants: ATT: 0.13[a] (0.3*) **SN: 0.34[a] (0.4*)** PBC: 0.33[a] (0.40*) Genders ATT: M: 0.07[a]; F: 0.18[a] **SN:** M: 0.37[a]; **F: 0.34[a]** **PBC:** **M: 0.37[a]**; F: 0.27[a] [a]Sig at CR>1.96	0.07[a] M: 0.09 F: 0.06	All Participants: INT: 0.11[a] **PBC: 0.20[a]** Genders: INT M: 0.16[a] F: 0.06[a] **PBC** **M: 0.19[a]** **F: 0.22[a]** [a]Sig at CR>1.96

Appendix B. Detailed summaries of the Theory of Planned Behavior (TPB) non-intervention studies in children and adolescents.

Author (year) **Location** **Design** **Follow-up**	**Purpose** **Additional Constructs Measured**	**Participants**	**Behavior: Nutrition Outcome/Measure** **Dietary Assessment Instrument Used** **Validity/Reliability**	**Variance explained Intention (i.e. INT from ATT, SN, PBC) R2 (*r*)**	**Predictors of and Relationships with INT β's, (*r*'s), OR's, *Mean* and CI's** **Age, gender, BMI, or Ethnic Differences**	**Variance Explained Behavior (i.e. BR from ATT, SN, PBC) R2 (*r*)**	**Predictors of and Relationships with Behavior β's and (*r*'s)** **Age, gender, BMI, or Ethnic Differences**
Mullan et al., 2013 Europe (UK) and Australia Cross-sectional	Assess if the TPB and addition of risk awareness can predict breakfast consumption in a sample of adolescents from Australia (Aus) and the UK Absolute risk (AR) Relative risk (RR) Risk severity (RS)	Age range: 11-18 years *M* age: 14 (±1.1) years Aus: 36% and UK: 20% male N=605 (335: Aus, 270: UK)	Breakfast consumption (i.e. eating a meal with 2 hours of waking) 1-item, self report on how many times over past 4 weeks had breakfast been consumed NR	All participants: 0.42 Aus: 0.28 UK: 0.58 EXTENDED TPB: 0.43	ATT: 0.27*** (0.52**) SN: 0.18*** (0.4**) **PBC: 0.35*** (0.58**)** PBC strongest in UK sample EXTENDED TPB: ATT: 0.24*** (0.52**) SN: 0.15*** (0.4**) **PBC: 0.33*** (0.58**)** AR: 0.09* (0.40**) RR: 0.05 (NS) (0.35**) RS: -0.01 (NS) (0.11**)	All participants: 0.58 Aus: 0.59 UK: 0.54	**INT: 0.70*** (0.75**)** ATT: (0.44**) SN: (0.29**) PBC: 0.07*(0.48**) AR: (0.31**) RR: (0.29**) RS: (0.85*) PBC only sig in UK sample EXTENDED TPB: ATT: 0.24*** (0.52**) SN: 0.15*** (0.4**) **PBC: 0.33*** (0.58**)**
Murnaghan et al., 2010 Canada Longitudinal - Prospective 1 month	Evaluate the TPB's effectiveness in predicting adolescents' physical activity, fruit and vegetable intake, and being smoke-free over a 1 month period and assess associations between BR normative, and control beliefs and the global TPB constructs	Age Range: 12-16 years (7-9th graders) 49% male N=183	5 servings of fruit and vegetables per day 1-item, self-report: "During the past 30 days I ate at least 5 servings of fruit and vegetables on (0-30) days." NR	0.50	**ATT: 0.34* (0.59***)** SN: 0.27* (0.53***) PBC: 0.30* (0.54***)	0.40 (fruit and vegetable intake)	**INT: 0.57* (0.61***)** ATT: 0.19* (0.54***) SN 0.15* (after passing through INT) (0.33***) PBC: 0.07 (0.24* after passing through INT) (0.38***)
Pawlak and Malinauskas, 2008 USA - North Carolina Cross-sectional	Identify how well the TPB and its underlying behavioral beliefs predict 9th graders' INT to consume 2.5 servings of vegetables per day and if findings were consistent across genders and ethnicities.	Age Range: 9th graders *M* age = 14.7 (±0.82) years 34.4% male N=157	INT to consume 2.5 servings of vegetables per day NA NR	0.77*** (0.88)	**ATT: 0.43***** SN: 0.37*** PBC: 0.16* No gender differences on TPB constructs. PBC only sig in Caucasian F and not African American F or all M.	NA	NA
Seo et al., 2011 Korea Cross-sectional	Examine the factors influencing fast food consumption using the TPB in adolescents.	Age Range: "Middle School students" 52.5% male N = 354	Fast food consumption (i.e. intake of hamburgers, pizza, fried chicken, doughnuts, and French fries) Unclear/FFQ: number of days when fast foods were used often, place of fast food consumption, and people with whom used fast food NR	0.68***	ATT: 0.05 (0.46**) SN: 0.15** (0.42**) **PBC: 0.56*** (0.66**)**	0.56***	**INT: 0.61***(0.74**)** ATT: (0.38**) SN: (0.35**) PBC: 0.19*** (0.59**) No sig gender differences.
Sharifirad et al., 2013 Iran Cross-sectional	Analyze the predictive ability of the TPB and TPB and actual behavior control and past behavior in Iranian adolescents in regards to fast food consumption. Actual behavior control (ABC) Past behavior (PB)	Age Range: 15-18 years *M* age: 16.3 (±0.8) years 53.2% male Total of 18 classes (9 M and 9 F) N=521	Fast food consumption (i.e. sandwiches, Berger-piroshky, hot dogs, snacks, pizza, chicken nuggets, and fried chicken) Unclear/FFQ: how many times each food listed above consumed over the past week NR	0.26 EXTENDED TPB: 0.31	**ATT: 0.31*** (0.40**)** SN: 0.29*** (0.38**) PBC: -0.10 (-0.21**) M had higher SN scores vs. F* EXTENDED TPB: ATT: 0.25*** **SN: 0.27***** PBC: -0.10* ABC: -0.09* (-0.09*) PB: 0.24*** (0.36**)	0.06*** EXTENDED TPB: 0.21	**INT: 0.24** (0.24**)** ATT: 0.15**(0.19**) SN: 0.18***(0.21**) PBC: -0.01 (NS) (-0.05 (NS)) EXTENDED TPB: INT: 0.09* ATT: 0.15** SN: 0.18*** PBC: NR and NS ABC: NR and NS (-0.05 (NS)) **PB: 0.42*** (0.45**)**
Tak et al., 2011 Europe - The Netherlands Cross-sectional	Investigate the associations between home environment factors, habit strength, and the TPB with soft drink consumption in youth and if the TPB and habit strength mediates the association between home environment and soft drink intake. Availability Accessibility Parental modeling Parental rules Habit strength	Age Range: 12-13 and 14-15 years *M* age: 14.1 (±1.2) years 54% male N=1361	Sugar-sweetened soft drink consumption (i.e. "carbonated beverages, other non-carbonated sugar-sweetened drinks [water-based beverages that contain sugar] and sports drinks") FFQ: 2 questions: 1) How many days per week do you usually drink sugar-sweetened (not diet or light) drinks?, and 2) How many glasses, cans, and/or bottles on average per day? Validity NR; Reliability	NR/NA	ATT: (0.58***) SN: (0.39***) PBC: (0.43***) **Habit Strength: (0.61***)**	NR/NA	INT: (0.54***) ATT: (0.48***) SN: (0.31***) PBC: (0.3***) **Habit Strength: (0.64***)**
van der Horst et al., 2008 Europe - The Netherlands Cross-sectional	Examine the associations between cognitions (i.e. the TPB constructs) and soft drink and snack consumption in youth and if the effect of environmental factors on these BR are mediated by cognitions. School food availability Food stores in school neighborhood Parental norm (PN) Parent modeling (PM) Friend modeling (FM)	Age Range: 12-13 and 14-15 years *M* age: 14.1 (±1.2) Soft drinks: 52.9% male Snacks: 53.6% male N = 1174 for soft drinks N = 1139 for snacks	Sugar-sweetened soft drink (same definition as Tak et al., 2011) and snack consumption (i.e. sweet being candy, bars, chocolate, cake, and biscuits and savory being fast-food, pizza, fries, chips, and nuts) Unclear/FFQ: 2 questions sugary drinks (same as Tak et al., 2011) and 2 questions for each type of snack: "How many days a week do you usually eat X?" and "On average, how many times a day do you eat X?" Validity NR; Reliability	NR	NR	NR	Data only for soft-drink consumption[a] **INT: 0.42***** ATT: 0.32*** PN: 0.20*** PM: 0.29*** FM: 0.19*** PBC: 0.04 (NS) [a]All unstandardized beta coefficients

Abbreviations: Accult=Acculturation, Affective ATT=Affective Attitude, AMPM=Automated Multiple Pass Method, ATT=Attitude, BB=Behavioral Beliefs, BR=Behavior, CI=Confidence Intervals; CR=Critical Ratio, CS=Chocolate and Sweets, demos=demographics, Des N=Descriptive Norm, ES=Effect Size, F=Female, FFM=Full-fat Milk, FFQ=Food Frequency Questionnaire, HFB (High-Fiber Bread), Inj N=Injunctive Norm, Instru ATT=Instrumental Attitude, INT=Intention, LFM=Low-fat Milk, M=Male, M=Mean, MFM=Medium-fat Milk, MR=Multiple Regression, NA=Not Applicable, NR=Not Reported, NS=Not significant, nw=Normal Weight, OR=odds ratio, ow/ob=overweight/obese, P Cnfid=Perceived Confidence, P Cntrl=Perceived Control, PB=Past Behavior, PBC=Perceived Behavioral Control, SES=Socioeconomic Status, sig=significance, SM=Skim Milk, SN=Subjective Norm, SSB=Sugar-Sweetened Beverages, T1=Time 1, T2=Time 2, TPB=Theory of Planned Behavior, USDA=United State Department of Agriculture

*$p \leq .05$
**$p \leq .01$
***$p \leq .001$
****$p \leq .0001$

Appendix C. Study bias risk assessment adapted from Plotnikoff et al., 2013 (**Chapter 2** reference #40). A total score of 5 was classified as low risk for bias; 3-4 as a moderate risk of bias; 0-2 high risk for bias

Study	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**[a]	**Total**
Astrom 2004	0	1	1	1	0	**3**
Astrom and Okullo 2004	0	1	1	1	0	**3**
Backman et al., 2002	0	1	0	1	1	**3**
Bazillier et al., 2011	0	0	0	0	0	**0**
Beaulieu and Godin, 2011	0	1	0	1	NA	**2**
Berg et al., 2000	0	0	0	1[b]	0	**1**
Branscum and Sharma, 2011	1	0	1	1	1[c]	**4**
Branscum and Sharma, 2013	1	0	1	0	1[c]	**3**
Chan and Tsang, 2011	0	0	0	1	0	**1**
Conner et al.,	0	0	0	1	0	**1**

2011 (same study as Berg 2000)						
Cottrell et al., 2012	0	1	0	0[d]	0[d]	**1**
de Bruijn, et al., 2005	0	1	0[e]	1	1	**3**
de Bruijn, et al., 2007	0[f]	0[f]	0[e]	1	1	**2**
Dennison and Shepherd, 1995	0	0	0	1	NA	**1**
Diaz et al., 2009 (same study as Backman 2002)	1	1	1	1	0[g]	**4**
Fila and Smith, 2006	0	0	0	1	0	**1**
Gratton, Povey, Clark-Carter, 2007	0	1	1	1	0	**3**
Grønhøj et al., 2012 (see Chan from above for data)	0	0	0	1	0	**1**
Gummeson et al.,	1	0	0	1	1	**3**

1997						
Hewitt and Stephens, 2007	0	0	0	1	0	**1**
Ickes and Sharma, 2011	0	0	1	1	0	**2**
Kassem et al., , 2003	0	0	1	1	0	**2**
Kassem and Lee, 2004	0	0	1	1	0[g]	**2**
Kida and Astrom, 1998	0	0	0	1	NA	**1**
Lien et al., 2002	1	1	0	1	0[h]	**3**
Mullan et al., 2013	0	0	0	1	0	**1**
Murnaghan et al., 2010	1	0	0	1	0	**2**
Pawlak and Malinauskas, 2008	0	0	0	1	0	**1**
Seo et al., 2011	0	0	0	1	0	**1**
Shahanjarini, et al., 2013	0	1	1	NA[i]	1	**3**

Sharifirad, et al., 2013	0	1	0	1	0	**2**
Tak, et al., 2011	0[j]	1	1[k]	1	0[l]	**3**
Tsorbatzoudis, 2005	0	1	0	1	1	**3**
van der Horst et al., 2008	0[j]	1	0	1	0[l]	**2**

Note:

(Q1) Did the study describe the participant eligibility criteria and location and setting where data were collected?

(Q2) Were study participants randomly selected and was the process of randomization described?

(Q3) Did the study report a power calculation and was it specifically stated as being adequately powered? (If the study did not report adequate power, a score of 0 was assigned).

(Q4) Was the TPB questionnaire developed as per Ajen's recommendations (Chapter 2 reference# 29) and internal consistency reported. (If Ajen's recommendations were not followed or reported and/or internal consistency measured or reported, a score of 0 was assigned.)

(Q5) Did the study report the source(s) and details regarding the validity and reliability of the dietary assessment tool?

[a]Studies reported as NA (i.e. not applicable) measured intention and not behavior; thus, did not formally assess dietary intake

[b]Spearman correlation coefficients reported

[c]Details provided explaining how dietary data obtained similar to USDA's Automated Multiple Pass Method, 24-hour recall with this being a "snack" 24-hour recall

[d]Refers to prior work which upon further investigation provides internal consistency and validity information on dietary assessment in adults

[e]No power calculation provided; however, magnitude of effect reported (r).

[f]Not reported here, but refers to Study on Medical Information and Lifestyle in Eindhoven (SMILE), a prospective cohort, from which the sample was obtained

[g]Unclear if tested for validity and/or reliability in target population; TPB tool was reported as being tested for face and content validity and pilot tested; however, no psychometric properties provided for dietary assessment.

[h]Validity not reported (past work referenced); Reliability reported

[i]Shahanjarini et al., 2013 was not applicable (NA) since their work did not assess the TPB constructs per se, but utilized the theory to develop and implement an intervention

[j]Not reported here, but referes to Environmental Determinants of Obesity in Rotterdam School-Children (ENDORSE) study from which the sample was obtained and assessment tools used

[k]Design effect calculated

[l]Reliability, not validity

Appendix D. Institutional Review Board approval

VirginiaTech

Office of Research Compliance
Institutational Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE: September 17, 2013

TO: Brenda Davy, Shaun Karl Riebl

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)

PROTOCOL TITLE: Determining the Validity, Reliability, and Sensitivity of the d13C Added Sugar Biomarker and BEVQ-15 in Adolescents and a Qualitative Analysis of Beverage Choices in Adolescents and Their Parents using the Theory of Planned Behavior.

IRB NUMBER: **13-810**

Effective September 17, 2013, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	**Expedited, under 45 CFR 46.110 category(ies) 7**
Protocol Approval Date:	**September 17, 2013**
Protocol Expiration Date:	**September 16, 2014**
Continuing Review Due Date*:	**September 2, 2014**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
An equal opportunity, affirmative action institution

Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

Appendix E. Institutional Review Board continuing review approval

VirginiaTech

Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE: August 19, 2014

TO: Brenda Davy, Shaun Karl Riebl

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)

PROTOCOL TITLE: Determining the Validity, Reliability, and Sensitivity of the d13C Added Sugar Biomarker and BEVQ-15 in Adolescents and a Qualitative Analysis of Beverage Choices in Adolescents and Their Parents using the Theory of Planned Behavior.

IRB NUMBER: **13-810**

Effective August 19, 2014, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the Continuing Review request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	**Expedited, under 45 CFR 46.110 category(ies) 7**
Protocol Approval Date:	**September 17, 2014**
Protocol Expiration Date:	**September 16, 2015**
Continuing Review Due Date*:	**September 2, 2015**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
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Date*	OSP Number	Sponsor	Grant Comparison Conducted?
07/16/2014	13173902	NIH, Center for Scientific Review	Compared on 07/17/2014

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

Appendix F. Beverage intake questionnaire

Beverage Questionnaire (BEVQ-15)

Instructions:

In the past month, please indicate your response for each beverage type by marking an "X" in the bubble for "how often" and "how much each time".

Participant ID ________________

Date ________________

1. Indicate how often you drank the following beverages, for example, if you drank 5 glasses of water per week, mark 4-6 times per week.
2. Indicate the approximate amount of beverage you drank each time, for example, if you drank 1 cup of water each time, mark 1 cup under "how much each time".
3. Do not count beverages used in cooking or other preparations, such as milk in cereal.
4. Count milk added to tea and coffee in the *tea/coffee with cream beverage category* **NOT** in the milk categories.

	HOW OFTEN (MARK ONE)							HOW MUCH EACH TIME (MARK ONE)				
Type of Beverage	**Never or less than 1 time per week (go to next beverage)**	**1 time per week**	**2-3 times per week**	**4-6 times per week**	**1 time per day**	**2+ times per day**	**3+ times per day**	**Less than 6 fl oz (3/4 cup)**	**8 fl oz (1 cup)**	**12 fl oz (1 1/2 cups)**	**16 fl oz (2 cups)**	**More than 20 fl oz (2 1/2 cups)**
Water	o	o	o	o	o	o	o	o	o	o	o	o
100% Fruit Juice	o	o	o	o	o	o	o	o	o	o	o	o
Sweetened Juice Beverage/ Drink (fruit ades, lemonade, punch, Sunny Delight)	o	o	o	o	o	o	o	o	o	o	o	o
Whole Milk	o	o	o	o	o	o	o	o	o	o	o	o
Reduced Fat Milk (2%)	o	o	o	o	o	o	o	o	o	o	o	o
Low Fat/Fat Free Milk (Skim, 1%, Buttermilk, Soymilk)	o	o	o	o	o	o	o	o	o	o	o	o
Soft Drinks, Regular	o	o	o	o	o	o	o	o	o	o	o	o
Diet Soft Drinks/Artificially Sweetened Drinks (Crystal Light)	o	o	o	o	o	o	o	o	o	o	o	o
Sweetened Tea	o	o	o	o	o	o	o	o	o	o	o	o
Tea or Coffee, with cream and/or sugar (includes non-dairy creamer)	o	o	o	o	o	o	o	o	o	o	o	o
Tea or Coffee, black, with/ without artificial sweetener (no cream or sugar)	o	o	o	o	o	o	o	o	o	o	o	o
Beer, Ales, Wine Coolers, Non-alcoholic or Light Beer	o	o	o	o	o	o	o	o	o	o	o	o
Hard Liquor (shots, rum, tequila, etc.)	o	o	o	o	o	o	o	o	o	o	o	o
Wine (red or white)	o	o	o	o	o	o	o	o	o	o	o	o
Energy & Sports Drinks (Red Bull, Rockstar, Gatorade, Powerade, etc.)	o	o	o	o	o	o	o	o	o	o	o	o
Other (list):	o	o	o	o	o	o	o	o	o	o	o	o

Appendix G. Theory of Planned Behavior questionnaire for adolescents

Participant ID: ____________________ Date: ______________________

Administer Initials: ______________ Check if Entered: ___________

The following questions ask you to rate how you feel about sugary drinks. Let's first review what counts as a sugary drink and what does not.

Sugary drinks include:	**Sugary drinks DO NOT include:**
• **Regular Soft Drinks or Soda** such as Coke or Pepsi, Sprite or 7-up, Dr. Pepper, Mountain Dew • **Sugar-Sweetened Juice Beverages** such as fruit aides, lemonade, punch or Kool-Aid, Sunny Delight • **Sweetened Tea (Tea with sugar)** • **Coffee with Sugar** Think about these types of drinks when you respond to the next set of questions.	• **Diet Soft Drinks or Sodas** such as Diet Coke or Diet Pepsi, Diet Sprite or Diet 7-up, Diet Dr. Pepper, Diet Mountain Dew • **Unsweetened tea or other beverages with artificial sweeteners** such as Splenda, Equal, or Sweet n Low • **100% fruit juice** DO NOT think about these types of drinks when you respond to the next set of questions.

All of the questions will ask you about <u>drinking less than 1 cup</u> of sugary drinks each day. <u>Less than 1 cup</u> equals **0 to 1 cups** total of sugary drinks for an entire day.
Sugary drinks include: • **Regular Soft Drinks or Soda** such as Coke or Pepsi, Sprite or 7-up, Dr. Pepper, Mountain Dew • **Sugar-Sweetened Juice Beverages** such as fruit aides, lemonade, punch or Kool-Aid, Sunny Delight • **Sweetened Tea (Tea with sugar)** • **Coffee with Sugar** Think about these types of drinks when you respond to the next set of questions.

PART A: Your beliefs about sugary drinks

The next questions ask what you think about drinking less than 1 cup of sugary drinks per day. Pick the number that best represents you for each question and circle it.

For you, drinking less than 1 cup of sugary drinks each day would be:

1.

1	2	3	4	5
extremely enjoyable	sort-of enjoyable	neither enjoyable or unenjoyable	sort-of unenjoyable	extremely unenjoyable

2.

1	2	3	4	5
extremely healthy	sort-of healthy	neither healthy or unhealthy	sort-of unhealthy	extremely unhealthy

3.

1	2	3	4	5
extremely unsatisfying	sort-of unsatisfying	neither satisfying or unsatisfying	sort-of satisfying	extremely satisfying

4.

1	2	3	4	5
extremely wise	sort-of wise	neither wise or unwise	sort-of unwise	extremely unwise

5.

1	2	3	4	5
extremely boring	sort-of boring	neither boring or exciting	sort-of exciting	extremely exciting

6.

1	2	3	4	5
extremely harmful	sort-of harmful	neither harmful or beneficial	sort-of beneficial	extremely beneficial

PART B: What other people think about you drinking sugary drinks

The next questions ask you about what other people (like your friends and family) think about you drinking sugary drinks. Pick the number that best represents you for each question and circle it. Remember to think about your friends and family when answering.

1. Most people who are important to you want you to drink less than 1 cup of sugary drinks each day.

1	2	3	4	5
strongly disagree	sort-of disagree	neither disagree or agree	sort-of agree	strongly agree

2. For most people whose opinions you care about, how would they feel about you drinking less than 1 cup of sugary drinks each day?

1	2	3	4	5
completely disapprove	sort-of disapprove	neither disapprove or approve	sort-of approve	completely approve

3. Most people who are important to you will drink less than 1 cup of sugary drinks each day.

1	2	3	4	5
completely untrue	sort-of untrue	neither untrue or true	sort-of true	completely true

PART C: Barriers to drinking less than 1 cup of sugary drinks each day

These next questions are concerned with how much control you believe you have over limiting your sugary drinks to 1 cup or less each day. Pick the number that best represents you for each question and circle it.

1. You have complete personal control over limiting your sugary drinks to less than 1 cup each day, if you really wanted to.

1	2	3	4	5
strongly disagree	sort-of disagree	neither disagree or agree	sort-of agree	strongly agree

2. Limiting your sugary drinks to less than 1 cup each day is mostly up to you if you wanted to.

1	2	3	4	5
strongly disagree	sort-of disagree	neither disagree or agree	sort-of agree	strongly agree

3. Limiting your sugary drinks to less than 1 cup of sugary drinks each day if you wanted to do so would be:

1	2	3	4	5
extremely difficult	sort-of difficult	neither difficult or easy	sort-of easy	extremely easy

PART D: Motivation to limit sugary drinks to less than 1 cup each day

The next questions ask you about your motivation to limit your sugary drinks to less than 1 cup each day. Pick the number that best represents you for each question and circle it.

1. You plan to limit your sugary drinks to less than 1 cup each day.

1	2	3	4	5
strongly disagree	sort-of disagree	neither disagree or agree	sort-of agree	strongly agree

2. How many days per week do you intend to limit your sugary drinks to less than 1 cup?

0	1	2	3	4	5	6	7

3. How motivated are you to limit your sugary drinks to less than 1 cup each day?

1	2	3	4	5
extremely unmotivated	sort-of unmotivated	neither unmotivated or motivated	sort-of motivated	extremely motivated

4. How determined are you to limit you sugary drinks to less than 1 cup each day?

1	2	3	4	5
extremely undetermined	sort-of undetermined	neither undetermined or determined	sort-of determined	extremely determined

PART E: Plans to limit your sugary drinks to less than 1 cup each day

The next questions ask you about your plans to limit your sugary drinks to less than 1 cup each day. Pick the number that best represents you for each question and circle it.

1. You have made plans for <u>when</u> you are going to limit your sugary drinks to less than 1 cup each day.

1	2	3	4	5
strongly disagree	sort-of disagree	neither disagree or agree	sort-of agree	strongly agree

2. You have made plans for <u>where</u> you are going to limit your sugary drinks to less than 1 cup each day (for example: at home or at school).

1	2	3	4	5
strongly disagree	sort-of disagree	neither disagree or agree	sort-of agree	strongly agree

3. You have made plans on <u>what</u> drinks you will use as a replacement for your sugary drinks each day.

1	2	3	4	5
strongly disagree	sort-of disagree	neither disagree or agree	sort-of agree	strongly agree

4. You have made plans on <u>how</u> you are going to limit your sugary drinks to less than1 cup each day.

1	2	3	4	5
strongly disagree	sort-of disagree	neither disagree or agree	sort-of agree	strongly agree

Appendix H. Theory of Planned Behavior questionnaire for parents

Participant ID: ____________________ Date: _______________________

Administer Initials: _______________ Check if Entered: ___________

The following questions ask you to rate how you feel about sugary drinks. Let's first review what counts as a sugary drink and what does not.

Sugary drinks include:	**Sugary drinks DO NOT include:**
• **Regular Soft Drinks or Soda** such as Coke or Pepsi, Sprite or 7-up, Dr. Pepper, Mountain Dew • **Sugar-Sweetened Juice Beverages** such as fruit aides, lemonade, punch or Kool-Aid, Sunny Delight • **Sweetened Tea (Tea with sugar)** • **Coffee with Sugar** Think about these types of drinks when you respond to the next set of questions.	• **Diet Soft Drinks or Sodas** such as Diet Coke or Diet Pepsi, Diet Sprite or Diet 7-up, Diet Dr. Pepper, Diet Mountain Dew • **Unsweetened tea or other beverages with artificial sweeteners** such as Splenda, Equal, or Sweet n Low • **100% fruit juice** DO NOT think about these types of drinks when you respond to the next set of questions.

All of the questions will ask you about <u>drinking less than 1 cup</u> of sugary drinks each day. <u>Less than 1 cup</u> equals **0 to 1 cups** total of sugary drinks for an entire day.
Sugary drinks include: • **Regular Soft Drinks or Soda** such as Coke or Pepsi, Sprite or 7-up, Dr. Pepper, Mountain Dew • **Sugar-Sweetened Juice Beverages** such as fruit aides, lemonade, punch or Kool-Aid, Sunny Delight • **Sweetened Tea (Tea with sugar)** • **Coffee with Sugar** Think about these types of drinks when you respond to the next set of questions.

PART A: Your beliefs about sugary drinks

The next questions ask what you think about drinking less than 1 cup of sugary drinks per day. Pick the number that best represents you for each question and circle it.

For you, drinking less than 1 cup of sugary drinks each day would be:

1.

1	2	3	4	5	6	7
extremely enjoyable	quite enjoyable	slightly enjoyable	neither enjoyable or unenjoyable	slightly unenjoyable	quite unenjoyable	extremely unenjoyable

2.

1	2	3	4	5	6	7
extremely healthy	quite healthy	slightly healthy	neither healthy or unhealthy	slightly unhealthy	quite unhealthy	extremely unhealthy

3.

1	2	3	4	5	6	7
extremely pleasant	quite pleasant	slightly pleasant	neither pleasant or unpleasant	slightly unpleasant	quite unpleasant	extremely unpleasant

4.

1	2	3	4	5	6	7
extremely wise	quite wise	slightly wise	neither wise or unwise	slightly unwise	quite unwise	extremely unwise

5.

1	2	3	4	5	6	7
extremely boring	quite boring	slightly boring	neither boring or exciting	slightly exciting	quite exciting	extremely exciting

6.

1	2	3	4	5	6	7
extremely harmful	quite harmful	slightly harmful	neither harmful or beneficial	slightly beneficial	quite beneficial	extremely beneficial

PART B: What other people think about you drinking sugary drinks

The next questions ask you about what other people (like your friends and family) think about you drinking sugary drinks. Pick the number that best represents you for each question and circle it. Remember to think about your friends and family when answering.

1. Most people who are important to you want you to drink less than 1 cup of sugary drinks each day.

1	2	3	4	5	6	7
strongly disagree	moderately disagree	slightly disagree	neither disagree or agree	slightly agree	moderately agree	strongly agree

2. For most people whose opinions you value, how would they feel about you drinking less than 1 cup of sugary drinks each day?

1	2	3	4	5	6	7
completely disapprove	moderately disapprove	slightly disapprove	neither disapprove or approve	slightly approve	moderately approve	completely approve

3. Most people who are important to you will drink less than 1 cup of sugary drinks each day.

1	2	3	4	5	6	7
completely untrue	quite untrue	slightly untrue	neither untrue or true	slightly true	quite true	completely true

PART C: Barriers to drinking less than 1 cup of sugary drinks each day

These next questions are concerned with how much control you believe you have over limiting your sugary drinks to 1 cup or less each day. Pick the number that best represents you for each question and circle it.

4. You have complete personal control over limiting your sugary drinks to less than 1 cup each day, <u>if you really wanted to</u>.

1	2	3	4	5	6	7
strongly disagree	moderately disagree	slightly disagree	neither disagree or agree	slightly agree	moderately agree	strongly agree

5. Limiting your sugary drinks to less than 1 cup each day is mostly up to you <u>if you wanted to</u>.

1	2	3	4	5	6	7
strongly disagree	moderately disagree	slightly disagree	neither disagree or agree	slightly agree	moderately agree	strongly agree

6. Limiting your sugary drinks to less than 1 cup of sugary drinks each day <u>if you wanted to do so</u> would be:

1	2	3	4	5	6	7
extremely difficult	quite difficult	slightly difficult	neither difficult or easy	slightly easy	quite easy	extremely easy

PART D: Motivation to limit sugary drinks to less than 1 cup each day

The next questions ask you about your motivation to limit your sugary drinks to less than 1 cup each day. Pick the number that best represents you for each question and circle it.

4. You plan to limit your sugary drinks to less than 1 cup each day.

1	2	3	4	5	6	7
strongly disagree	moderately disagree	slightly disagree	neither disagree or agree	slightly agree	moderately agree	strongly agree

5. How many days per week do you intend to limit your sugary drinks to less than 1 cup?

0 1 2 3 4 5 6 7

6. How motivated are you to limit your sugary drinks to less than 1 cup each day?

1	2	3	4	5	6	7
extremely unmotivated	quite unmotivated	slightly unmotivated	neither unmotivated or motivated	slightly motivated	quite motivated	extremely motivated

4. How determined are you to limit you sugary drinks to less than 1 cup each day?

1	2	3	4	5	6	7
extremely undetermined	quite undetermined	slightly undetermined	neither undetermined or determined	slightly determined	quite determined	extremely determined

PART E: Plans to limit your sugary drinks to less than 1 cup each day

The next questions ask you about your plans to limit your sugary drinks to less than 1 cup each day. Pick the number that best represents you for each question and circle it.

5. You have made plans concerning <u>when</u> you are going to limit your sugary drinks to less than 1 cup each day.

1	2	3	4	5	6	7
strongly disagree	moderately disagree	slightly disagree	neither disagree or agree	slightly agree	moderately agree	strongly agree

6. You have made plans concerning <u>where</u> you are going to limit your sugary drinks to less than 1 cup each day (for example: at home or at work).

1	2	3	4	5	6	7
strongly disagree	moderately disagree	slightly disagree	neither disagree or agree	slightly agree	moderately agree	strongly agree

7. You have made plans concerning <u>what</u> drinks you will use as a replacement for your sugary drinks each day.

1	2	3	4	5	6	7
strongly disagree	moderately disagree	slightly disagree	neither disagree or agree	slightly agree	moderately agree	strongly agree

8. You have made plans concerning <u>how</u> you are going to limit your sugary drinks to less than1 cup each day.

1	2	3	4	5	6	7
strongly disagree	moderately disagree	slightly disagree	neither disagree or agree	slightly agree	moderately agree	strongly agree

Appendix I. Parent response to beverage choice questionnaire

Participant ID: ______________________ Date: _________________________

Administrator Initials: ________________ Check if Entered: _______________

<u>*Instructions:*</u> In the following items, please indicate on a scale of 1 (very unlikely) to 7 (very likely) the likelihood that you would respond in the described ways for each scenario. Please read each item carefully and respond as honestly as you can. Please circle a number from 1 to 7.

Reference Response Scale:

1	2	3	4	5	6	7
Very Unlikely			Neither Unlikely or Likely			Very Likely

---

1. If I find my child drinking a <u>coffee-type of beverage</u> (e.g. hot or cold coffee/tea, Frappuccino®, latte, etc.) **at home**, I would:

a.	take it away or restrict him/her from drinking it	1	2	3	4	5	6	7
b.	get angry or upset with my child	1	2	3	4	5	6	7
c.	encourage him/her to continue drinking or to drink more of it	1	2	3	4	5	6	7
d.	do nothing	1	2	3	4	5	6	7
e.	offer a different drink or ask why she/he chose that drink	1	2	3	4	5	6	7

2. If I find my child drinking a <u>sports or energy drink</u> (e.g. Red Bull, Monster, Gatorade, G2, Powerade, Vitaminwater, etc.) **at home**, I would:

a.	get angry or upset with my child	1	2	3	4	5	6	7
b.	do nothing	1	2	3	4	5	6	7
c.	offer a different drink or ask why she/he chose that drink	1	2	3	4	5	6	7
d.	take it away or restrict him/her from drinking it	1	2	3	4	5	6	7
e.	encourage him/her to continue drinking or to drink more of it	1	2	3	4	5	6	7

Please turn the page →

Reference Response Scale:

1	2	3	4	5	6	7
Very Unlikely			Neither Unlikely or Likely			Very Likely

3. If I find my child drinking <u>regular soda</u> (e.g. Coca-cola, Pepsi, Mountain Dew, Sprite, Sierra Mist, Dr. Pepper, Root Beer, cola, etc.) **at home**, I would:

a.	offer them a different drink or ask why she/he chose that drink	1	2	3	4	5	6	7
b.	get angry or upset with my child	1	2	3	4	5	6	7
c.	take it away or restrict him/her from drinking it	1	2	3	4	5	6	7
d.	do nothing	1	2	3	4	5	6	7
e.	encourage him/her to continue drinking or to drink more of it	1	2	3	4	5	6	7

4. If I find my child drinking <u>diet soda</u> (Diet Coke, Coke Zero, Diet Pepsi, Diet Sprite, Diet Sierra Mist, Diet Dr. Pepper, Diet Root Beer, diet cola, etc.) **at home**, I would:

a.	take it away or restrict him/her from drinking it	1	2	3	4	5	6	7
b.	encourage him/her to continue drinking or to drink more of it	1	2	3	4	5	6	7
c.	offer them a different drink or ask why she/he chose that drink	1	2	3	4	5	6	7
d.	do nothing	1	2	3	4	5	6	7
e.	get angry or upset with my child	1	2	3	4	5	6	7

5. If I find my child drinking <u>100% fruit juice</u> (e.g. 100% orange juice, 100% grape juice, 100% apple juice, etc.) **at home**, I would:

a.	take it away or restrict him/her from drinking it	1	2	3	4	5	6	7
b.	get angry or upset with my child	1	2	3	4	5	6	7
c.	do nothing	1	2	3	4	5	6	7
d.	offer them a different drink or ask why she/he chose that drink	1	2	3	4	5	6	7
e.	encourage him/her to continue drinking or to drink more of it	1	2	3	4	5	6	7

Please turn the page →

Reference Response Scale:

1	2	3	4	5	6	7
Very Unlikely			Neither Unlikely or Likely			Very Likely

6. If I find my child drinking a juice drink (e.g. Capri Sun, Hi-C, Kool-Aid, Sunny D, etc.) **at home**, I would:

a.	do nothing	1	2	3	4	5	6	7
b.	offer them a different drink or ask why she/he chose that drink	1	2	3	4	5	6	7
c.	encourage him/her to continue drinking or to drink more of it	1	2	3	4	5	6	7
d.	get angry or upset with my child	1	2	3	4	5	6	7
e.	take it away or restrict him/her from drinking it	1	2	3	4	5	6	7

7. If I find out my child drinking a coffee-type of beverage (e.g. hot or cold coffee/tea, Frappuccino®, latte, etc.) **outside of our home** (i.e. party, athletic event, amusement park, etc.), I would:

a.	offer them a different drink or ask why she/he chose that drink	1	2	3	4	5	6	7
b.	take it away or restrict him/her from drinking it	1	2	3	4	5	6	7
c.	encourage him/her to continue drinking or to drink more of it	1	2	3	4	5	6	7
d.	do nothing	1	2	3	4	5	6	7
e.	get angry or upset with my child	1	2	3	4	5	6	7

8. If I find my child drinking a sports or energy drink (e.g. Red Bull, Monster, Gatorade, G2, Powerade, Vitaminwater, etc.) **outside of our home** (i.e. party, athletic event, amusement park, etc.), I would:

a.	take it away or restrict him/her from drinking it	1	2	3	4	5	6	7
b.	do nothing	1	2	3	4	5	6	7
c.	offer them a different drink or ask why she/he chose that drink	1	2	3	4	5	6	7
d.	get angry or upset with my child	1	2	3	4	5	6	7
e.	encourage him/her to continue drinking or to drink more of it	1	2	3	4	5	6	7

Please turn the page

Reference Response Scale:

1	2	3	4	5	6	7
Very Unlikely			Neither Unlikely or Likely			Very Likely

9. If I find my child drinking <u>regular soda</u> (e.g. Coca-cola, Pepsi, Mountain Dew, Sprite, Sierra Mist, Dr. Pepper, Root Beer, cola, etc.) **outside of our home** (i.e. party, athletic event, amusement park, etc.), I would:

a.	encourage him/her to continue drinking or to drink more of it	1	2	3	4	5	6	7
b.	get angry or upset with my child	1	2	3	4	5	6	7
c.	offer them a different drink or ask why she/he chose that drink	1	2	3	4	5	6	7
d.	do nothing	1	2	3	4	5	6	7
e.	take it away or restrict him/her from drinking it	1	2	3	4	5	6	7

10. If I find my child drinking <u>diet soda</u> (Diet Coke, Coke Zero, Diet Pepsi, Diet Sprite, Diet Sierra Mist, Diet Dr. Pepper, Diet Root Beer, diet cola, etc.) **outside of our home** (i.e. party, athletic event, amusement park, etc.), I would:

a.	get angry or upset with my child	1	2	3	4	5	6	7
b.	do nothing	1	2	3	4	5	6	7
c.	take it away or restrict him/her from drinking it	1	2	3	4	5	6	7
d.	offer them a different drink or ask why she/he chose that drink	1	2	3	4	5	6	7
e.	encourage him/her to continue drinking or to drink more of it	1	2	3	4	5	6	7

11. If I find my child drinking <u>100% fruit juice</u> (e.g. 100% orange juice, 100% grape juice, 100% apple juice, etc.) **outside of our home** (i.e. party, athletic event, amusement park, etc.), I would:

a.	encourage him/her to continue drinking or to drink more of it	1	2	3	4	5	6	7
b.	do nothing	1	2	3	4	5	6	7
c.	offer them a different drink or ask why she/he chose that drink	1	2	3	4	5	6	7
d.	take it away or restrict him/her from drinking it	1	2	3	4	5	6	7
e.	get angry or upset with my child	1	2	3	4	5	6	7

Please turn the page →

Reference Response Scale:

1	2	3	4	5	6	7
Very Unlikely			Neither Unlikely or Likely			Very Likely

12. If I find my child drinking a juice drink (e.g. Capri Sun, Hi-C, Kool-Aid, Sunny D, etc.) **outside of our home** (i.e. party, athletic event, amusement park, etc.), I would:

a.	offer them a different drink or ask why she/he chose that drink	1	2	3	4	5	6	7
b.	get angry or upset with my child	1	2	3	4	5	6	7
c.	encourage him/her to continue drinking or to drink more of it	1	2	3	4	5	6	7
d.	take it away or restrict him/her from drinking it	1	2	3	4	5	6	7
e.	do nothing	1	2	3	4	5	6	7

Please turn the page →

Instructions: **Please respond to the following questions as fully and honestly as possible.**

How often do you talk with your child about the beverage choices she/he makes (circle one)?

Often Sometimes Never

Why do you or don't you talk with your child about the beverage choices he/she makes?

If you do talk with your child about beverage choices, what are things you think are important to say?

What types of beverages **do you allow** your child to drink or purchase?

What types of beverages would you like your child **not to drink or purchase**?

Thank you very much!

Appendix J. Summary of responses to open-ended questions from the Parent Response to Beverage Choice Questionnaire (Par-B-Q)

Question 1. How often do you talk with your child about the beverages choices she/he makes?

		Frequency	Percent
Often		21	32%
Sometimes		42	65%
Never		2	3%
	Total	65	

Question 2. Why do or don't you talk about beverage choices with your child/children?

Health impacted by choices	36	55%
Have positive influence on choices	23	35%
Don't want kids drinking sugary beverages	9	14%
Artificial sweeteners	6	9%
Calories, sugar, fat content	6	9%
Child controls intake well	5	8%
Maximize energy in sports	5	8%
Out of my control	2	3%
Religious reasons	2	3%
All they want is soda	1	2%
Discuss what friends drink	1	2%
Prevent addictions	1	2%
Fake colors	0	0%

Question 3. If you do speak with your children about beverages what is important?

Choices can impact health	29	45%
Sugary drinks are not good/too much sugar is not good	25	38%
Encourage water/water is important	22	34%
Moderation	18	28%
Avoid caffeine	13	20%
Calories	8	12%
Avoid sugar substitutes	7	11%
Weight gain	7	11%
Hydration	6	9%
Sugary beverages are not good for teeth	5	8%
Milk is good for bones	4	6%
Religious beliefs	1	2%
Drink milk and juice	1	2%
Why some choices are better than others	1	2%

Question 4. What beverages do you allow your child to drink or purchase?

Water	46	71%
100% Fruit juice	41	63%
Soda on special occasions	38	58%
Milk	31	48%
Sports drinks (including G2)	20	31%
Sweet tea/lemonade	17	26%
Tea (brewed)	12	18%
Diet soda	6	9%
No sugar added/low	6	9%

sugar/artificially sweetened		
Anything legal/mostly anything	6	9%
Hot cocoa	5	8%
Uncaffeinated soda	3	5%
Coffee drinks	2	3%

Question 5. What types of beverages would you like your child not to drink or purchase?

Energy drinks	40	62%
Soda	30	46%
Coffee	21	32%
Caffeinated drinks	19	29%
Sugar-sweetened beverages/Sweet tea	18	28%
Diet soda/artificially sweetened drinks	16	25%
Alcohol	14	22%
Sports drinks (incld. only during sports)	7	11%
Juice/eat fruit instead	4	6%
Fake colors	4	6%
High calories	1	2%
Anything with high fructose corn syrup	1	2%
Anything but water	1	2%

Appendix K. Riebl S, Davy B. The Hydration Equation: Update on Water Balance and Cognitive Performance. *ACSMs Health Fit J.* 2013;17(6):21-28. Wolters Kluwer Health Lippincott Williams & Wilkins© No modifications will be permitted

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Author: Shaun Riebl and Brenda Davy

Publication: ACSM's Health & Fitness Journal

Publisher: Wolters Kluwer Health, Inc.

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THE HYDRATION EQUATION

Update on Water Balance and Cognitive Performance

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LEARNING OBJECTIVES

- To become aware of the most practical measures of hydration status.
- To describe sources of water input and output and the basics of water balance.
- To understand how hydration status may impact daily cognitive performance.

Key words:
Fluid, Cognitive Function, Hydration Assessment, Water Intake, Mood

INTRODUCTION

Although it often is overlooked as an essential nutrient, water is vital for life because it serves several critical functions. Total body water comprises approximately 45% to 75% of a person's body weight (27). Muscle mass is 70% to 75% water, whereas water in fat tissue can vary between 10% and 40% (25). Water acts as a transporter of nutrients, regulates body temperature, lubricates joints and internal organs, provides structure to cells and tissues, and can help preserve cardiovascular function (26). Water consumption also may facilitate weight management (15,17). Water deficits can impact physical performance (25,38), and recent research suggests that cognitive performance also may be impacted (4,13,20–22,35,36). This article will address water balance, hydration assessment, and the effect of water balance on cognitive performance.

WATER BALANCE

Water balance (*i.e.,* input vs. output) is influenced by dietary intake, physical activity level, age, and environmental conditions. Although total body water balance is regulated tightly during a 24-hour period (25), deficits and excesses can occur. Dehydration develops from inadequate fluid intake or excessive fluid losses, and overhydration can result from excessive water (or fluid) intake with or without proper electrolyte replacement (25,33).

Water Output and Its Regulation

The skin, kidneys, lungs, and digestive system are all sources of water output (Figure). Environmental factors (*e.g.,* humidity, temperature) and intensity and duration of physical activity also impact urine output (*e.g.,* increased urine output in colder climates, decreased urine output in hot climates and greater water loss via sweat with longer-duration activities) (25). Respiratory water loss averages 250 to 350 mL per day in sedentary adults; however, physical activity can increase losses to about 600 mL per

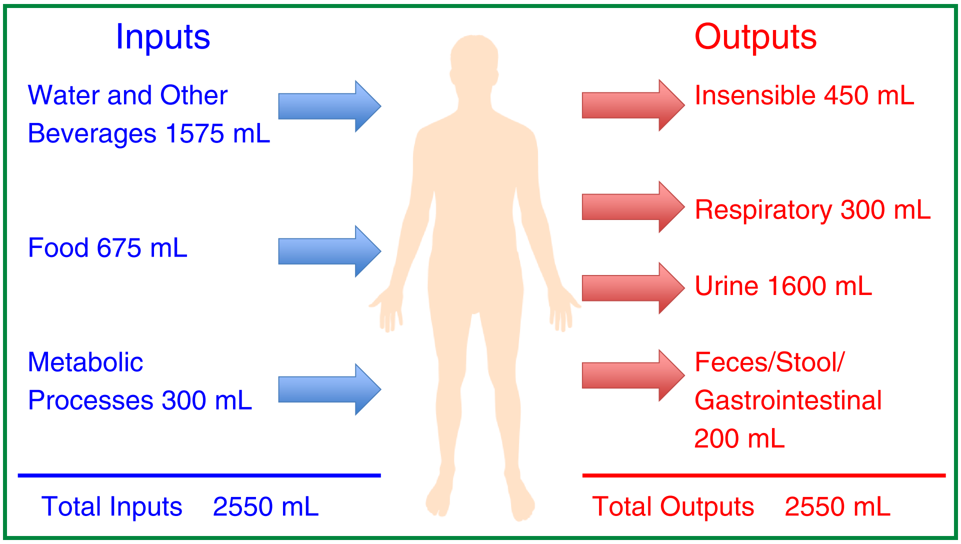


Figure. Average daily fluid balance in adults. 1 cup = 237 mL. (*Based upon estimates reported by* Jequier E, Constant F. Water as an essential nutrient: the physiological basis of hydration. *European Journal of Clinical Nutrition 2010;64(2):115–23.*)

day (19,25). Insensible water loss, which includes sweat loss, can vary with environmental conditions (*i.e.,* wind speed, humidity, and sun exposure), activity level, body composition, degree of physical fitness, and other variables (*e.g.,* clothing worn, sweat rate) (19,25,38). On average, insensible water losses are about 450 mL per day; however, during vigorous physical activity in a hot environment, losses in excess of 3 L per hour are possible (37). Urine output generally ranges 1,000 to 2,000 mL per day but can be altered by exercise and heat strain (25). Gastrointestinal and fecal water output accounts for 100 to 300 mL per day (19,25,27). Total water output is estimated to be approximately 1,500 to 3,100 mL per day for adults in temperate climates (19,25).

When water loss exceeds intake, blood volume decreases and plasma osmolality increases. The reduction in blood volume decreases blood pressure, leading to increases in renin and angiotensin II concentrations. The latter, along with aldosterone, promote sodium and chloride reabsorption in the kidneys and, thus, water via osmosis and decreased urine output. Increased blood osmolality and angiotensin II stimulate the hypothalamus and arginine vasopressin (AVP) is released, promoting renal water retention and reduced urinary output. Increased plasma osmolality also stimulates thirst through peripheral osmoreceptors in the mouth and gastrointestinal tract to replace the remaining water lost. Baroreceptors promote AVP release and thirst when reductions in plasma volume are significant; however, this mechanism is not as sensitive as the osmotic regulation of thirst (31).

Water Input and Its Regulation

Water input comes from food and beverage ingestion and normal metabolic processes (Figure). There are regulated or physiological (*e.g.,* osmoreceptors in the brain and mouth, baroreceptors in blood vessels and atrium) and nonregulated (*e.g.,* social, cultural, behavioral) factors that influence water intake (25,35,43) and fluid balance. The thirst sensation is triggered with a body water loss of 1% to 2% — a range where physical and cognitive performance may decline (4,9,21,22, 25,34,38). Typically, plasma osmolality is maintained tightly between 280 and 290 mOsm/kg; however, an increase of approximately 1% to 3% creates a drive to drink (12,43).

Fluid water intake generally accounts for approximately 70% to 80% of total water consumed (25), and approximately 20% to 30% of total water intake comes from solid foods (5,19,25). In a typical sedentary adult, this represents approximately 7 cups (1,575 mL) from beverages, approximately 3 cups (675 mL) from foods, and approximately 1 cup (300 mL) from normal metabolic processes (27). Despite popular myths, coffee can be considered a source of fluid (7,25), and although alcohol may increase fluid losses short-term, it is not believed to result in significant water loss over a day's time (25).

When fluid is consumed, osmoreceptors in the mouth are stimulated, which reduces AVP secretion. This allows the kidneys to release excess water and preserve water balance. If plasma osmolality decreases and blood volume increases, the thirst sensation fades. The desire to drink may cease before achieving water balance (13), however, plasma osmolality will remain elevated and thirst sensations may return until water homeostasis is achieved (12,43).

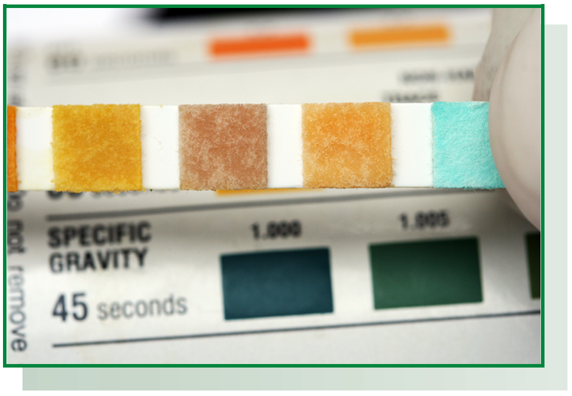
Hyperhydration and Hyponatremia

Typically, healthy individuals can maintain water balance through urination when excess fluid is consumed; hyperhydration is not commonly encountered (19,25). However, during extreme and extended-duration exercise, excessive consumption of hypotonic fluids and sodium losses that exceed the rate of replacement, and sometimes even in the absence of overconsumption of fluids, can cause hyponatremia (25,33,38). Hyponatremia, which is defined as a blood sodium concentration lower than 135 mmol/L (25), can have serious health implications (19,25). Hyperhydration (*i.e.,* "water intoxication") can present with symptoms such as fatigue, lethargy, disorientation, confusion, headache, nausea, vomiting, and, if not treated properly, coma and death (23,25). The signs and symptoms of dehydration and overhydration can be similar (*i.e.,* lightheadedness, dizziness, headaches, nausea, fatigue) (4,21,22,30). When working with clients, health and fitness professionals can use a variety of methods to assess the presence and nature of water imbalance to ensure that clients receive proper treatment.

METHODS TO ASSESS HYDRATION STATUS

Hydration refers to having adequate fluid within body tissues, and it can be determined through a variety of methods. Dilution techniques, plasma osmolality, neutron activation analysis, and bioelectrical impedance spectroscopy can be used to assess hydration status in a laboratory setting, whereas thirst, 24-hour urine volume, change in weight (*i.e.,* body mass), urine color, and urine specific gravity (USG) can be used in the field (3). Others have reviewed these techniques, their ease of use, and potential limitations extensively (2,3,11,38); however, a brief discussion of practical measures to assess hydration status is provided.

USG is an accurate and rapid indicator of hydration status (2). A urine specimen is placed on the glass plate at one end of a handheld refractometer and, on holding it up to natural light and looking through the eyepiece, a fitness professional can read the USG. Normal ranges are from 1.013 to 1.029; a USG of 1.030 or higher suggests dehydration, and 1.001 to 1.012 may indicate overhydration (2). USG is more indicative of recent fluid consumption versus overall chronic hydration status (8); however, it can be used in conjunction with other practical measures of hydration status such as changes in body weight (19,38). To obtain accurate information, weight should be measured on waking on three successive days, after voiding, and before consumption of any fluids (3,38). If fluctuations exceed more than 1% from baseline, water imbalance may be present (3). Although subjective, urine color can be a marker of hydration status when used in combination with a more quantifiable method such as USG (6,8,38). A person's urine sample is compared with a color chart that identifies euhydration or the need to consume additional fluids (8,32). A lighter color indicates adequate hydration, whereas darker colors indicate the need for fluid consumption. However, diet, supplements, and medications can affect body weight and urine color (19,32); thus, these factors must be considered when using this method.



Cheuvront and Sawka (11) suggest that athletes use the WUT framework (available at: http://www.gssiweb.com/Article/sse-97-hydration-assessment-ofathletes), which takes into account not only body mass but also the degree of thirst and urine parameters. In addition, a client's usual fluid intake can be measured using the beverage intake questionnaire (BEVQ-15) (24), which can be administered rapidly by the practitioner (~3 to 4 minutes) to provide a valid and reliable estimate of total beverage intake (including water, juice, and sports drinks) in terms of volume and calories (24). Although there are several measures to estimate hydration status, all have limitations (3); using multiple methods may allow the health and fitness professional to obtain the most accurate assessment of a client's hydration status (5,6,8,38).

WATER INTAKE RECOMMENDATIONS

Water needs can vary from person to person — and no one person will need the same amount of fluid from one day to the next, thus, developing a recommended dietary allowance for water is challenging. The Institute of Medicine (IOM) established an Adequate Intake (AI) for water, which is a guideline to help most healthy individuals avoid dehydration (25,26). Table 1 outlines the AI for total water and total fluid intake for various age groups. On average, Americans typically consume about 1 L (approximately four cups) of drinking water per day (40).

Whereas the AI addresses water needs of the general public, the health and fitness professional must consider an individual's physical activity regimen and environment when assessing hydration needs (25,38). ACSM's Exercise and Fluid Replacement guidelines can be used when counseling clients on appropriate hydration strategies to avoid dehydration and overhydration. Dehydration can impact physical performance negatively (25,34,38), and the magnitude of decrements in physical performance may be influenced by fitness level, environmental acclimatization, and mode of activity (25,38). As the level of dehydration increases, physical performance decreases — that is, performance suffers with greater degrees of

TABLE 1: The Institute of Medicine's Water Intake Recommendation*

	Age, years	Total Daily Water Needs†	Total Fluid Intake Including Water
Children			
	1–3	6c (1,300 mL)	4c (900 mL)
	4–8	7c (1,700 mL)	5c (1,200 mL)
Adolescents			
Males	9–13	10c (2,400 mL)	8c (1,800 mL)
	14–18	14c (3,300 mL)	11c (2,600 mL)
Females	9–13	9c (2,100 mL)	7c (1,600 mL)
	14–18	10c (2,300 mL)	8c (1,800 mL)
Adults			
Males	19+	16c (3,700 mL)	13c (3,000 mL)
Females	19+	11c (2,700 mL)	9c (2,200 mL)

** Adequate intake (AI) for total water and total fluid intake including water in cups (c) and milliliters (mL). 1 cup = 8 fluid oz; 1,000 mL = 33.8 fluid oz.*
†Total water needs = sum of plain drinking water and water from formulas, beverages, and foods consumed.

dehydration (25) — and recent literature suggests the same for cognitive performance (9,36,41).

COGNITIVE PERFORMANCE AND ASSESSMENT

Cognition refers to the process or act of knowing — a person's awareness and judgment. Cognitive functions can include a person's concentration or attentiveness, concept learning, critical thinking, and memory (39). Likewise, motivation, mood, arousal, and physical health affect cognitive processing (39). Cognitive performance is a measure of cognitive function (39), or how someone uses their judgment, memory, reasoning, and concentration to complete one or more tasks. Many tests exist to measure cognitive performance; however, debate on which assessment method is superior persists among practitioners (29). There are few standardized assessment methods, and causal mechanisms as to how dehydration may impact cognitive performance are unknown (30,35).

The degree of precision and/or rapidity of a response commonly is evaluated in cognitive performance assessments (39). For example, the time it takes for someone to respond to a visual stimulus would measure speed/reaction time and a word recall would measure an individual's cognitive accuracy. Table 2 provides definitions of common terminology and examples of cognitive performance assessment methods.

Two cognitive assessments that may be of practical use for the fitness professional are the ruler drop test and Trail Making Test (TMT) A and B (1,14,42,44). To conduct a ruler drop test, the practitioner holds a ruler vertically hovering above the outstretched dominant hand's index finger and thumb of a client. The 0-cm line of the ruler is parallel to the client's thumb. The client catches the ruler following the practitioner "dropping" it without notification. The distance is recorded and converted into a reaction time or interpreted as follows: poor, greater than 28 cm; below average, 20.4 to 28 cm; average, 15.9 to 20.4 cm; above average, 7.5 to 15.9 cm; and excellent, less than 7.5 cm (14). The TMT can measure vigilance and consists of form "A" on which a client is asked to connect 25 randomly placed numbers in sequence with a pen/pencil (42). The second form (*i.e.,* "B") is similar to the first except, in addition to numbers, alphabetical letters are incorporated (42). For example, a client would have to connect the number 1 with letter A and connect letter A to number 2, which would then be connected to letter B, and letter B would be connected to number 3, and so on (42). The outcome measure is time to completion, and mistakes do not stop timing. Average score for form A is 29 seconds, with scores greater than 78 seconds considered below average (1). For form B, average score is 75 seconds, and below average is 273 seconds (1).

Because of the complexity involved with cognitive processes, a battery of assessments should be administered to obtain the most accurate analysis (45). One such battery is called the Montreal Cognitive Assessment 7.1 (MoCA) (10). This screening tool was developed to assess mild cognitive impairment and early Alzheimer dementia through attention and concentration, executive functions, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation analyses (10). The MoCA can be administered in approximately 10 minutes, and a normal score is considered 26 of 30; however, scores of 24 may be acceptable (10). Although the tool was tested extensively in adults aged 49 years or older, it also can detect mild cognitive impairments in younger active individuals (16). The health and fitness professional may find the MoCA useful because of its rapid administration and scoring; however, if clients participate in contact sports or have experienced a concussion in years past, scores may be lower than suggested norms (16). The

TABLE 2: **Common Measures and Methods of Cognitive Performance Assessment**

Measure	Definition	Example of Assessment Method
Reaction time	Measure of elapsed time to a response after an audio, visual, or gustatory stimulus (46).	Ruler drop test — a ruler is dropped between an individual's extended index finger and thumb; the point on ruler where it was caught in centimeters is the recorded measure and can be converted into response time (28). More information about the ruler drop test can be found in Davis *et al.* (14).
Mood states	Prevailing emotional feelings.	Profile of mood states (POMS) — depending on the question, "How [the person feels] right now?" various descriptions of mood (*e.g.,* anxiety, confusion, anger, fatigue, indifference) are rated on a 5-point scale (42). Additional information about the POMS and the test itself can be purchased at: http://www.mhs.com/product.aspx?gr=cli&prod=poms&id=overview.
Working memory/ short-term memory	A test of how long someone can remember a certain number of words or numbers; it involves taking information and being able to process, absorb (*i.e.,* retail and recall) information for more complex tasks such as learning, comprehension, and reasoning.	Word list of about 30 words with 1 minute to study and 1 minute to recall as many words as possible (9); another variation can be on a computer screen where time to response, correct and incorrect answers, and false alarms are recorded.
Vigilance	Degree of responsiveness to stimuli; quality or state of being alert; ability to recognize a stimulus over time; wakefulness, alertness, and attention; ability to pay attention over time.	Trail Making Test (TMT) A and B (42,44) involves joining numbers 1 to 25 and/or numbers 1 to 13 and letters A to L, measured in seconds to completion with mistakes noted. Alternatively can be on a computer where individual scans screen for the appearance of a difficult to recognize stimulus occurring infrequently. Once observed, the individual is to press the space bar; this measure is in milliseconds, with false alarms being categorized as responses more than 2 seconds after the stimulus is presented. A PDF copy of the TMT A and B with instructions and scoring can be found at: http://doa.alaska.gov/dmv/akol/pdfs/uiowa_trailmaking.pdf.
Executive function	A compendium of mental processes used to organize, plan, strategize, pay attention, manage space and time, and remember details, and connect present action with past experiences (39).	No one test can measure executive function because of its complexity; however, individual tests assessing specific skills can measure the different facets of executive function.
Motor skills	Coordination of muscles to perform a specific act; can be complex (*i.e.,* gross, *e.g.,* slap shot in ice hockey) or simple (*i.e.,* fine, *e.g.,* posture while walking or sitting in a chair or the act of gasping) movements.	Range of motion or physical performance parameters (*e.g.,* walking on a straight line, jumping rope, or catching).
Visuoconstruction	Perception of object's relationships with each other in combination with fine motor skills.	Copying (redrawing) a three-dimensional object like a cube or drawing a clock at a specified time with all numbers (10).

test, administration, and scoring instructions can be found at http://www.mocatest.org/default.asp.

COGNITIVE PERFORMANCE AND DEHYDRATION

Cognitive performance had been reported previously to decline at or above a 2% body water loss (22,25). The level of reduction in cognitive performance can depend on environmental and individual factors (*e.g.,* level of fitness, acclimatization, and dehydration tolerance) (41), and it appears that, as the level of dehydration increases, efficiency of cognitive processing decreases (36). In long-distance walkers and runners, increased water intake has been associated with increased visual attentiveness and short-term memory (9). In women, aspects of mood (*i.e.,* vigor, alertness, fatigue, calmness, confusion, happiness) were affected negatively during fluid deprivation (36). Children also may have decrements in cognitive function as a result of inadequate water intake (20).

Recently, we have learned that even mild dehydration — a body water loss of 1% to 2% — can impair cognitive abilities (4,21). This amount of dehydration equates to about 1.5 to 3 lbs of body weight loss for a 150-lb person, which could occur through routine daily activities (4). Because many individuals experience fatigue later in the day when their workout time approaches, this could be important for fitness professionals to discuss with their clients. Problems with cognitive performance that can occur with mild dehydration include poor concentration, increased reaction time, and short-term memory problems, as well as moodiness and anxiety (4,21). Water consumption affects cognitive performance in adults (18), and an adequate daily water intake is important for maintaining optimal cognitive function.

Most studies on hydration and cognitive performance are short-term (*i.e.,* hours, days), and it is not certain if there are longer-term cognitive decrements resulting from hypohydration; however, a recent study suggests that, even after replenishing a fluid deficit, effects on mood may persist (36). Meaning, even after achieving euhydration, cognitive function may be compromised. This is an area in need of additional research.

CASE STUDY

Marion is a 38-year-old mother of 3 who works a full-time job from 8 a.m. to 4 p.m. 5 days a week. The BEVQ-15 revealed that she typically consumes approximately 2,700 mL of fluid from beverages daily. You often train her at your gym in the afternoons, and, on Monday, she came to you after successfully completing a 10K on Saturday and spending Sunday gardening and doing yard work with her family. It is the middle of August and when she shows up for her training session, she was stating how tired and lethargic she feels, that she has been making careless mistakes at work, that her head has been "pounding all day," and that she almost canceled the training session because she felt nauseous driving over from work. Marion's baseline body weight is 150 lbs and, from Friday on, her weights are as follows:

Friday: 150 lbs (0% change from baseline)
Saturday (race day): 151 lbs (1% increase from baseline)
Sunday: 149 lbs (<1% decrease from baseline)
Monday: 145 lbs (~3% decrease from baseline)

You question Marion about her fluid intake, and you find that her focus has not really been on hydration since finishing the race on Saturday. After obtaining a urine sample that was dark yellow, you analyze Marion's USG, which was 1.033. Suspecting that her fatigue and mistakes at work may be signs of compromised cognitive function, you administer the MoCA (10), and her score is 22. Marion's physical and cognitive signs and symptoms suggest that she is dehydrated, and her recent decreased morning body weight, USG, MoCA results, and urine color all confirm this. You provide Marion with guidelines for rehydration according to ACSM (38) and make plans to follow up with her tomorrow afternoon.

IMPLICATIONS AND CONCLUSIONS

Clients may experience mild dehydration — a 1% to 2% water loss — during routine daily activities (4,21,36). This may be a common problem, considering that adults drink only 1 L (~4 cups) of water a day on average (40), which is less than half of what is recommended currently by the IOM (25). The signs and symptoms of dehydration and overhydration can mirror each other, sharing light-headedness/dizziness, headaches, nausea, and fatigue — all subjective parameters sometimes used in hydration and cognition research (4,21,22,30,36). When working with clients, health and fitness professionals can use a number of means to assess water imbalances (*e.g.,* USG, body weight, and urine color) to ensure that clients receive proper treatment. In addition, fitness professionals can educate their clients on monitoring their own hydration status through morning body weight and the WUT framework (11), and when counseling patients on fluid needs before, during, and after exercise, the health and fitness professional can use the ACSM Exercise and Fluid Replacement guidelines (38). However, if a client has a chronic medical condition such as hypertension, cardiovascular disease, or diabetes, referring them to a registered dietitian for a personalized hydration plan may be necessary.

Cognitive functions, such as concentration, vigilance, memory, and critical thinking can be measured through a variety of cognitive performance assessments. Although there is no consensus as to which method of assessment is superior (29), tests such as the ruler drop test, Trail Making Test A and B (42), and MoCA (10) may be practical means for the health and fitness professional to assess rapidly a client's cognitive processing. Similar to physical performance, cognitive performance has been observed to decline at levels more than 2% body water loss (22,25), but recent research shows that mild dehydration (*i.e.,* 1% to 2% body water loss) may impair cognitive performance (4,21). Current literature provides insight into how cognitive function may be influenced by hydration status. However, the long-term consequences of dehydration on cognitive parameters and the mechanism by which fluid imbalances impact cognitive performance are unknown (35) — areas where future research efforts are needed.

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CONDENSED VERSION AND BOTTOM LINE

Water is a crucial nutrient, and euhydration is necessary for optimal daily function. Water balance is regulated precisely within the body, and many methods exist for assessing hydration status. Cognitive performance measures an individual's attentiveness, critical thinking skills, and memory. Traditionally, a 2% or more body water deficit was thought to produce cognitive performance decrements; however, recent literature suggests that even mild dehydration — a body water loss of 1% to 2% — can impair cognitive performance. Counseling clients about their health and well-being should include conveying the importance of water for normal body function, as well as its effects on physical and cognitive performance.

Appendix L. Riebl SK, Paone AC, Hedrick VE, Zoellner JM, Estabrooks PA, Davy BM. The Comparative Validity of Interactive Multimedia Questionnaires to Paper-Administered Questionnaires for Beverage Intake and Physical Activity: Pilot Study. *JMIR Res Protoc.* 2013;2(2):e40. www.researchprotocols.org/2013/2/e40. DOI: 10.2196/resprot.2830. PMID: 24148226. PMCID: PMC3806551

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Original Paper

The Comparative Validity of Interactive Multimedia Questionnaires to Paper-Administered Questionnaires for Beverage Intake and Physical Activity: Pilot Study

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Abstract

Background: Brief, valid, and reliable dietary and physical activity assessment tools are needed, and interactive computerized assessments (ie, those with visual cues, pictures, sounds, and voiceovers) can reduce administration and scoring burdens commonly encountered with paper-based assessments.

Objective: The purpose of this pilot investigation was to evaluate the comparative validity and reliability of interactive multimedia (IMM) versions (ie, IMM-1 and IMM-2) compared to validated paper-administered (PP) versions of the beverage intake questionnaire (BEVQ-15) and Stanford Leisure-Time Activity Categorical Item (L-Cat); a secondary purpose was to evaluate results across two education attainment levels.

Methods: Adults 21 years or older (n=60) were recruited to complete three laboratory sessions, separated by three to seven days in a randomly assigned sequence, with the following assessments–demographic information, two IMM and one paper-based (PP) version of the BEVQ-15 and L-Cat, health literacy, and an IMM usability survey.

Results: Responses across beverage categories from the IMM-1 and PP versions (validity; r=.34-.98) and the IMM-1 and IMM-2 administrations (reliability; r=.61-.94) (all P<.001) were significantly correlated. Paired t tests revealed significant differences in sugar-sweetened beverage (SSB) grams and kcal (P=.02 and P=.01, respectively) and total beverage kcal (P=.03), on IMM-1 and IMM-2; however, comparative validity was demonstrated between IMM-2 and the PP version suggesting familiarization with the IMM tool may influence participant responses (mean differences: SSB 63 grams, SEM 87; P=.52; SSB 21 kcal, SEM 33; P=.48; total beverage 65 kcal, SEM 49; P=.19). Overall mean scores between the PP and both IMM versions of the L-Cat were different (both P<.001); however, responses on all versions were correlated (P<.001). Differences between education categories were noted at each L-Cat administration (IMM-1: P=.008; IMM-2: P=.001; PP: P=.002). Major and minor themes from user feedback suggest that the IMM questionnaires were easy to complete, and relevant to participants' typical beverage choices and physical activity habits.

Conclusions: In general, less educated participants consumed more total beverage and SSB energy, and reported less engagement in physical activity. The IMM BEVQ-15 appears to be a valid and reliable measure to assess habitual beverage intake, although software familiarization may increase response accuracy. The IMM-L-Cat can be considered reliable and may have permitted respondents to more freely disclose actual physical activity levels versus the paper-administered tool. Future larger-scale investigations are warranted to confirm these possibilities.

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KEYWORDS

validity and reliability; multimedia; dietary assessment; beverages; physical activity

Introduction

Assessment Methods

Multiple unannounced 24-hour recalls, food records, and physical activity recalls have historically been recognized as gold standard approaches to assessing dietary and physical activity behaviors [1-3]. However, these assessment methods often require trained staff to administer and analyze, and are labor-intensive for both researchers and participants [1,2]. For these reasons, other valid methods of diet and physical activity assessments have been developed, such as food-frequency questionnaires as well as brief assessments of diet and physical activity. Recently, computerized diet and physical activity assessments have emerged as a way to decrease literacy barriers for participants, as well as decrease the research burden of processing paper-based surveys in large studies [4-8]. However, attention to the reliability, validity, and usability of computerized approaches to assessing diet and physical activity behaviors are imperative.

Due in part to the increased use and accessibility of computers in multiple settings (eg, homes, libraries, churches, recreational community centers, grocery stores, and schools) [7,9], the use of Web and computer-based assessments in large research trials have increased over the past 10 years [4,6,10]. The National Institutes of Health has recognized the need for novel/innovative assessment methods using technological advances in physical activity and dietary assessment (eg, PAR-12-198). There is no consensus to whether a paper-based assessment is superior to a computerized one [11]; however, computer-based tools can provide an alternative means to collect and analyze data [12] and may be appealing to practitioners and researchers because of their proposed benefits. Computer-administered assessments may overcome difficulties sometimes associated with paper-based surveys as they allow for interactivity-two-way communication between computer and participant through photographs, videos, and displayed text with or without audio [7]. Other advantages of computerized questionnaire administration include-complete responses (ie, prompting individuals to answer all questions), written and narrated text, visual cues of portion sizes, immediate and rapid data entry and scoring, decreased scoring errors, increased attentiveness from participants, instantaneous feedback, and a greater ability to access understudied populations [6,8,10,13,14]. Additionally, multi-part questions of computerized assessments can be programmed to reduce administration time by providing only relevant data and information for the participant [7]. In low health literacy populations, computerized questionnaires may be advantageous since text can be narrated and visual aids can be used, which may reduce response errors and the necessity of advanced reading skills [7]. Another potential advantage of computer-based assessments is that response-bias and intimidation may be reduced with computer-administered surveys, although additional research addressing this possibility is needed [5,7,15]. However, when using identical computerized versions of paper assessments comparability cannot be assumed because interface characteristics like font size, line length, scrolling ability, and amount of information visible on the screen can all influence user performance [16,17].

Two Paper-Based Questionnaires

Prior research has demonstrated the reliability and validity of two self-administered paper-based questionnaires. One assesses habitual beverage intake (BEVQ-15) [18], and the other measures usual physical activity level, Stanford Leisure-Time Activity Categorical Item 2.2 (L-Cat) [19]. There are several computerized nutrition education delivery [7,20,21] and dietary assessment tools [8,13,22-28] and a few Web-based physical activity questionnaires [12,29,30] currently available; however, to the best of our knowledge, no computer-based beverage intake questionnaire exists. The recently developed Automated Self-Administered 24-hour Recall [31] is computer-based and does contain questions about beverage intake; however, results on its validity and usability have yet to be published [32]. The purpose of this pilot investigation was to evaluate the comparative validity and reliability of newly developed interactive multimedia (IMM) versions compared to validated paper-administered (PP) versions of the BEVQ-15 [18] and L-Cat [19]. Individuals with lower educational attainment and/or health literacy levels may be at increased risk for health complications associated with poor dietary and health behaviors such as obesity, diabetes, hypertension, and coronary heart disease [33]. Therefore, a secondary purpose of this investigation was to evaluate the validity and reliability of the major BEVQ-15 categories, for example, total water, sugar-sweetened beverage (SSB), and total beverage grams and kcal, and L-Cat category across two education levels, in order to determine the suitability of the IMM versions for individuals from varying educational backgrounds.

Methods

Recruitment

Adults 21 years or older (n=60) were recruited from several community settings (a local university community, free medical clinic, area Community Services building, and church congregation) between January and August 2012 in southwest Virginia. The Virginia Tech Institutional Review Board approved the study protocol and participants provided written informed consent prior to enrollment.

Protocol

Participation entailed three laboratory sessions with three to seven days between each session. Sessions were completed in one of two randomly assigned visit sequences that differed in questionnaire administration format (ie, taking the paper or computerized instruments initially). Randomization was done to avoid a potential effect of session order on study outcomes. In addition to providing demographic information, each participant completed a total of two identical self-administered IMM BEVQ-15 [18] and L-Cat [19] questionnaires (denoted IMM-1 for the first administration and IMM-2 for the second administration), one PP BEVQ-15 and L-Cat (ie, one set being BEVQ-15 and L-Cat at each of the three lab sessions), the Newest Vital Sign tool to assess health literacy [34], and an open-ended feedback survey on the IMM questionnaire to address usability; a total of five questionnaires were completed by each participant. Responses from the feedback survey were either "yes" or "no", or rated on an ordered-response scale

(1=easy, 5=hard) with open-ended areas for comments following each question. Investigators supervised the assessments and provided limited instructions, but were available to answer questions during the survey if needed. Participants were compensated in the form of a $25 gift card upon completion of all three study visits.

Measurements

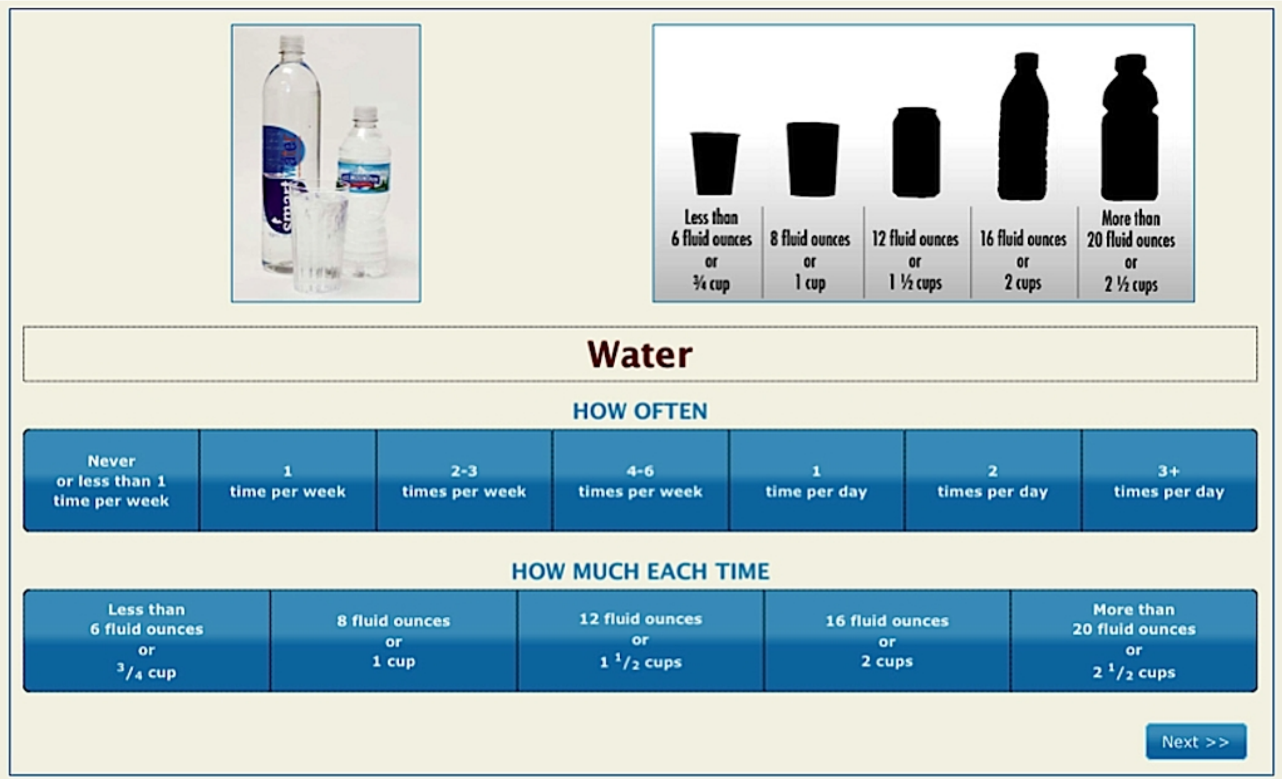
Participants provided information on demographic characteristics (ie, age, race/ethnicity, income level, and highest education level attained), and this was used to categorize participants into one of two education categories: (1) less than high school/high school, and (2) some college/college degree. Prior research suggests that the level of education reached can be a strong socioeconomic determinant of beverage intake [33,35]. Descriptive measurements were conducted by a graduate research assistant who is a registered dietitian (SKR) and a trained research assistant (ACP) and included the following-height measured in meters without shoes using a wall mounted stadiometer (Seca 216, Hamburg, Germany); body weight measured in light clothing without shoes to the nearest 0.2 kg using a digital scale (Scale-Tronix, Wheaton, IL); and body mass index (BMI), calculated as kg/m^2. The Newest Vital Sign (NVS) is a valid and sensitive tool that was used to assess health literacy and includes six questions based upon information contained in a nutrition facts label for a pint of ice cream. The scores range from 0-6 (0=limited health literacy, 6=adequate health literacy) [34].

The BEVQ-15 and L-Cat

The BEVQ-15 [18] is a brief, valid, and reliable quantitative food frequency questionnaire providing an estimate of habitual beverage intake across 15 beverage categories, which evaluates total beverage and SSB intake (ie, grams and kcal) over the past 30 days. Details regarding the development and evaluation of the BEVQ-15 have been previously published [18,36]. The PP BEVQ took 2 minutes-15 seconds to complete during its initial testing [18]. Self-reported physical activity was assessed using the brief L-Cat [19]. This tool was developed from the Stanford Brief Activity Survey [37-39] and consists of six descriptive categories (eg, 3="About three times a week, I did moderate activities such as brisk walking, swimming, or riding a bike for about 15-20 minutes each time. Or about once a week, I did moderately difficult chores such as raking or mowing the lawn for about 45-60 minutes. Or about once a week, I played sports such as softball, basketball, or soccer for about 45-60 minutes.") ranging from inactive (1=I did not do much physical activity) to very active (6=Almost daily, that is five or more times a week, I did vigorous activities). In a randomized trial involving 267 obese women, the L-Cat was found to be valid and reliable [19]. The paper versions of these tools were read and completed by the study participants independently with an investigator available for questions throughout the administration.

Using the validated PP versions of these two tools, computerized versions were developed. The IMM BEVQ-15 began with narrated text and graphic on-screen directions taking approximately three to four minutes. For each drink category, which replicated the paper-based BEVQ-15 in content and sequence, a photo of the beverage was presented on-screen (Figure 1 shows an example of the water intake category). Silhouettes of portion sizes with the quantities they represented in fluid ounces and cups were presented for each beverage category. For example, a soft drink can silhouette was pictured with other beverage containers with the text stating, "a typical beverage can represents 12 fluid ounces or 1 ½ cups." Once the IMM BEVQ-15 was completed, the participant was directed to an instructional page with narrated text (approximately 25 seconds) describing the L-Cat. As with the IMM BEVQ-15, the IMM L-Cat provided audio for each category wherever the mouse's cursor was placed. When the participant chose the physical activity/leisure time activity statement that best reflected their usual physical activity level another completion page was displayed which informed the participant that they were through with the computerized assessment. Completion time was covertly monitored for the IMM BEVQ and L-Cat. After finishing the first IMM administration, participants were invited to complete a user feedback survey that contained seven questions with ordered-response (eg, 1=easy and 5= hard), "Yes" or "No," and open-end response formats.

Figure 1. Screenshot example of the water beverage category from the interactive multimedia Beverage Intake Questionnaire-15.



Statistical Analysis

Statistical analyses were performed using SPSS statistical analysis software (version 20.0 for Macintosh, 2011, IBM Corporation, Chicago, IL). Demographic characteristics and mean daily beverage consumption (grams, kcal) for the two IMM and one PP BEVQ are reported as mean and standard error of the mean (SEM) or as frequencies (categorical variables). Paired sample *t* tests and bivariate correlations (Pearson's *r*) were used to assess validity (first IMM administration vs PP) and reliability (first vs second IMM administration, or IMM-1 vs IMM-2). Due to multiple *t* tests being conducted, data were reanalyzed to evaluate major outcomes using repeated measures analysis of variance with covariates where appropriate (eg, education), and results were consistent across analytical approaches. Chi square analyses and independent sample *t* tests were used to assess differences between education groups on categorical variables (eg, gender, race/ethnicity) and continuous variables (eg, BMI, beverage consumption), respectively. The alpha level was set *a priori* at $P \leq .05$. Responses from the open-ended ease of use questions on the IMM feedback survey were grouped into themes and quantified. *Major themes* were considered similar responses from ≥50% of participants (≥30 of 60 participants), while *minor themes* were considered similar responses from 25%-49% of participants (15 to 29, of 60 participants) [40]. A second investigator independently verified themes.

Results

Demographic Characteristics

Demographic characteristics of the study sample are presented in Table 1. Participants were predominantly white (88%, 53/60 participants), but balanced with respect to gender (55% female, 33/60 participants). Age ranged 21 to 70 years, with a mean age of 37 (SEM 2) years. There were no significant differences between education categories for age (P=.38), gender (P=.17), or race/ethnicity (P=.33); however, there were differences in BMI (P=.01), income (P<.001), and health literacy (P<.001) with those in the lower educational category having a higher BMI, and lower income level and health literacy score compared to those in the higher educational category. Differences were found by testing sequence, which was attributed to an unintentional greater random allocation of more participants in the "less than high school/high school" education group being assigned to one of the two sequences.

Completion times for the PP, IMM-1 BEVQ-15 and L-Cat, and IMM-2 BEVQ-15 and L-Cat were approximately three, five, and four minutes, respectively. The paper-based questionnaire time to completion was significantly shorter than both IMM-1 and IMM-2 (both P<.001). Time to completion on IMM-2 versus IMM-1 was also significantly different (P<.001) with the IMM-1 administration taking longer. There were no differences between education categories for time to completion between the PP (P=.69) and the computer-administered versions (IMM-1: P=.44; IMM-2: P=.73).

Table 1. Participant demographic characteristics.[a]

	Less Than High School/High School n=21	Some College/College Degree n=39	Full Sample N=60
Gender, n (%)			
Male	12 (57)	15 (39)	27 (45)
Female	9 (43)	24 (62)	33 (55)
Age, years	39 (SEM 3)	36 (SEM 2)	37 (SEM 2)
Race/Ethnicity, n (%)			
White	19 (91)	34 (87)	53 (88)
Black/African-American	2 (10)	1 (3)	3 (5)
Asian	0	3 (8)	3 (5)
Other	0	1 (3)	1 (2)
BMI, kg/m^2[b], mean (SEM)	31.8 (2.7)	26.3 (0.7)	28.2 (1.1)
BMI Category (kg/m^2), n (%)			
Underweight (<18.5)	1 (5)	1 (3)	2 (3)
Normal (18.5-24.9)	6 (29)	15 (39)	21 (35)
Overweight (25-29.9)	4 (19)	14 (36)	18 (30)
Obese (≥30)	10 (48)	9 (23)	19 (32)
Newest Vital Sign (Score[c])[d]	4.1	5.8	5.2
Total Annual Household Income, n (%)[d]			
≤$25,000 [e]	19 (90)	8 (21)	27 (45)
$25,000-50,000	1 (5)	9 (23)	10 (17)
≥$50,000	1 (5)	22 (56)	23 (38)

[a]Frequency variables are expressed as n (%), other variables are expressed as mean (SEM).

[b]Significant difference between education groups (*P*=.01).

[c]Scored from 0-6, with 0-1 (high likelihood of limited health literacy), 2-3 (potential limited health literacy), and 4-6 (adequate health literacy) representing the number of correct responses.

[d]Significant difference between education groups (*P*<.001).

[e]Representative of a family of four at or below the current federal income guidelines [41].

Comparative Validity of the IMM BEVQ-15 and L-Cat

Results from the comparative validity (ie, comparison of the responses from the IMM BEVQ-15 with the validated PP BEVQ-15) assessment of IMM and PP tools for beverage categories are presented in Table 2. Responses from all beverage categories from the IMM-1 and PP versions were correlated (*r*=.34-.98, all *P*<.001), and SSB and total beverage gram and kcal responses were correlated on IMM-1 and PP versions (*r*=.92-.95, all *P*<.001). Between IMM-1 and the PP version, no significant differences in beverage category responses were noted. The mean scores for the PP and IMM-1 L-Cat were 3.5 (SEM 0.2) and 2.4 (SEM 0.2), respectively. The paper-based and IMM-1 L-Cat responses were correlated (*r*=.85, *P*<.001), but mean values were different (*P*<.001).

Table 2. Comparative validity of the IMM BEVQ-15: a comparison of the individual beverage category responses from the first IMM administration to the PP BEVQ-15.

Beverage category	Validity IMM-1	Paper	Difference with IMM-1[a]	
	Mean (SEM)	Mean (SEM)	Mean (SEM)	Correlation (*r*)
Water (g)	804 (87)	725 (66)	-79 (45)	.866[b]
100% Fruit juice				
g	101 (23)	87 (17)	-14 (14)	.827[b]
kcal	58 (13)	50 (9)	-8 (8)	.827[b]
Juice drinks				
g	137 (47)	92 (13)	-45 (28)	.817[b]
kcal	64 (22)	43 (15)	-21 (13)	.817[b]
Whole milk				
g	75 (30)	75 (35)	0 (8)	.981[b]
kcal	56 (23)	56 (26)	0 (6)	.981[b]
Reduced-fat milk				
g	52 (16)	84 (36)	32 (34)	.339[c]
kcal	32 (10)	51 (22)	19 (21)	.339[c]
Fat-free milk				
g	68 (19)	83 (19)	15 (11)	.829[b]
kcal	26 (7)	31 (7)	6 (4)	.829[b]
Regular soft drinks				
g	324 (73)	361 (75)	38 (23)	.951[b]
kcal	143 (32)	160 (33)	17 (10)	.951[b]
Diet soft drinks				
g	263 (65)	255 (57)	-8 (37)	.828[b]
kcal	3 (1)	3 (1)	-1 (0)	.828[b]
Sweet tea				
g	211 (54)	186 (52)	-25 (26)	.879[b]
kcal	68 (17)	60 (17)	-8 (8)	.879[b]
Sweetened coffee				
g	298 (59)	277 (57)	-21 (34)	.823[b]
kcal	83 (16)	77 (16)	-6 (9)	.831[b]
Regular coffee/tea				
g	168 (48)	246 (60)	78 (39)	.762[b]
kcal	2 (1)	3 (1)	1 (1)	.758[b]
Beer				
g	101 (32)	98 (32)	-3 (6)	.983[b]
kcal	35 (11)	34 (11)	-1 (2)	.983[b]

Beverage category		Validity IMM-1	Paper	Difference with IMM-1[a]	
		Mean (SEM)	Mean (SEM)	Mean (SEM)	Correlation (*r*)
Liquor					
	g	17 (8)	19 (10)	3 (4)	.936[b]
	kcal	39 (19)	45 (23)	6 (9)	.936[b]
Wine					
	g	23 (6)	18 (6)	-5 (4)	.745[b]
	kcal	16 (4)	13 (4)	-3 (3)	.745[b]
Energy drinks					
	g	120 (47)	73 (35)	-47 (30)	.780[b]
	kcal	54 (21)	33 (16)	-21 (13)	.780[b]
Sugar-sweetened beverage					
	g	1107 (212)	989 (182)	-177 (72)	.944[b]
	kcal	417 (82)	373 (70)	-44 (28)	.945[b]
Total beverage					
	g	2792 (261)	2678 (263)	-115 (106)	.918[b]
	kcal	682 (116)	657 (122)	-25 (42)	.938[b]

[a]Mean difference according to paired sample *t* test; slight difference may be noted from the preceding columns due to rounding, as whole numbers are presented in the table.

[b]$P<.001$

[c]$P=.01$

Test-Retest Reliability of the IMM BEVQ-15 and L-Cat

All beverage category responses on IMM-1 and IMM-2 administrations were correlated (Table 3; r=.61-.94, all P<.001). SSB and total beverage gram and kcal responses were correlated on both IMM versions (r=.73-.96, all P<.001). No significant differences in beverage category responses were noted between IMM-1 and IMM-2 with the exception of SSB grams and kcal (P=.02 and P=.01, respectively) and total beverage kcal (P=.01). However, when comparing the responses from the paper and IMM-2 questionnaire administrations on these categories there were no significant differences (mean differences: SSB 63 grams, SEM 87; P=.52; SSB 21 kcal, SEM 33; P=.48; and total beverage 65 kcal, SEM 49; P=.19). The mean L-Cat score on IMM-2 was 2.5 (SEM 0.2), and the IMM L-Cat responses were correlated (r=.86, P<.001). No significant differences were observed between L-Cat responses on the IMM-1 and IMM-2 questionnaires (P=.72); however, differences were noted in IMM-2 and PP L-Cat responses (P<.001).

Table 3. Reproducibility of the IMM BEVQ-15: Comparison of the first and second IMM administrations.

Beverage Category		Reliability IMM-1 Mean (SEM)	IMM-2 Mean (SEM)	Difference with IMM-1[a] Mean (SEM)	Correlation (*r*)
Water (g)		804 (87)	756 (76)	-47 (62)	.721[b]
100% Fruit juice					
	g	101 (23)	76 (17)	-24 (18)	.666[b]
	kcal	58 (13)	44 (10)	-13 (10)	.665[b]
Juice drinks					
	g	137 (47)	134 (48)	-3 (23)	.888[b]
	kcal	64 (22)	63 (22)	-1 (10)	.888[b]
Whole milk					
	g	75 (30)	54 (26)	-20 (13)	.898[b]
	kcal	56 (23)	41 (20)	-15 (10)	.898[b]
Reduced-fat milk					
	g	52 (16)	33 (10)	-19 (10)	.807[b]
	kcal	32 (10)	20 (6)	-12 (6)	.807[b]
Fat-free milk					
	g	68 (19)	74 (18)	6 (11)	.811[b]
	kcal	26 (7)	28 (7)	2 (4)	.811[b]
Regular soft drinks					
	g	324 (73)	289(69)	-35 (35)	.881[b]
	kcal	143 (32)	128 (31)	-15 (15)	.881[b]
Diet soft drinks					
	g	263 (65)	246 (63)	-16 (42)	.784[b]
	kcal	3 (1)	3 (1)	0 (0)	.784[b]
Sweet tea					
	g	211 (54)	172 (53)	-39 (31)	.834[b]
	kcal	68 (17)	55 (17)	-12 (10)	.834[b]
Sweetened coffee					
	g	298 (59)	254 (52)	-44 (45)	.676[b]
	kcal	83 (16)	71 (14)	-13 (12)	.689[b]
Regular coffee/tea					
	g	168 (48)	199 (51)	31 (44)	.616[b]
	kcal	2 (1)	2 (1)	0 (1)	.610[b]
Beer					
	g	101 (32)	121 (42)	19 (24)	.830[b]
	kcal	35 (11)	42 (15)	7 (8)	.830[b]

Beverage Category		Reliability IMM-1 Mean (SEM)	IMM-2 Mean (SEM)	Difference with IMM-1[a] Mean (SEM)	Correlation (*r*)
Liquor					
	g	17 (8)	19 (8)	3 (3)	.944[b]
	kcal	39 (19)	45 (19)	6 (6)	.944[b]
Wine					
	g	23 (6)	24 (6)	1 (4)	.827[b]
	kcal	16 (4)	17 (4)	1 (3)	.827[b]
Energy drinks					
	g	120 (47)	78 (34)	-42 (30)	.771[b]
	kcal	54 (21)	35 (14)	-19 (14)	.771[b]
Sugar-sweetened beverage					
	g	1107 (212)	927(189)	-180 (71[c])	.944[b]
	kcal	417 (82)	351 (75)	-65 (26[d])	.948[b]
Total beverage					
	g	2792 (261)	2755 (296)	-38 (207)	.731[b]
	kcal	682 (116)	592 (107)	-91 (34 [d])	.955[b]

[a]Mean difference according to paired sample *t* test; slight difference may be noted from the preceding columns due to rounding, as whole numbers are presented in the table.

[b]Significant correlations ($P<.001$)

[c]Significant difference between IMM-2 and IMM-1 ($P=.02$).

[d]Significant difference between IMM-2 and IMM-1 ($P=.01$).

Comparative Validity and Reliability Within Educational Categories

Figures 2-4 show the results of the major beverage outcomes (water, SSB, total beverage intake) and L-Cat according to educational level. The IMM version of the beverage questionnaire demonstrated comparative validity across the major beverage outcomes with the exception of water intake in the "some college/college degree" participants (mean difference between PP and IMM-1 119, SEM 59; $P=.048$) with correlation coefficients ranging from .76-.95 (all $P<.001$). However, responses to the L-Cat were significantly higher with the PP version in both educational groups (mean differences between PP and IMM-1 in less than high school/high school 0.9, SEM 0.2; and in some college/college degree 1.1, SEM 0.1; both $P<.001$).

No differences were noted in repeated IMM responses for beverage intake or physical activity. Differences were noted in the repeated IMM responses from the "less than high school/high school" participants for SSB grams and kcal (both $P=.02$) and total beverage energy ($P=.03$), with lower intake reported on the second administration. However, pair samples *t* tests results revealed no significant differences between the PP and IMM-2 tools (mean differences–SSB 99 grams, SEM 245; $P=.69$; SSB 24 kcal, SEM 92; $P=.79$; total beverage 152 kcal, SEM 134; $P=.27$). There were no significant differences on L-Cat responses in the "less than high school/high school" participants ($P=.67$).

Figure 2. Beverage intake in grams for education categories. The following abbreviations mean: Low Ed=Less than high school/high school; High Ed=Some college/college degree; SSB=Sugar-sweetened beverages; IMM=Interactive Multi-media, 2 separate administrations; and PP=Paper and Pencil version. The "Water" "Low Ed" solid black and solid grey bars and the "Total Beverage" "Low Ed" grey-striped bar show a significant difference from "High Ed" group (*P*=.02). The "SSB" "Low Ed" solid black, solid grey, and grey-striped bars and "Total Beverage" "Low Ed" solid black and solid grey bars show a significant difference from "High Ed" group (*P*<.001).

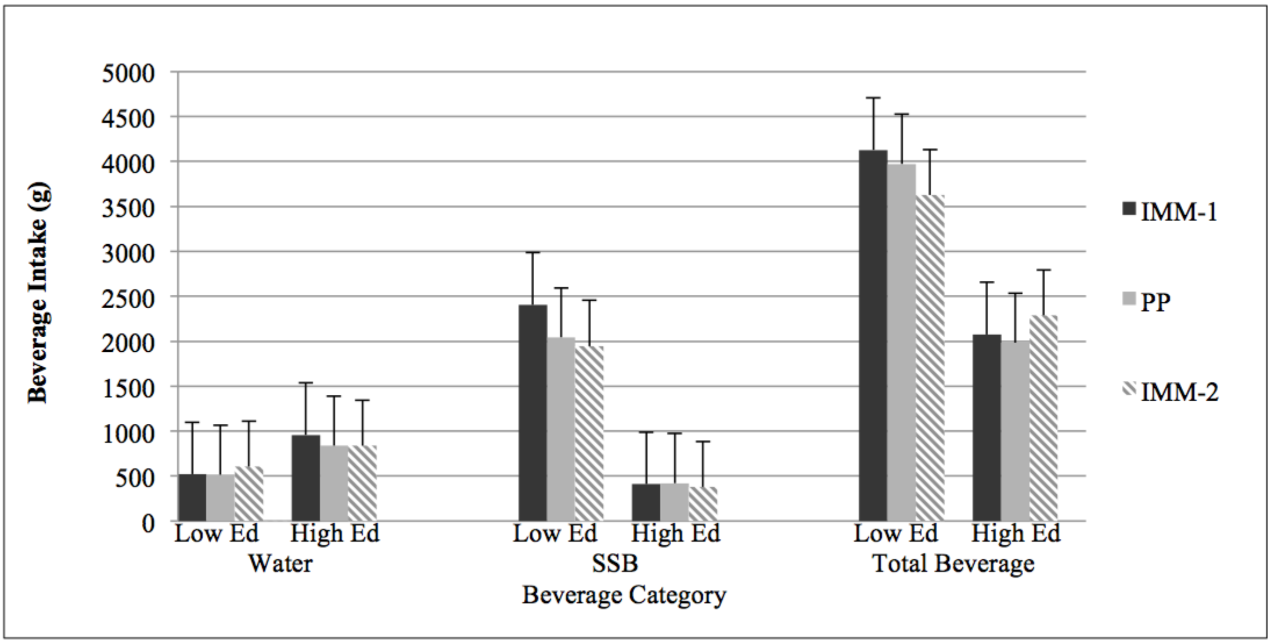
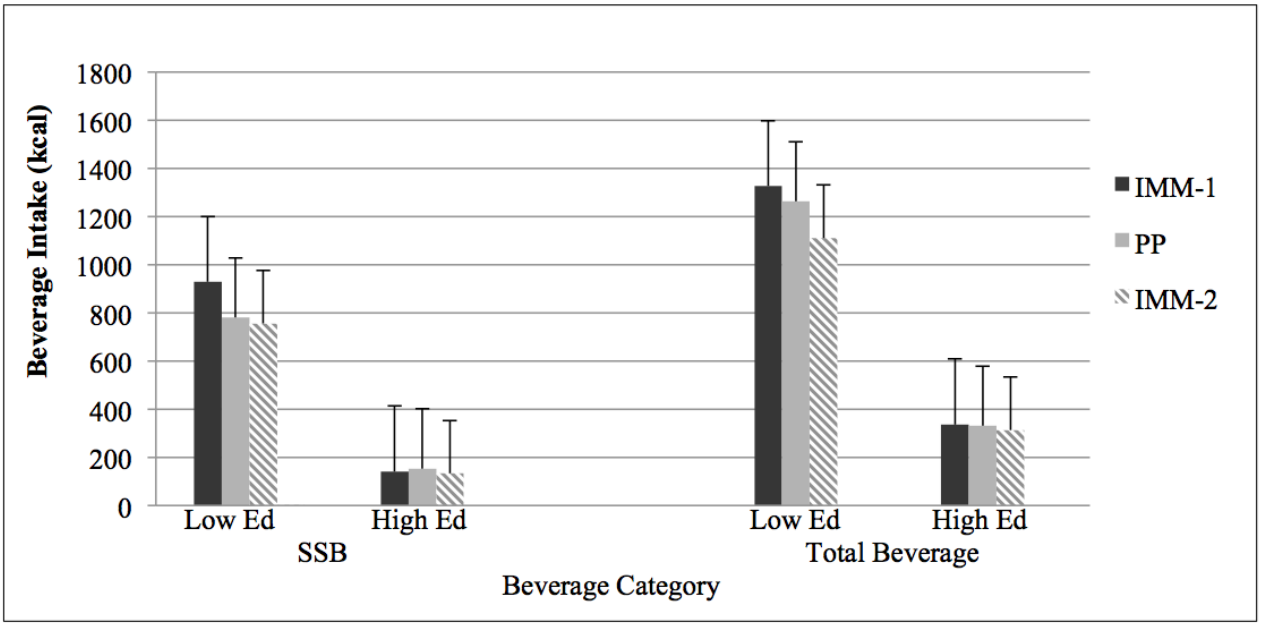


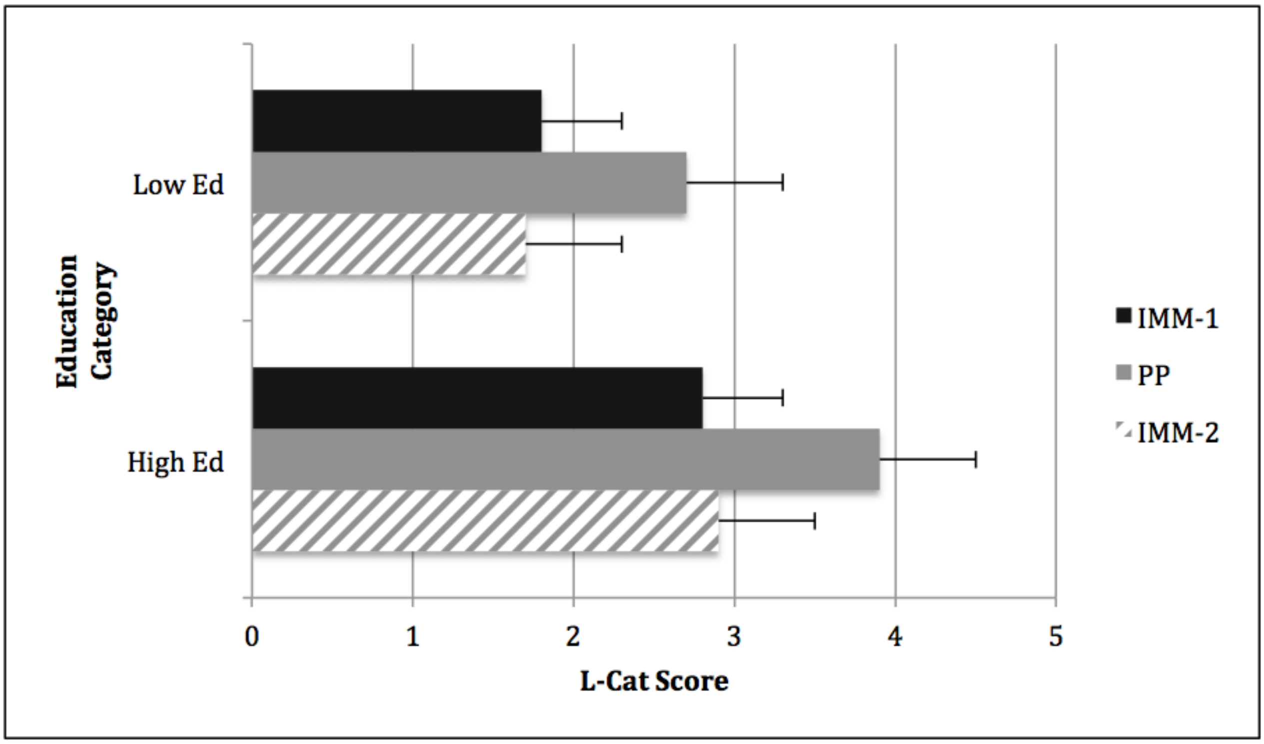
Figure 3. Beverage intake in calories (kcal) for education categories. The following abbreviations mean: Low Ed=Less than high school/high school, High Ed=Some college/college degree; SSB=Sugar-sweetened beverages; IMM=Interactive Multi-media, two separate administrations; and PP=Paper and Pencil version. The six "Low Ed" solid black, solid grey, and grey-striped bars show a significant difference from "High Ed" group (*P*<.001).



Comparison of Lower and Higher Educational Groups

Differences in water consumption between education categories on the first IMM and PP questionnaire administrations were significant (both *P*=.02), but not on the second IMM (*P*=.14), with the "less than high school/high school" participants reporting significantly lower water consumption than the "some college/college degree" participants (Figure 2). Daily SSB (grams and kcal) and total beverage consumption (grams and kcal) were different between education categories at each questionnaire administration (IMM-1, IMM-2, PP) (Figures 2 and 3). Differences between education categories were noted at each L-Cat administration (IMM-1: *P*=.008; IMM-2: *P*=.001; PP: *P*=.002) (Figure 4).

Figure 4. Comparison of education group responses on the Stanford Leisure-Time Activity Categorical Item (L-Cat). The following abbreviations mean: Low Ed=Less than high school/high school; High Ed=Some college/college degree; IMM=Interactive Multi-media, two separate administrations; and PP=Paper and Pencil version. The "Low Ed" top black solid bar shows the significant difference from the "High Ed" group (*P*=.008). The "Low Ed" center grey solid bar shows the significant difference from the "High Ed" group (*P*=.002). The "Low Ed" bottom grey-striped bar shows the significant difference from the "High Ed" group (*P*=.001). The "Low Ed" and "High Ed" center solid grey bars show the significant difference from "IMM-1" and "IMM-2" (both *P*<.001).



User Feedback

Of the 60 participants, 59 completed the feedback survey. *Major themes* were as follows. Most believed that the IMM BEVQ-15 was "easy"(mean ordered-response rating 1.2, SEM 0.1; n=54), that it was "clear" or "straightforward"(mean 1.4, SEM 0.1; n=30), and that it covered beverages consistent with their usual intake habits (mean 1.1, SEM 0.0; n=56). Most also reported that the computerized L-Cat was "easy" (mean 1.2, SEM 0.1; n=49), and that they were able to identify a physical activity statement relating to their lifestyle with the L-Cat (mean 1.1, SEM 0.1; n=49). *Minor themes* were that the graphics, images, and voiceover made completing the questionnaires "easy" (mean 1.4, SEM 0.1; n=15), and that nothing needed to be changed in the IMM BEVQ-15 (mean 1.0, SEM 0.1; n=22). Many participants reported that the IMM L-Cat assessment was "clear" or "straightforward" (mean 1.6, SEM 0.1; n=23), and recommended changing nothing about the IMM L-Cat (mean 1.0, SEM 0.1; n=23). Eighteen participants of 60 (30%) suggested that the speed of the narrated text be increased on both the IMM BEVQ-15 and L-Cat. Only two participants (one in each education category) reported the computerized BEVQ-15 as being "hard."

Discussion

Comparative Validity and Test-Reliability of the IMM BEVQ-15 and L-Cat

With the exception of reduced-fat milk, all correlations were greater than .74 (Table 2) and this can be considered superior to other validation studies where typical *r* values range from .4 to .7 [3], and consistent with initial BEVQ testing [36]. The lower correlation coefficient for reduced-fat milk may be due to participants not being familiar with the form of milk they consume. Some participants may not be the primary food shoppers in their home and not read product packaging prior to consumption; they may not know if the milk they choose to consume is skim, 1%, 2%, or whole milk, and thus choose an option arbitrarily on the questionnaire. The differences between PP and IMM-1 for total beverage intake were 25 kcal, and between PP and IMM-2, while higher at approximately 90 kcal, were not statistically significant. However, we recognize that a 90 kcal difference can be clinically significant at the individual level. Compared to the original BEVQ validation studies, the present differences are higher than what was observed for SSB and total beverage kcal intake. The lower mean age, smaller sample size, and the beverage intake patterns of the "less than high school/high school" education group may have contributed to differences across studies. Future investigations including a larger sample size could provide greater insight into this possibility.

While no significant differences in beverage category responses were noted between IMM-1 and the PP version, mean values were different on the PP and both IMM physical activity items (both $P<.001$). Computer-based tools can be perceived as more private and less intimidating [7]. If this were so in the present study, the IMM L-Cat responses may be more reflective of actual physical activity levels. Participants may have felt more comfortable reporting a less socially desirable level of physical activity on the computerized assessment versus on the paper-based tool since, when taking the paper version, responses were immediately observable to study personnel, while computerized responses would be accessed following the participant's departure. Overall, the findings of this pilot investigation indicate that the IMM BEVQ-15 is a valid measure of beverage intake when compared to the PP version. Further research is warranted to assess the comparative validity of the IMM L-Cat.

Differences were observed between SSB grams and kcal and total beverage intake (P=.02 and P=.01, respectively) and total beverage kcal (P=.01) between IMM-1 and IMM-2; however, no differences were apparent when comparing these responses on the paper and IMM-2 responses. Thus, the lower responses for the reported usual intake on the second IMM administration were closer to that reported in the PP tool. This may be attributed to a familiarity effect as observed in other computerized assessments [42-44]. In a trial investigating how test mode may impact assessment outcomes, content familiarity and not computer familiarity, gender, or competitiveness positively influenced test performance [16].

Food frequency questionnaires are considered reliable with correlations ranging from .5 to .7 [3,45,46], and many of the coefficients observed for reliability testing of the IMM questionnaires are within or exceed this rage. Thus, the IMM BEVQ-15 and L-Cat can be considered reliable measures of habitual beverage intake and physical activity patterns.

Comparative Validity and Reliability Within Educational Categories

With the exception of water intake in the "some college/college degree" group, the IMM version of the BEVQ-15 demonstrated comparative validity across the major beverage categories. As depicted in Figure 4, both educational groups responded significantly higher on the paper version versus the computerized version of the L-Cat. Since the layout and appearance of computerized surveys can impact participant responses [16,17], differences between the IMM and PP modes of assessment may have occurred in the present investigation. Although lower intakes of SSB grams, kcal, and total beverage kcal were reported on IMM-2 compared to IMM-1 from the "less than high school/high school" participants, no differences were observed between the paper and IMM-2 tools. These results may be attributed to participants being more familiar with the IMM version at the second administration, as stated earlier. Participants potentially had a greater awareness of the upcoming beverage categories within the IMM tool, and thus were able to answer each question more accurately, better reflecting their usual consumption habits.

Comparison of Lower and Higher Educational Groups

In the present investigation, the "less than high school/high school" participants reported significantly lower water consumption than the "some college/college degree" participants (Figure 2). Similarly, the National Health and Nutrition Examination Surveys from 1999-2006 revealed that adults with higher education attainment had a higher plain water intake [47]. In addition, daily grams and kcal were different between educational categories at each questionnaire administration (Figures 2 and 3). Consistent with prior research addressing the influence of educational level and health literacy on beverage consumption patterns [48-50], participants in the lower educational category consumed significantly more total beverage and SSB (grams, kcal). This is noteworthy since excessive SSB consumption has been related to the development of some chronic diseases [51-54]. Similar to the discrepancies observed between physical activity engagement and education attainment in a recent report from the American Heart Association Statistic Committee and Stroke Statistics Subcommittee [55], the "less than high school/high school" category reported lower physical activity engagement than those with "some college/college degree" (Figure 4). However, neither group reported a level of physical activity that met current guidelines [56], exemplifying the need for continued efforts to promote the benefits of regular participation in physical activity.

Usability and User Feedback

Although no differences in completion time were observed between educational categories, the IMM-1 administration took significantly more time to complete versus IMM-2. This is possibly due to unfamiliarity with page-to-page navigation and questionnaire content at the first IMM administration [16].

Participants found the IMM questionnaires easy to use, and that they "fit" their usual beverage intake and leisure-time activity habits. Our results are comparable to others who have reported positive feedback with IMM delivery of nutrition education and dietary and physical activity assessments [7,8,12,14], suggesting acceptability and promise for the use of computer-administered surveys in future research. One area for potential improvement in the IMM tools is the speed of narrated text. Analogous to prior research [7], approximately one-third (n=18) of participants suggested that the speed of the voiceover be increased. The present study received positive feedback overall; however, improvements can be made with the IMM itself (eg, touch screens) [7], which may further increase ease of use and administration.

Limitations

Strengths of this pilot investigation include the random assignment of participants to study session sequences, the novel method to assess dietary intake and physical activity engagement, and the inclusion of participants with lower and higher educational attainment levels. However, several limitations are recognized. The short duration between participant sessions could have caused acclimatization to the questionnaires or participants to be more aware of their beverage intake patterns, thus biasing their responses. Subsequent trials should consider both familiarity with computers and questionnaire content [16,57,58] during participant screening and longer intervals between study sessions. Second, we used validated paper versions of the BEVQ-15 and L-Cat as our comparative criterion; however, self-reported diet and physical activity assessments may not reflect an individual's true intake [1,3,59] or physical activity engagement [60]. In addition, some consider paper versions of computerized surveys to be anything but a "gold standard" when assessing computerized versions of similar assessments [6]. Future studies should not only use validated paper forms of computerized questionnaires, but multiple modes of dietary and physical activity assessment (eg, 24 hour recalls and doubly labeled water) for the greatest degree of accuracy. Although different circumstances may impact beverage intake from day to day (eg, illness, activity level, social events), we do not believe this influenced our overall findings, since the BEVQ-15 has been found valid in estimating group habitual beverage intake [18]. Another potential limitation of the present investigation is the limited racial representation and small sample size. Subsequent larger-scale investigations should include a more diverse sample in terms of race/ethnicity and educational attainment.

Conclusions

There is a need for reliable and valid dietary and physical activity assessment tools that are brief and easily administered [61]. As many as 20% of American adults read at a fifth-grade level or less [62,63], and health literacy is thought to better predict a person's health than ethnicity, employment status, age, income, and education level [64]. Using computer-based assessments can overcome some common barriers preventing the collection of complete dietary data [13], particularly in populations with lower educational achievement [8]. Interactive multimedia versions of dietary and physical activity questionnaires have the potential to decrease participant and study personnel burden, allowing for high quality data to be collected and analyzed [6-8,10,13,14]. Further, computerized assessments could be advantageous for large epidemiological studies [6] as they may reduce costs [8] by streamlining data collection and analysis [4,6-8,13,14]. Overall, the results of the present investigation show that the IMM BEVQ-15 may be used to evaluate habitual beverage intake; although, familiarizing participants with the software prior to data collection may assist in obtaining more accurate data. Respondents may have answered differently on the IMM L-Cat due to computerized tools being considered more confidential and less intimidating [7]. Further research is necessary to fully evaluate the validity of the IMM L-Cat due to its consistency between IMM measures, but differences from the PP version. Future investigations are warranted to include more participants from racially diverse and hard-to-reach audiences (ie, low educational and health literacy levels), develop assessment tools that may be administered to both younger and older individuals (eg, children, adolescents, seniors), and utilize contemporary technological features to further reduce participant burden.

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Conflicts of Interest

None declared.

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Abbreviations

BEVQ: beverage intake questionnaire
BEVQ-15: beverage intake questionnaire
BMI: body mass index
IMM: interactive multimedia
L-Cat: Stanford Leisure-Time Activity Categorical Item
NVS: Newest Vital Sign
PP: paper-administered
SSB: sugar-sweetened beverage

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