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MULTIMEDIA-BASED ADDED-SUGAR AWARENESS EDUCATION FOR KINDERGARTEN CHILDREN: A QUASI-EXPERIMENTAL STUDY

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ABSTRACT
Background: Early nutrition education may support children's understanding of added-sugar-related health risks; however, evidence regarding developmentally appropriate multimedia interventions during kindergarten remains limited.
Objective: This study evaluated changes in added-sugar awareness associated with participation in a 16-week multimedia-based nutrition-awareness program among children aged 5–6 years and examined the association between baseline parental awareness and post-test child awareness. BMI categories were described as contextual weight-status indicators, and two children with autism spectrum disorder (ASD) were followed as descriptive embedded cases.
Methods: A quasi-experimental pre-test–post-test control-group design was implemented at one kindergarten center in Makkah, Saudi Arabia. The inferential sample comprised 110 typically developing children allocated to an experimental group ($n = 55$) or a control group ($n = 55$). Two additional children with ASD participated in the intervention and were analysed descriptively.Child awareness was assessed using a 10-item Pictorial Child Awareness Scale. Baseline parental awareness was assessed using a Parental Awareness Questionnaire, and age- and sex-adjusted BMI category was recorded descriptively.
Results: Experimental-group awareness scores increased from 6.07 ± 1.51 at pre-test to 17.53 ± 1.26 at post-test, $t(54) = 39.04$, $p < .001$. At post-test, the experimental group scored higher than the control group (17.53 ± 1.26 vs. 6.87 ± 1.32, respectively). Because post-test scores demonstrated a pronounced ceiling pattern, the very large observed effect estimates should be interpreted cautiously. Baseline parental awareness and post-test child awareness were moderately correlated ($r = .34$, 95% CI [.16, .50], $p < .001$). Parental awareness also differed significantly between groups at baseline; however, an ANCOVA adjusting for baseline child awareness and parental awareness showed that the adjusted group difference ($B = 10.82$, 95% CI [10.29, 11.36], $p < .001$) remained very similar to the unadjusted estimate, and neither covariate was significant. Forty-three children were classified as obese; no biochemical measures were collected, and BMI findings should not be interpreted as evidence of prediabetes or metabolic disease. The two ASD cases demonstrated individual improvement, but no population-level conclusions can be drawn.
Conclusions: Participation in the multimedia-based nutrition program was associated with substantial short-term improvement in study-specific added-sugar-awareness scores among kindergarten children. However, the single-center non-randomised design, pronounced post-test ceiling effect, study-specific outcome measure, absence of behavioral and biochemical outcomes, and descriptive nature of the two ASD cases limit causal and clinical interpretation. Multi-center studies using independently validated measures and longer-term behavioral outcomes are warranted.

KEYWORDS: added sugar; nutrition education; kindergarten; health awareness; multimedia intervention; parental awareness; early childhood; autism spectrum disorder

1. INTRODUCTION

Childhood dietary patterns are increasingly recognised as an important component of long-term metabolic health. Frequent consumption of foods and beverages high in added sugars can contribute to excessive energy intake, poorer overall dietary quality, and excess adiposity, all of which may increase vulnerability to insulin resistance and Type 2 diabetes in susceptible children. Early childhood is particularly relevant because dietary preferences, food-related attitudes, and health behaviours begin to develop during this period. Consequently, developmentally appropriate nutrition education during the kindergarten years may provide an opportunity to establish foundational awareness of healthier food choices before less healthy dietary patterns become firmly established (Chiavaroli et al., 2023; Collado-Soler et al., 2023).In this study, "added sugars" refers to sugars added to foods or beverages during processing, preparation, or consumption. This term is distinguished from the broader concept of "free sugars," which additionally encompasses sugars naturally present in honey, syrups, fruit juices, and fruit-juice concentrates. Accordingly, these terms are not treated as interchangeable in this manuscript. Unless otherwise specified, the intervention and primary child outcome concern awareness of dietary choices involving added sugars.

Childhood obesity represents an important public-health concern and is associated with multiple behavioral, environmental, and metabolic factors. Although Type 1 diabetes is primarily autoimmune and is not prevented through sugar reduction, excessive energy intake, frequent consumption of sugar-sweetened products, physical inactivity, and excess adiposity are relevant to the development of insulin resistance and Type 2 diabetes. Early nutrition education may therefore contribute to broader prevention efforts by improving children's and caregivers' understanding of healthy dietary choices; however, awareness education alone should not be regarded as sufficient to prevent diabetes, which is influenced by multiple genetic, metabolic, behavioral, and environmental factors (American Diabetes Association Professional Practice Committee, 2025).

The challenge is further compounded for children with autism spectrum disorder (ASD; American Psychiatric Association, 2013). Children with ASD frequently experience food selectivity and sensory-related eating preferences, including preferences for foods with predictable or consistent sensory properties. Such patterns may contribute to restricted dietary variety and, in some children, greater reliance on selected processed foods (Curtin et al., 2010, 2014; Rodrigues et al., 2023). However, risk varies considerably across individuals and should not be inferred from diagnosis alone. Family and health-system factors are a further consideration for this population: parents of autistic children report specific barriers and facilitators to accessing nutrition-related care that differ from those of interdisciplinary health professionals (Blaine et al., 2023), and existing regional guidance highlights the need for tailored nutritional support for children with ASD (King Salman Center for Disability Research, 2021). Their limited representation in early nutrition-awareness research constitutes an important evidence gap. In the present study, however, the ASD component is restricted to two descriptive cases and is not intended to establish effectiveness for the broader ASD population.

Despite growing evidence linking added sugar intake with childhood obesity and metabolic risk, few intervention studies have examined sugar-risk awareness during the kindergarten stage using developmentally appropriate visual and multimedia strategies. Moreover, children with autism spectrum disorder are often underrepresented in early nutrition-awareness programs, despite their elevated risk of food selectivity and restricted dietary patterns. Therefore, this study addresses two related areas in which evidence remains limited: developmentally appropriate added-sugar-awareness interventions for children aged 5–6 years and descriptive evidence concerning the participation of young children with ASD in visually mediated nutrition education.

This study developed, implemented, and evaluated a four-month, multimedia-based health awareness program at the ShathaAl-Baraem Center in Makkah. Its aims were: (1) to evaluate short-term changes in children's added-sugar awareness following a 16-week multimedia intervention; (2) to compare post-test awareness between the experimental and control groups; (3) to examine the association between baseline parental awareness and post-test child awareness; (4) to describe the sample's age- and sex-adjusted BMI distribution; and (5) to report exploratory descriptive observations for two children with ASD who participated in the intervention.

2. Research Problem and Questions

This study is structured around two central premises. The first concerns the extent of children's awareness of the harmful effects of added sugars, the correlation between parental and child awareness, and the distribution of BMI-based weight-status categories as a contextual health indicator. The second concerns the association of a structured multimedia health-awareness program with children's short-term added-sugar awareness and the potential value of early nutrition education as one component of broader health-promotion efforts.

The study addresses the following research questions:

- Do kindergarten children participating in a structured multimedia-based awareness program demonstrate greater improvement in added-sugar awareness than children receiving standard educational activities?
- Is baseline parental awareness significantly associated with children's post-test added-sugar awareness?
- What was the distribution of age- and sex-adjusted BMI categories in the study sample?
- How do children with ASD respond descriptively to visual and multimedia sugar-awareness strategies?

3. Research Objectives

- Evaluate changes in children's added-sugar awareness associated with participation in a 16-week multimedia-based program.
- Examine the association between baseline parental awareness and children's post-test added-sugar awareness.
- Describe the distribution of age- and sex-adjusted BMI categories in the study sample.
- Provide exploratory descriptive observations for two children with ASD exposed to the visual components of the program.

3.1 Study Hypotheses

- H1: Children in the experimental group will demonstrate higher post-test awareness scores than their own pre-test scores.
- H2: Children in the experimental group will demonstrate higher post-test awareness scores than children in the control group.

• H3: Baseline parental awareness will be positively associated with children's post-test added-sugar awareness.
• BMI category was treated as a descriptive secondary analysis; therefore, no inferential hypothesis concerning diabetes or metabolic risk was specified.

Because the sample of children with ASD (n = 2) was too small to support inferential statistical testing, no formal hypothesis was tested for this group. Instead, the study pursued an exploratory objective: to descriptively examine the awareness responses of two children with ASD to visual and multimedia health-education strategies.

4. Theoretical Framework

4.1 Cognitive Development and Health Awareness (Piaget)

Children aged 5–6 years are generally situated within Piaget's pre-operational stage, during which learning is strongly supported by concrete, perceptual, and symbolic representations. Accordingly, abstract health concepts may be more accessible when presented through developmentally appropriate visual and sensory associations. The visual and interactive design of the awareness program was therefore informed by this developmental perspective, emphasising imagery, stories, and concrete examples rather than relying primarily on abstract verbal instruction (Piaget, 1964).

4.2 Social Learning and Parental Modelling (Bandura)

Bandura's social learning theory emphasises that children can acquire attitudes and behavioral patterns through observing significant models, including parents and primary caregivers. In the nutritional domain, parental modelling and the home food environment may therefore contribute to children's developing food-related attitudes and behaviours. This theoretical perspective supports examining parental awareness as one potentially important correlate of child awareness and provides a rationale for including a parallel parental-engagement component within the intervention (Bandura, 1977).

4.3 Added Sugars, Energy Intake, and Metabolic Health

Added sugars contribute energy without providing the fibre present in whole fruits and many minimally processed foods. Frequent consumption of sugar-sweetened beverages and energy-dense foods may increase total energy intake and contribute to excess weight gain. Over time, excess adiposity can increase vulnerability to reduced insulin sensitivity and Type 2 diabetes. These pathways are multifactorial and are influenced by overall diet, physical activity, sleep, genetics, and environmental conditions; therefore, sugar intake should not be considered an isolated cause of diabetes.

4.4 Childhood Obesity as a Contextual Health-Risk Indicator

Childhood obesity is a multifactorial condition influenced by dietary intake, physical activity, sleep, family practices, socioeconomic circumstances, genetic susceptibility, and environmental exposures (World Health Organization, 2022). In the present study, BMI category was included as a descriptive contextual indicator rather than as a tested mediator of the intervention effect. BMI was not used to diagnose insulin resistance, pre-diabetes, or diabetes, and no causal pathway from awareness to obesity or diabetes was tested.

5. Review of Related Literature

5.1 Health Awareness Programs for Young Children

Abdelrahman et al. (2025) compared puppet-show, flashcard, and traditional lecture-based nutrition education programs among Egyptian children aged 6–12 years (N = 91) and found that all three interactive formats produced statistically significant pre-to-post improvements in nutritional knowledge and attitudes, with the puppet-show format achieving the largest gains. This is consistent with broader systematic-review evidence indicating that school- and kindergarten-based nutrition intervention programs have generally been associated with improvements in nutrition knowledge and healthy-eating behaviours and, in some studies, with improvements in BMI-related outcomes (Collado-Soler et al., 2023).

5.2 Parental Awareness and Child Dietary Behavior

Ghabashi et al. (2025) examined maternal and child nutritional knowledge among 60 mother–child pairs in Makkah, Saudi Arabia, finding that mothers' nutritional knowledge scores were significantly associated with their children's nutritional knowledge scores, although maternal knowledge was not associated with children's weight status. The authors concluded that nutrition knowledge alone may not be sufficient to address childhood overweight and obesity, and that family-directed awareness efforts are best paired with broader behavioral and lifestyle components. Parental engagement remains valuable nonetheless: this is broadly consistent with a recent systematic review and meta-analysis of randomised controlled trials, which found that parental involvement in childhood obesity prevention and management programs significantly improves children's BMI z-score and dietary self-efficacy, supporting the Bandura-derived hypotheses of the current study (Aleid et al., 2024). A recent systematic review similarly links parental food-related parenting practices to children's sugar-related dietary behavior (Hübner&Bartelmeß, 2024), while other work highlights external pressures on parental efforts, such as the persistence of unhealthy food and beverage marketing directly to children despite industry self-regulation pledges (Jensen et al., 2023).

5.3 The Obesity–Diabetes Relationship

Childhood obesity is associated with an increased likelihood of adverse metabolic outcomes later in childhood and adolescence. However, BMI alone does not identify pre-diabetes or insulin resistance, and current paediatric diabetes guidance recommends risk-based metabolic screening primarily in older children with elevated BMI and additional risk factors. Excess adiposity accumulated through sustained high-sugar diets is broadly associated with insulin resistance and hepatic fat accumulation, though the strength of this association varies by the specific food source of fructose-containing sugars and the degree of energy control in the diet (Chiavaroli et al., 2023). Sugar-sweetened beverages consumed in excess of energy needs are the food source most consistently linked to increased adiposity, while the broader metabolic pathways linking dietary fructose to insulin resistance and fatty liver disease remain an active area of investigation (Agarwal et al., 2024). Current paediatric guidelines recommend risk-based screening for pre-diabetes and type 2 diabetes beginning around the onset of puberty or age 10 in children with elevated BMI and additional risk factors, rather than universal screening during the kindergarten years (American Diabetes Association Professional Practice Committee, 2025).

6. METHODOLOGY

6.1 Research Design

A quasi-experimental pre-test–post-test control-group design was employed to examine changes in children's added-sugar awareness associated with participation in the multimedia intervention and to compare post-test outcomes between the experimental and control groups. The design also permitted examination of the association between baseline parental awareness and post-test child awareness.

6.2 Participants

Participants were recruited from children enrolled at the ShathaAl-Baraem Center in Makkah during the 2023 academic year. Eligibility was restricted to children aged 5–6 years whose parents or legal guardians provided written consent. The study included 110 typically developing children and two children with ASD. The typically developing children were assigned to an experimental group (n = 55) or a control group (n = 55) according to their existing classroom organisation. Participants were drawn from five existing kindergarten classrooms. Three classrooms were assigned to the experimental condition and two classrooms to the control condition. Among the 110 typically developing children included in the inferential sample, the three experimental classrooms contributed 18, 18, and 19 children, respectively, while the two control classrooms contributed 27 and 28 children, respectively. The two children with ASD participated additionally within the experimental condition and were excluded from inferential analyses. Classroom organisation was retained throughout the study, and children were not individually randomised between conditions. Accordingly, the study used a quasi-experimental, non-randomised allocation procedure. The two children with ASD participated in the experimental condition as embedded descriptive cases and were excluded from all inferential group comparisons.

- Experimental Group (n = 57): 55 typically developing children and 2 children with ASD, exposed to the structured 16-week awareness program.
- Control Group (n = 55): 55 typically developing children who continued their standard educational activities without programmatic intervention.

6.2a Eligibility Criteria

Inclusion criteria were: (1) age between 5 and 6 years; (2) enrolment at the participating center during the study period; (3) ability to engage with the pictorial assessment with developmentally appropriate support; and (4) written parental or guardian consent. Exclusion criteria were: (1) absence from a substantial proportion of intervention sessions; (2) missing pre-test or post-test data; or (3) a medical or developmental condition that prevented completion of the study procedures. The diagnostic status of the two children with ASD was documented from existing educational or clinical records; no diagnostic assessment was conducted as part of this study.

6.2b Participant Flow (CONSORT-Style Diagram)

Participant flow through the study, from eligibility screening to final analysis, is presented in Figure 1.

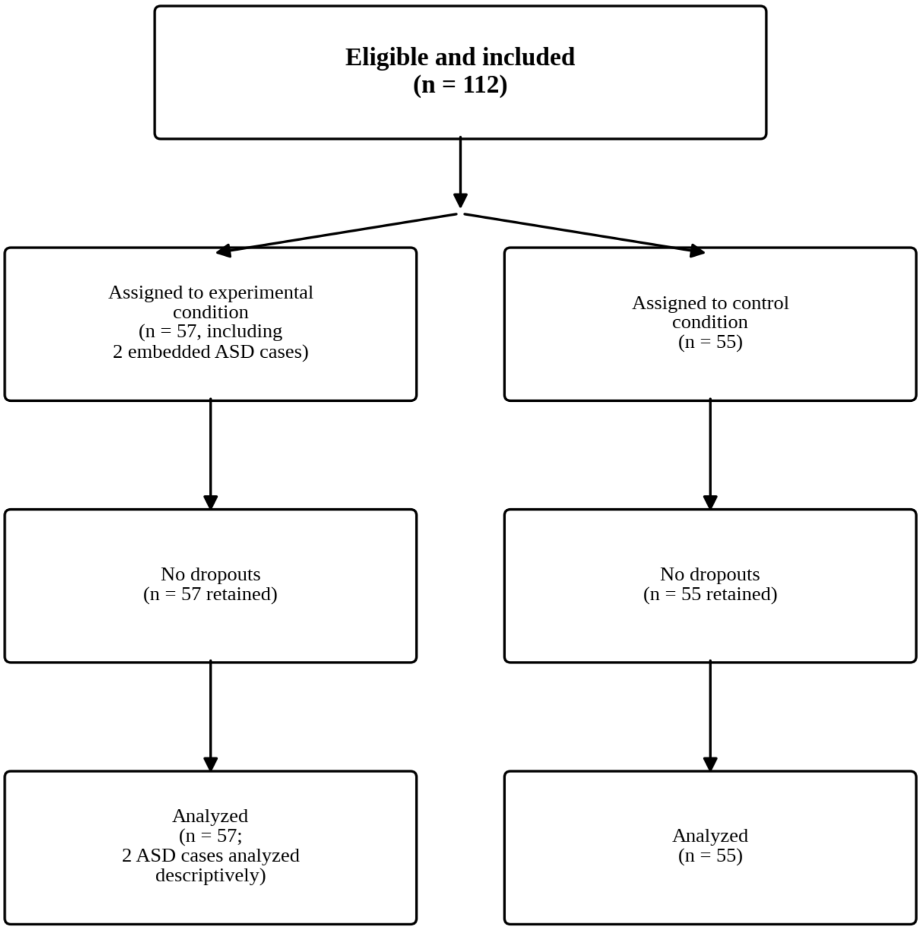

Figure 1. CONSORT-style participant flow diagram (N = 112 eligible and included; 57 assigned to experimental condition including 2 embedded ASD cases; 55 assigned to control condition; no dropouts; N = 112 analysed, with the 2 ASD cases analysed descriptively).

6.2c Sample Characteristics and Baseline Equivalence

Table 1 reports demographic and pre-test characteristics of the experimental and control groups (typically developing children, n = 55 per group; N = 110), together with the corresponding tests of baseline equivalence. The two children with ASD are excluded from these comparisons and are reported separately in Section 8.5.

Table 1: Sample Demographic Characteristics and Baseline Group Equivalence

Characteristic	Experimental (n = 55) [1]	Control (n = 55)	Group Comparison
Age, years (Mean ± SD)	5.49 ± 0.50	5.56 ± 0.50	$t(108) = -0.76$, $p = .450$
Sex, n male / n female	29 / 26	23 / 32	$\chi^2(1) = 0.91$, $p = .340$
BMI at baseline, kg/m² (Mean ± SD)	17.68 ± 2.59	17.88 ± 2.49	$t(108) = -0.42$, $p = .678$
Pictorial Awareness Scale, pre-test (Mean ± SD)	6.07 ± 1.51	6.27 ± 1.28	$t(108) = -0.75$, $p = .456$
Parental Awareness Questionnaire (Mean ± SD) [2]	2.31 ± 0.32	2.05 ± 0.32	$t(108) = 4.23$, $p < .001$

Note. [1]The experimental-group value of n = 55 includes typically developing children only; the two embedded ASD cases are excluded from all baseline inferential comparisons and are reported separately in Section 8.5. [2]Baseline parental-awareness scores were significantly higher in the experimental group than in the control group ($p < .001$). This variable was therefore included as a covariate in the adjusted post-test analysis. Age, baseline BMI, and pre-test child-awareness scores did not differ significantly between groups (all $p > .05$).

6.3 Study Variables

The primary outcome was the child's total score on the Pictorial Child Awareness Scale. The primary exposure was participation in the 16-week multimedia awareness program. Baseline child-awareness score was treated as an important pre-intervention covariate. Parental awareness was examined as an explanatory correlate and potential confounding variable because it differed between groups. Age, sex, and baseline BMI were treated as participant characteristics. BMI category wasanalysed descriptively and was not treated as a clinical indicator of pre-diabetes or diabetes.For the purposes of this study, child "awareness" refers specifically to recognition and understanding of added-sugar-related food and health choices as assessed by the Pictorial Child Awareness Scale. It should not be interpreted as equivalent to objectively measured dietary behavior.The parental measure incorporates nutrition-related knowledge, attitudes, and self-reported family practices. Although these components contribute to the broader construct labelled parental awareness in this study, knowledge, attitudes, reported practices, and objectively observed behavior are conceptually distinct and are not treated as interchangeable outcomes.

6.4 Instruments

- Pictorial Child Awareness Scale: A 10-item visual assessment instrument (maximum: 20 points) presenting paired images — healthy vs. unhealthy choices — across four dimensions: food discrimination, risk awareness, healthy alternatives, and preventive behavior.
- Parental Awareness Questionnaire: A 10-item three-point Likert scale (Agree = 3, Neutral = 2, Disagree = 1) measuring nutritional knowledge, attitudes toward sugar-related risks, and reported dietary practices within the family.

The Parental Awareness Questionnaire was administered once, before the commencement of the intervention and before parents attended any workshops or received educational materials. It was therefore treated as a baseline explanatory measure rather than as a parental intervention outcome.The questionnaire was sent to parents or legal guardians for independent completion and was subsequently returned to the study team. Parents completed the questionnaire without assistance from study personnel.

- Anthropometric Recording Form: Weight, height, and calculated BMI, classified by WHO age- and sex-adjusted standards (underweight, normal, overweight, obese).

Weight was measured to the nearest 0.1 kg using a calibrated digital scale, with children wearing light clothing and no shoes. Height was measured to the nearest 0.1 cm using a stadiometer, with the child standing upright according to standardised procedures. BMI was calculated as weight in kilograms divided by height in meters squared. Age- and sex-adjusted BMI category was determined using the WHO 2007 BMI-for-age growth reference for children aged 5–19 years (de Onis et al., 2007).

6.5 Intervention Program

The intervention was delivered over 16 consecutive weeks, with one 30–40-minute session per week. Each session included: (1) a brief visual introduction to the target concept; (2) an illustrated story or animated video addressing added sugar, healthy alternatives, tooth health, physical activity, or packaged beverages; (3) an interactive game or guided food-choice activity; and (4) a short review using pictorial prompts. Activities were delivered in small groups by trained early-childhood educators.Three teachers provided general supervision of program implementation across the experimental classrooms. The intervention followed the same predefined session structure and educational content across the experimental condition to support consistency of delivery.

The parent component consisted of three workshops, each lasting approximately 30 minutes. One workshop was delivered during the first week of each month over a three-month period. Parents also received 10 digital educational materials and awareness activities designed to reinforce the intervention content. Attendance was documented for every workshop, and intervention fidelity was monitored using a standardised checklist completed by the facilitator after each child and parent session. Weekly take-home activities were also used to reinforce the educational content and to obtain supplementary contextual information regarding children's food choices in the home environment, because school-based information alone could not capture these choices adequately. Children completed the activities at home and returned them through their families. Information obtained through these activities was used as supplementary contextual information and was not treated as a primary intervention outcome. The control group continued its standard kindergarten activities and did not receive the structured multimedia added-sugar-awareness program delivered to the experimental group. Exposure to nutrition-related information or activities outside the study intervention was not controlled during the 16-week study period.Post-intervention outcome data were scored after completion of the awareness program by an assessor who was independent of the intervention team and blinded to participants' experimental or control-group assignment.

6.6 Validity and Reliability

Face and content validity were assessed by five experts in early childhood education, clinical nutrition, public health, and educational psychology. Items receiving less than 80% expert agreement were revised before administration. Internal consistency in the present sample was acceptable for the Pictorial Child Awareness Scale (Cronbach's $\alpha = .84$) and the Parental Awareness Questionnaire (Cronbach's $\alpha = .81$). Test–retest reliability of the pictorial scale was evaluated in a pilot subsample of 55 children over a 15-day interval and demonstrated good stability ($r = .87$, $p < .01$). The pilot participants were subsequently retained in the final study sample. Consequently, repeated exposure to the pictorial measure may have introduced some degree of testing familiarity, and this possibility is acknowledged as a methodological limitation.

Because data collection had already been completed, potentially imprecise wording in two parental-questionnaire items—one concerning honey and another concerning hyperactivity—was retained for transparent reporting. These items should be revised before future use, and findings derived from the parental-awareness measure should therefore be interpreted with appropriate caution.

6.7 StatisticalAnalysis

Analyses were conducted using IBM SPSS Statistics. Descriptive statistics were calculated for all study variables. Baseline equivalence between the experimental and control groups was examined using independent-samples t-tests for continuous variables and chi-square tests for categorical variables.

Within-group change in the experimental group was examined using a paired-samples t-test. Because of departures from normality, the Wilcoxon signed-rank test was additionally conducted as a robustness analysis, with the matched-pairs rank-biserial correlation (r_{rb}) reported as the corresponding non-parametric effect-size estimate. Before conducting ANCOVA, linearity, homogeneity of regression slopes, homoscedasticity, independence of observations, and the distribution of residuals were examined. The primary between-group analysis compared post-test child-awareness scores while adjusting for pre-test child-awareness scores and parental-awareness scores using analysis of covariance (ANCOVA); group assignment was entered as the primary predictor, with baseline child awareness and parental awareness entered as covariates. Adjusted mean differences, 95% confidence intervals, p values, and effect-size estimates are reported in Section 8.2.

Pearson correlation was used to examine the association between baseline parental awareness and post-test child awareness. BMI categories were summarised descriptively and were not interpreted as clinical metabolic outcomes. The two children with ASD were excluded from all inferential analyses and reported descriptively. Statistical significance was set at $p < .05$, two-tailed.Data completeness was assessed before inferential analysis. No missing observations were identified for pre-test child awareness, post-test child awareness, baseline parental awareness, age, sex, height, weight, or BMI among the 110 typically developing children included in the primary analyses. Accordingly, no imputation was required, and all 110 children had complete paired pre-test and post-test awareness data.

A post hoc sensitivity analysis indicated that, with 55 typically developing children per group, $\alpha = .05$, and 80% power, the study could detect a between-group standardised mean difference of approximately $d = .54$ or larger. This analysis describes the sensitivity of the achieved sample and should not be interpreted as a substitute for an a priori sample-size calculation.

Table 2. Statistical Analysis Plan by Research Question

RQ	Outcome	Predictor/ comparison	Analysis	Principal estimate
RQ1/H1	Pictorial Child Awareness Scale	Experimental pre-test vs. post-test	Paired-samples t-test; Wilcoxon signed-rank robustness analysis with matched-pairs rank-biserial correlation	Mean change = 11.46, 95% CI [10.88, 12.03]; Cohen's d = 5.26; Wilcoxon W = 0, $p < .001$; matched-pairs $r_{rb} = 1.00$
RQ1/H2	Post-test child-awareness score	Experimental vs. control	Independent-samples t-test and adjusted ANCOVA	Unadjusted difference = 10.66, 95% CI [10.17, 11.14]; adjusted B = 10.82, 95% CI [10.29, 11.36]
RQ2/H3	Post-test child-awareness score	Baseline parental awareness	Pearson correlation	$r = .34$, 95% CI [.16, .50]
RQ3	BMI category	Sample classification	Frequencies and percentages	n and %

RQ	Outcome	Predictor/ comparison	Analysis	Principal estimate
RQ4	Child-awareness scores in two ASD cases	Pre-test vs. post-test within each case	Descriptive case analysis	Case 1: 5→17; Case 2: 7→20

Note.RQ = research question; H = hypothesis.
The two children with ASD were excluded from all inferential statistical analyses. BMI categories were analysed descriptively only. No missing observations were identified among the 110 typically developing children for variables included in the primary analyses.

6.8 Ethical Considerations

Ethical approval for the study was obtained from the relevant research ethics authority in accordance with the requirements of the National Committee of Bioethics (NCBE), King Abdulaziz City for Science and Technology (KACST), Saudi Arabia. Written informed consent was obtained from the parents or legal guardians of all participating children before data collection. Developmentally appropriate verbal assent was obtained from participating children. Participation was voluntary, and parents or legal guardians could withdraw their children without penalty. All study data were anonymised and stored securely.

7. Measurement Instruments

7.1 Pictorial Child Awareness Scale

The scale consisted of 10 pictorial items scored from 0 to 2, yielding a total score ranging from 0 to 20. Each item was scored from 0 to 2. A score of 0 indicated an incorrect response or absence of recognition of the target concept. A score of 1 represented partial recognition, defined as identification of the appropriate option accompanied by an incomplete, uncertain, or only partially relevant verbal or behavioural justification. A score of 2 represented correct recognition accompanied by an appropriate verbal or behavioural justification demonstrating understanding of the target concept. Full item content, response options, and item-level scoring exemplars are provided in Supplementary File S1 (Appendix A).

7.2 Parental Awareness Questionnaire

Parental awareness of sugar-related risks was measured using a 10-item, three-point Likert questionnaire (Appendix B).The full item wording for the Parental Awareness Questionnaire is provided in Supplementary File S1 (Appendix B).

8. RESULTS

8.1 Within-Group Change in the Experimental Group (Hypothesis 1)A paired-samples t-test revealed a statistically significant increase in experimental-group awareness scores among typically developing children ($n = 55$). Mean Pictorial Child Awareness Scale scores increased from 6.07 ± 1.51 at pre-test to 17.53 ± 1.26 at post-test, corresponding to a mean increase of 11.46 points (95% CI [10.88, 12.03]), $t(54) = 39.04$, $p < .001$.

Table 3: Paired-Samples T-Test — Child Awareness, Experimental Group

Outcome	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference	95% CI for mean Difference	t(df)	p	Cohen's d_z
Pictorial awareness score	6.07 ± 1.51	17.53 ± 1.26	11.46	[10.88, 12.03]	39.04 (54)	< .001	5.26

Note. The statistically significant pre-to-post difference indicates an improvement in children's pictorial added-sugar awareness following the program (typically developing children only, $n = 55$). Shapiro–Wilk tests indicated departures from normality for both pre-test ($W = 0.943$, $p = .012$) and post-test ($W = 0.939$, $p = .008$) scores. A Wilcoxon signed-rank test was therefore conducted as a robustness analysis and confirmed a significant increase in post-test scores ($W = 0$, $Z = −6.45$, $p < .001$). All 55 children had higher post-test than pre-test scores (55 positive ranks, 0 negative ranks, and 0 ties; sum of positive ranks = 1540). The corresponding matched-pairs rank-biserial correlation was $r_{rb} = 1.00$, indicating complete directional separation of the paired ranks in this sample. Nevertheless, both this non-parametric effect estimate and the very large, standardised effect size (Cohen's $d = 5.26$) should be interpreted cautiously because the outcome measure had a restricted 0–

20 range and demonstrated a pronounced post-test ceiling. The raw mean difference (11.46 points, 95% CI [10.88, 12.03]) is therefore emphasised alongside the standardised effect estimates to provide a directly interpretable estimate on the original measurement scale.

The observed improvement may be related to the program's visual and interactive design; however, causal interpretation should remain cautious because group allocation was quasi-experimental and parental-awareness scores differed between groups.

Interpretation. In line with Piaget's pre-operational stage, young children require concrete sensory representations of abstract health concepts. The illustrated stories and interactive videos may have helped translate abstract sugar-related health concepts into concrete associations involving tooth health, energy, and healthier food choices. Following the intervention, all 55 typically developing children in the experimental group (100%) reached the "High Awareness" classification band (14–20 points) on the Pictorial Awareness Scale, compared with none pre-intervention.

Comparison with the Literature. These findings align with the active learning literature, which indicates that the specific animation and interactivity features of digital storybooks — not multimedia content in general — determine whether comprehension and encoding improve for young children (Son & Butcher, 2024). The corresponding shift in awareness classification is shown in Figure 2.

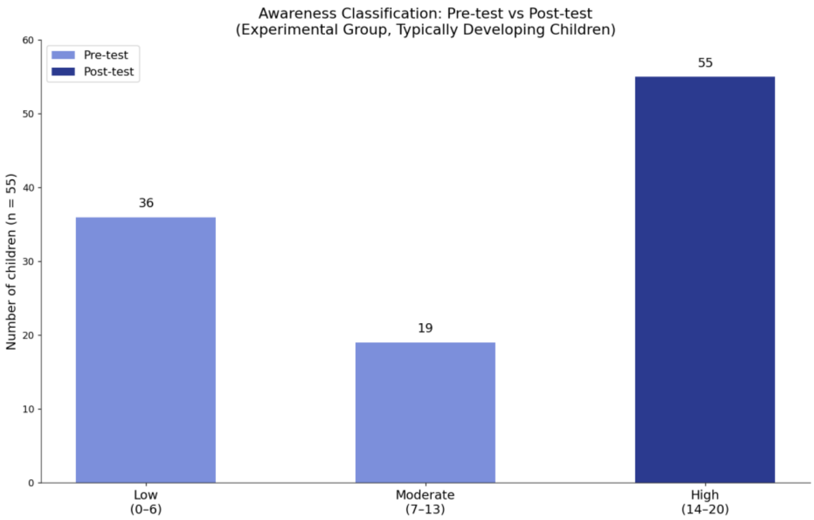

Figure 2. Awareness classification distribution before and after the program (Experimental group, typically developing children, n = 55): shift from Low/Moderate to High awareness.

8.2Adjusted Between-Group Post-test Comparison (Hypothesis 2)

At post-test, the experimental group had a higher mean awareness score than the control group (17.53 ± 1.26 vs. 6.87 ± 1.32). An unadjusted independent-samples t-test yielded $t(108) = 43.30$, $p < .001$, with a mean difference of 10.66 points (95% CI [10.17, 11.14]). Because parental-awareness scores differed significantly between groups and because group allocation was quasi-experimental, an ANCOVA was conducted adjusting for pre-test child-awareness and parental-awareness scores (Table 4). The adjusted group difference ($B = 10.82$, 95% CI [10.29, 11.36], $p < .001$) was very similar in magnitude to the unadjusted difference, and neither pre-test awareness ($p = .670$) nor parental awareness ($p = .751$) was a significant covariate once group was accounted for. The adjusted means were 17.48 for the experimental group and 6.66 for the control group. In this sample, adjustment for baseline child awareness and parental awareness did not materially attenuate the estimated between-group difference.Nevertheless, the very large partial eta-squared (.938) should be interpreted in light of the pronounced post-test ceiling effect described in Section 9.1.

Table 4: ANCOVA — Post-test Child Awareness Adjusted for Baseline Awareness and Parental Awareness

Predictor	Adjusted B	SE	95% CI	p
Intervention group (Experimental vs. Control)	10.82	0.27	[10.29, 11.36]	< .001
Baseline (pre-test) child awareness	-0.04	0.10	[-0.23, 0.15]	.670
Parental awareness	0.13	0.41	[-0.69, 0.95]	.751
Model: $F(3, 106) = 631.80$, $p < .001$, $R^2 = .947$, partial η^2 (group) = .938				

Visual inspection of standardised residuals did not indicate substantial departures from linearity or homoscedasticity, supporting the appropriateness of the ANCOVA model. The interaction terms between treatment group and each covariate were examined and were non-significant.

Although adjustment for baseline child awareness and parental awareness did not materially alter the group estimate, the exceptionally large model fit and group effect should be interpreted cautiously. The intervention content closely corresponded to the pictorial assessment domains, and the restricted score range produced a pronounced post-test ceiling. These factors may have inflated the apparent magnitude of the adjusted group effect. No multicollinearity was detected among the covariates, and the available diagnostic checks did not indicate major violations of the ANCOVA assumptions examined.

8.3 Parental–Child Awareness Correlation (Hypothesis 3)

The association between baseline parental-awareness scores and children's post-test sugar-risk awareness scores was examined using Pearson correlation across the 110 typically developing children (Table 5).

Table 5. Pearson Correlation Between Baseline Parental Awareness and Post-test Child Added-Sugar Awareness

Variables	n	Pearson r	95% CI	Significance
Baseline Parental Awareness × Post-test Child Awareness	110	.34	.16, .50	$p < .001$

Note. $r = .34$ indicates a moderate positive relationship: higher baseline parental awareness is significantly associated with higher post-test child awareness, though baseline parental awareness accounts for only around 12% of the variance in post-test child scores ($r^2 = .12$).

Because parental-awareness scores differed significantly between the experimental and control groups, the pooled correlation may partly reflect between-group differences. The ANCOVA reported in Section 8.2 addressed this by adjusting the primary outcome for parental awareness directly. In the adjusted model, baseline parental awareness was not significantly associated with post-test child awareness after accounting for group assignment and baseline child awareness ($p = .751$).Interpretation. Higher baseline parental-awareness scores were moderately associated with higher post-test child-awareness scores. No causal direction can be established from this correlation, and the association may reflect shared family, educational, or socioeconomic influences.

Comparison with the Literature. This finding is consistent with the recommendation that child-directed health awareness programs benefit from a substantive, concurrent parental engagement component (Ghabashi et al., 2025; Aleid et al., 2024).

Practical Implications. See Section 9.3 for the applied significance of this parent–child concordance for program design.

8.4 BMI Category Distribution

The distribution of BMI categories for the full sample is summarised in Table 6.

Table 6: BMI Category Distribution

BMI Category	n	%
Underweight	14	12.5
Normal weight	30	26.8
Overweight	25	22.3
Obese	43	38.4

Note. Among the 112 participating children, 14 (12.5%) were classified as underweight, 30 (26.8%) as normal weight, 25 (22.3%) as overweight, and 43 (38.4%) as obese according to the WHO 2007 age- and sex-adjusted BMI-for-age reference (de Onis et al., 2007). BMI categories are reported descriptively and should not be interpreted as direct indicators of metabolic disease. Interpretation. Overweight and obesity, as screened by BMI, were common in this sample. Excess adiposity is biologically associated with reduced insulin sensitivity in the broader paediatric literature; however, this study did not measure insulin sensitivity, fasting glucose, or any other biochemical marker, and the BMI findings should be read strictly as a descriptive weight-status profile of the sample.

Comparison with the Literature. This pattern is broadly consistent with prior evidence linking excess energy intake from fructose-containing sugars to increased adiposity (Chiavaroli et al., 2023; Agarwal et al., 2024), although the present study cannot confirm such a pathway in the absence of biochemical data. The distribution of BMI categories across the sample is shown in Figure 3.Practical Implications. See Section 9.3.

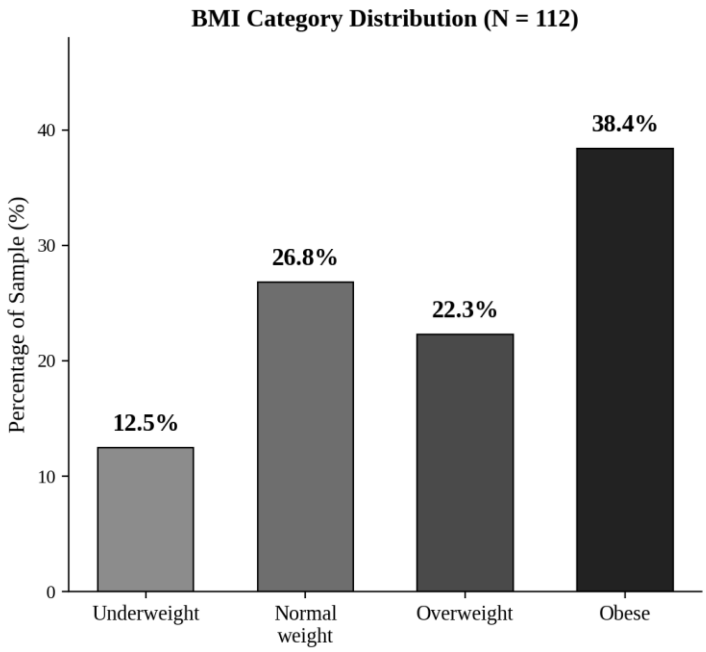

Figure 3. BMI category distribution in the study sample (N = 112).

8.5 Exploratory Descriptive Observations for Two Children with ASD

The two children with ASD participated in the intervention but were excluded from inferential analyses. Case 1, a 5-year-old boy with a BMI of 15.8 kg/m², increased from 5 at pre-test to 17 at post-test. Case 2, a 6-year-old girl with a BMI of 16.9 kg/m², increased from 7 to 20. Both children completed the pictorial assessment and obtained higher scores at post-test than at pre-test. However, because only two cases were included and no standardised sensory-processing, food-selectivity, or qualitative observation protocol was administered, the present data cannot establish that visual strategies are uniquely effective for children with ASD or that their response mechanism differed from that of typically developing children. Accordingly, these two cases are reported solely as descriptive feasibility observations and should not be interpreted as evidence of intervention effectiveness in children with ASD.

9. DISCUSSION

The principal finding of this study was a marked short-term increase in pictorial added-sugar-awareness scores among typically developing children who participated in the multimedia program compared with their baseline scores and with children in the control condition at post-test. This pattern is broadly consistent with previous evidence indicating that developmentally appropriate, interactive nutrition-education approaches can improve nutrition-related knowledge and awareness in young children (Abdelrahman et al., 2025; Collado-Soler et al., 2023). From a developmental perspective, pictorial, interactive, and story-based formats may facilitate children's engagement with concepts such as added sugar, healthier alternatives, and preventive food choices.Importantly, the primary outcome represents pictorial awareness rather than objectively observed dietary behaviour. Improvement in awareness should therefore not be assumed to indicate corresponding changes in food intake, purchasing patterns, or other behavioural outcomes.

The magnitude of the observed effect was unusually large and should be interpreted cautiously. All typically developing children in the experimental group reached the high-awareness category at post-test, indicating a pronounced ceiling effect. This pattern may reflect close alignment between intervention content and assessment items, repeated exposure to target concepts, testing familiarity, or limited difficulty at the upper end of the scale. Accordingly, the findings are best interpreted as short-term improvement on the study-specific awareness measure rather than equivalent change in real-world dietary behaviour. Additional methodological limitations are summarised in Section 9.1. Baseline parental awareness showed a moderate positive association with post-test child awareness in the pooled sample, a pattern that is compatible with, but does not independently establish, a social-learning or family-influence explanation. Parental-awareness scores were also significantly higher in the experimental group than in the control group at baseline. However, the ANCOVA reported in Section 8.2 showed that parental awareness did not significantly predict post-test child awareness once group assignment was accounted for, and the adjusted group effect closely matched the unadjusted one. Adjustment for baseline parental awareness did not materially alter the estimated intervention-group difference. Nevertheless, because allocation was non-randomised and the parental-awareness association was correlational, residual confounding and alternative explanations cannot be excluded.

The BMI findings indicate that overweight and obesity were common in this single-center sample. However, BMI is a screening measure of weight status and cannot identify insulin resistance, pre-diabetes, or diabetes without additional clinical and biochemical assessment. Accordingly, the BMI findings provide contextual information about the weight-status profile of this sample but do not demonstrate that the intervention altered obesity, insulin resistance, or diabetes risk.The two ASD cases completed the intervention and demonstrated higher post-test awareness scores. These observations indicate that participation in the pictorial nutrition-awareness activities and completion of the study assessment were feasible for these two children. However, the sample is insufficient to estimate intervention effectiveness in children with ASD or to compare response patterns between neurodevelopmental groups.

9.1 LIMITATIONS

This study has several limitations. First, it was conducted in a single educational center, limiting external validity. Second, allocation followed five existing classrooms—three assigned to the experimental condition and two to the control condition—rather than individual randomisation, leaving the study vulnerable to selection bias and unmeasured classroom- or group-level differences. In addition, exposure to nutrition-related information or activities outside the structured study intervention was not controlled, and external exposure or contamination between conditions therefore cannot be completely excluded.Third, parental-awareness scores differed significantly between groups at baseline; an ANCOVA adjusting for this and for baseline child awareness found the group effect essentially unchanged, but the quasi-experimental design means unmeasured confounders cannot be ruled out. Fourth, post-test awareness scores showed a pronounced ceiling effect, which may have inflated standardised effect estimates and reduced the scale's ability to distinguish among children with high awareness. The primary outcome was also assessed using a study-specific pictorial measure rather than an independently validated external instrument, which limits direct comparison with other studies and may have contributed to the unusually large observed score differences.In addition, 55 participants had prior exposure to the pictorial instrument during the test–retest reliability assessment, which may have increased familiarity with the assessment format. Fifth, the outcome measure assessed pictorial awareness rather than objectively observed food intake, purchasing behavior, dietary consumption, BMI change, or biochemical health outcomes. Sixth, BMI was measured descriptively and cannot establish metabolic disease. Seventh, the parental-awareness measure relied on self-report and contained two potentially imprecise items: one did not clearly distinguish honey from other free-sugar sources, and another could be read as implying a causal relationship between added sugar and hyperactivity or attention difficulties. These wording limitations may have affected construct validity and should be corrected in future versions of the instrument. Eighth, only two children with ASD were included, and no standardised sensory-processing or food-selectivity measure was administered. Finally, no long-term follow-up was conducted, so the maintenance of awareness gains and their translation into behavior remain unknown.

9.2 Strengths

The study has several strengths, including its focus on an early developmental period, the use of developmentally appropriate pictorial and multimedia content, the inclusion of both child and parental awareness measures, the use of a concurrent comparison group, and the reporting of BMI category as contextual sample information. The inclusion of two children with ASD also demonstrates preliminary feasibility of participation, although it does not establish effectiveness for this population. The adjusted analysis (ANCOVA) additionally allowed the primary between-group comparison to account for baseline child awareness and the observed baseline difference in parental awareness.

9.3 Practical and Educational Implications

The present findings generate hypotheses for future implementation rather than recommendations for widespread adoption. In early-childhood settings, visually delivered nutrition-awareness activities may represent a feasible approach for supporting developmentally appropriate learning about added sugars, although broader school- and family-based intervention models suggest that implementation should be considered within a multidimensional health-promotion framework (Basilico et al., 2024).The observed association between baseline parental awareness and post-test child awareness provides a rationale for further evaluating caregiver components alongside child-directed nutrition-awareness interventions, consistent with broader family-inclusive and school-based nutrition approaches (Lott et al., 2025; Morales-Ruán et al., 2025).Similarly, the two descriptive ASD cases indicate that participation in pictorial activities was feasible for these children, but larger dedicated samples are required before population-level recommendations can be made. This observation is conceptually consistent with the longstanding use of visually cued instructional approaches for children with autism (Quill, 1995), although the present two-case evidence does not establish the comparative effectiveness of visual instruction. Future implementation research should therefore evaluate these possibilities across diverse educational settings using independently validated outcomes and longer-term behavioural follow-up.

10. CONCLUSION

This quasi-experimental study found substantial short-term improvement in pictorial added-sugar-awareness scores among kindergarten children who participated in a 16-week multimedia program compared with their baseline scores and with the control group at post-test. However, the pronounced post-test ceiling effect and the study-specific nature of the primary outcome measure require caution when interpreting the magnitude and generalisability of this difference. Baseline parental awareness was moderately associated with post-test child awareness (r = .34); however, this pooled association should not be interpreted as evidence of causal transmission of awareness from parents to children. BMI classification indicated that 38.4% of the sample fell within the obesity category according to the age- and sex-adjusted reference used; because no biochemical markers were collected, this finding describes weight status only and does not establish metabolic dysfunction or diabetes risk. The two embedded ASD cases obtained higher post-test pictorial-awareness scores, providing descriptive evidence that participation and assessment completion were feasible in these two cases without supporting conclusions regarding effectiveness in the broader ASD population. Replication using multi-center, adequately controlled designs, independently validated outcome measures, behavioral follow-up, and larger dedicated ASD samples is warranted.

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