ALL PURÉES ARE NOT CREATED EQUAL: THICKNESS, COHESIVENESS, AND ADHESIVENESS OF COMMERCIALLY AVAILABLE FIRST FOODS

by

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ABSTRACT

The purpose of this study was to investigate the thickness, cohesiveness, and adhesiveness of foods typically consumed as feeding skills develop in the first year of life. The subjective feeding difficulty levels 1-4, presented by Gerber and Beech-Nut, were examined with the International Dysphagia Diet Standardization Initiative (IDDSI) drip test, spoon tilt test, and fork pressure test to determine the thickness, cohesiveness, and adhesiveness of the foods offered at each of the four levels. The drip test, which measures overall thickness, was conducted by recording the amount of liquid that drips out of a 10-mL syringe after 10 seconds. The spoon tilt test, which evaluates cohesiveness and adhesiveness, was performed by tilting a sample of purée in a spoon and assessing the state of the sample as it slides off. Lastly, the fork pressure test utilized a standard metal fork to apply pressure to food samples to determine if particles are safe to swallow. The results of this study concluded that thickness, cohesiveness, and adhesiveness are not impacted by brand, marketed stage (levels 1-4), or packaging. However, this study did establish that food packaged in pouches are slightly less adhesive than food packaged in jars. This finding indicates that food in pouches require less oral motor skill to swallow. The results signify that the proposed levels of baby food are not based on a hierarchy of difficulty but are instead for marketing purposes. The results also concluded that the texture of food was not impacted by the use of “natural ingredients.” The difficulty level of each food was determined and mapped to the IDDSI framework to provide guidance on the developmental appropriateness of each “starter food” for use by clinicians treating pediatric patients with dysphagia.

DEDICATION

This thesis is dedicated to my family, friends, and mentors who encouraged me to pursue my dreams and supported me throughout the process of this study.

LIST OF ABBREVIATIONS AND SYMBOLS

ANOVA	Analysis of Variance
$\underline{F}$	Fisher's F ratio: A ration of two variances
IDDSI	International Dysphagia Diet Standardisation Initiative
IOPI	Iowa Oral Performance Instrument
$\underline{M}$	Mean: the sum of a set of measurements divided by the number of measurements in the set
$\underline{r_s}$	Spearman's rho: a statistical measure of the strength of a relationship between two sets of data
$\underline{SD}$	Standard Deviation: a measure used to quantify the amount of variation in a set of data values
$\underline{p}$	Probability associated with the occurrence of the null hypothesis of a value as extreme as or more extreme than the observed value
PEG	Percutaneous Endoscopic Gastrostomy
X^2	"Chi squared" = distribution for multinomial experiments and contingency tables
=	Equal to

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Feeding development in infancy is associated with the natural development of gross and fine motor skills, including oral motor skills. Commercial baby food companies, such as Gerber and Beech-Nut, base their 3 stages of foods, in both jars and pouches, on achievement of major motor milestones and chronological age. Several studies support the relationship between various feeding skills and gross motor milestones (Carruth et al., 2004; Delaney and Arvedson, 2008; Rudolph, 1994). Children with dysphagia often need therapeutic support to develop their feeding and swallowing skills due to having missed the opportunity to develop feeding skills at concurrently with their gross motor skills (Davis et al., 2009). As a result, many children with dysphagia may have already met many motor milestones but are unable to eat the corresponding food textures because of undeveloped oral motor skills or missed experiential opportunities with food textures. Therefore, it would be advantageous for therapists to understand the hierarchical nature of developmental foods in terms of their difficulty level for chewing and swallowing to guide the clinical application of these foods for pediatric dysphagia therapy.

BACKGROUND & LITERATURE REVIEW

Development of Normal Feeding

The act of swallowing is as a well-coordinated sequence of sensory and motor mechanisms in the oral cavity, pharynx, and esophagus (Garcia and Chambers, 2010). The developmental progression of feeding function includes the following steps:

Feeding Skills	Age of Development
Suckle feeding and Pre-feeding period	The pre-feeding period begins in utero. Non-nutritive sucking, an indicator of oral feeding readiness, can be observed as early as 15 weeks gestation (Delaney and Arvedson, 2008).

Feeding Skills	Age of Development
Acquiring the ability to take food with closed lips	This skill is present in approximately 88% of 9-11-month-old children, with little to no spilling (Carruth et al., 2004).
Mashing food against hard palate	Although a specific age of development has not been documented for this skill, it has been documented that this skill is a precursor for the ability to perform mastication. The ability to shape a bolus with the tongue also occurs at this time (Ayano et al., 2000).
Mastication	Eighty-seven percent of children 9-11-months old are able to independently eat foods that require chewing (Carruth et al., 2004). Chewing is fully established by 12 months of age. This skill is continuously refined as the child ages (Delaney and Arvedson, 2008).
Self-feeding	The percentage of children who self-feed by grasping food in the palm of their hands is 68% at 4-6 months of age. This skill increases to 96% and is refined around 7-8 months of age (Carruth et al., 2004).
Finger-feeding	At approximately 9 months, children develop the ability to hold something between their thumb and forefinger, a skill known as the pincer grasp. Once this skill is developed the child will begin to finger-feed. This skill is typically mastered by 18 months of age. (Dosman, Andrews, and Goulden, 2012).
Use of tableware	Eleven percent of 9-11-month olds are able to successfully self-feed using a spoon. This percentage increases to 88% from 19-24-month-olds (Carruth et al., 2004).

Motor Learning Theory

The dynamic process of swallowing can be classified into a series of movements throughout four distinct phases: oral preparation phase, oral transit phase, pharyngeal phase, and esophageal phase. Throughout these four phases, more than thirty muscles and nerves are coordinated for the purpose of reflexive and voluntary motor activity (Matsuo and Palmer, 2009). Swallowing is also affected by coordination of respiration, as well as postural control. Developing motor skills throughout infancy and childhood requires the child to manipulate muscle movements into functional activities. Oral motor skills required for feeding and swallowing follow the same developmental progression as gross motor skills (Rudolph, 1994). It has been hypothesized that a critical period for developing oral motor skills exists during the first two years of life. This would account for the ease of acquiring feeding skills that typically developing children experience. However, in some cases, children require alternative methods for feeding, causing the "critical period" to be disrupted, and the motor skills to be delayed. Children are most successful in learning delayed motor skills through consistent practice in a variety of natural environments, which also leads to generalization of the skills (Sheppard, 2008). Rehabilitating the structure and function of muscles depends largely on seven principles of exercise: overload, progression, intensity, adaptability, reversibility, specificity, and recovery (Groher and Crary, 2010).

Muscles are elastic and highly adaptable by nature; therefore, to increase strength, a muscle must be exercised at a higher level than the resting intensity. The principle of overload challenges the muscle to create change through increasing the intensity, time, and frequency of exercise. When the principle of adaptation is applied, the condition of the muscle is altered, and muscle memory is produced through repeated practice of exercise. Specificity requires the exercises performed must be specifically designed for the end goals in order to achieve success.

Therefore, the best exercises to improve swallowing function include the act of swallowing itself. While muscles are flexible and strengthen through exercise, they also weaken with disuse. It is the principle of reversibility which is behind the concept of “use it or lose it.” Rapid deconditioning will be observed in patients who are unable to swallow for an extended period of time. Although disuse of muscles leads to atrophy, recovery is an important component of exercise. Muscles restore, fibers grow, and fatigue is reduced during periods of rest integrated into exercises (Crary and Cranaby, 2014). The most effective rehabilitative strategies for dysphagia are those that increase the intensity, time, and frequency, while considering the systematic progression of those components, and are specific to the overall goal of swallowing. Food texture can be conceptualized in a hierarchy of increasing difficulty moving from pureed foods that require little oral effort to solid foods that require chewing. Understanding the hierarchical progression of first foods can assist in designing effective treatment plans that provide a gradual increase of oral motor skills, while not over-challenging the muscles in place, thus endangering the child.

Pediatric Dysphagia

Dysphagia is defined as an impairment in the process of swallowing and can be characterized as oral, pharyngeal, esophageal, or a combination of these. Dysphagia is always the symptom of another disease. In 2012, the National Health Interview Survey identified 569 ± 63 thousand children in the United States that reported difficulty swallowing. Approximately 13.5% of these children received a formal diagnosis of pediatric dysphagia (Bhattacharyya, 2014). According to the American Speech and Hearing Association, pediatric dysphagia is typically a symptom of the following etiologies: neurological disorders, genetic syndromes, pre-mature birth, behavioral and developmental conditions, difficulty processing sensory information, structural abnormalities, respiratory conditions, and/or gastroesophageal conditions.

Leaving dysphagia untreated can lead to greater problems such as failure to thrive, malnutrition, dehydration, and aspiration pneumonia (Prasse & Kikano, 2009). Coordination of sucking, swallowing, and breathing is one of the more complicated tasks required of a pre-term, newborn infant. Infants born less than 32 weeks gestation are neurologically undeveloped and seldom proficient in this coordination (Delaney and Arvedson, 2008). It may become necessary to provide an alternative method for nutritional intake in the form of a Percutaneous Endoscopic Gastrostomy (PEG) tube or a Gastrostomy tube. Concurrent health issues, nutritional status, oral motor skills, swallowing function, and readiness of caregivers are all factors contributing to the readiness of the patient to be weaned off of their tube (Schauster and Dwyer, 1996). However, due to prolonged medical conditions, lack of motivation, or active refusal to eat, overtime children may become dependent on their tubes to fulfill nutritional requirements (Krom et al., 2017). Children that rely on feeding tubes for several years bypass the transition from reflexive to voluntary feeding. As a result, the transition from tube feeding to oral feeding is often initiated after the typical developmental milestones occur that increase proportionally to feeding skills. Therefore, these children have a more difficult time transitioning to oral feeding than children who were weaned off of their tube before 6-months of age (Blackman and Nelson, 1985). However, tube feeding is not always warranted in children with pediatric dysphagia. Clinicians must first consider incorporating approaches that are safe, non-invasive, and functional before determining that someone should primarily receive their nutrition via gastrostomy tube. It can be assumed that until children with dysphagia begin therapy to explicitly teach oral motor feeding skills, they are also bypassing the critical period that these skills naturally develop. Oral motor swallowing therapies and compensatory strategies include implementing postural support or specialized seating, modifying foods, liquids, and utensils, applying tactile stimulation, and developmentally appropriate activities targeting swallowing musculature (Lefton-Greif, 2008).

Diet Modification

Although modification of food and liquid is intended to be implemented only as a compensatory strategy, and after exploring other interventions, it has become the primary method for treating and managing dysphagia (Garcia, Chambers, and Molander, 2005). This practice stems from the notion that thin liquids flow too quickly and can easily be aspirated, while thick liquids require less swallowing skill (Steele et al., 2014). However, certain food textures and consistencies such as solid foods require more advanced oro-motor patterns in young children, as opposed to consistencies that are easier for children to manipulate and swallow (Ruark et al,, 2001). Diet modification includes thickening of both solids and liquids for those at risk for aspirating and limiting solid textures for those at risk for choking. Food textures that affect the management of dysphagia include: adhesiveness, cohesiveness, firmness, fracturability, hardness, springiness, viscosity, and yield stress (Garcia and Chambers, 2008). The National Dysphagia Diet, introduced in 2002, provided the first national standardized terminology for modifying foods and liquids. Through this framework, liquids were classified into the following categories: thin, nectar-thick, honey-thick, and spoon-thick; while modified solids were categorized as pureed, mechanically altered, advanced, and regular diet (National Dysphagia Diet Task Force, 2002). A survey conducted by the Neonatal and Infant Feeding Disorders Program in Colombus, Ohio, found that 79% of their 313 respondents utilized diet modification in the Neonatal Intensive Care Unit, with nectar-thick consistencies being the most common recommendation (Madhoun et al., 2015). These various forms of thickened liquids are a product of the combination of thin liquids with pureed solids. However, although the National Dysphagia Diet provided standardization of terminology, their descriptors were subjective, and no tools for standardized testing were provided.

Due to the lack of standardized testing, each clinic prepared each of their thickened liquids differently, resulting in decreased patient safety and treatment outcomes (Cichero et al., 2013).

The Development of IDDSI

The International Dysphagia Diet Standardisation Initiative (IDDSI) was released in 2015, to provide a standardized terminology and a universal measuring system for diet modification. The most significant purpose of IDDSI is to increase the safety of swallowing for people of all ages, in all care settings, and all cultures (Cichero et al., 2013). The framework consists of 8 continuous levels represented by colors, numbers, and terminology. The categories are defined as follows: Level 0, Thin Liquids; Level 1, Slightly Thick Liquids; Level 2, Mildly Thick Liquids; Level 3, Moderately Thick Liquids and Liquidized Solids; Level 4, Extremely Thick Liquids or Pureed Solids; Level 5, Minced & Moist Food; Level 6, Soft & Bite Sized Food; Level 7, Regular Foods.

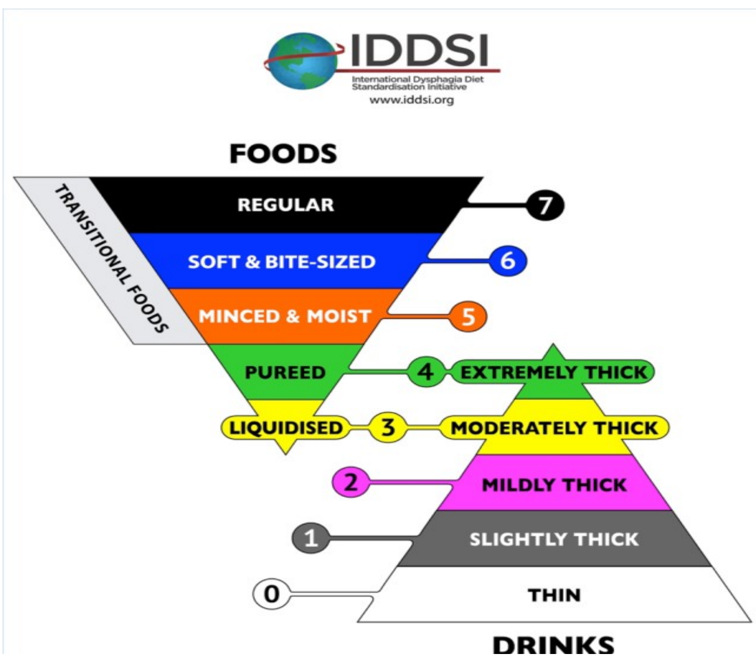

Figure 1: (c) The International Dysphagia Diet Standardisation Initiative 2016@http://iddsi.org/resources/framework/.

To evaluate the thickness of liquids and liquidized foods, IDDSI uses a gravity flow test with a 10mL syringe. This test analyzes the amount of liquid that flows from the syringe in a 10 second time frame and categorizes the liquid by comparing it to the descriptions of each level.
The Fork Drip Test uses a similar method to test thicker liquids and liquidized foods. The flow of the liquid between the prongs of the fork is analyzed and used to categorize the food or liquid. Harder foods are best assessed by using the Fork Pressure Test. The tines of a standard metal fork provide valuable information regarding the particle size of foods. The Spoon Tilt Test is a suitable tool for analyzing purees and determining the cohesiveness and adhesiveness of the food. Foods can also be evaluated by using chopsticks or fingers if traditional silverware is not readily accessible in the area. These tests were designed to be easily replicated throughout clinics and homes worldwide. The simplicity of this design, in addition to hands-on training, resulted in the ease of implementation of this framework in areas that have recently applied the IDDSI terminology into their clinics (Lam, Stanschus, Zamen, and Cichero, 2017). This framework is now widely accepted throughout the United Kingdom, the United States of America, Canada, and some areas in Europe. It is the hope of the IDDSI committee that every clinic worldwide will not just accept, but also implement this framework into their programs in order to improve patient safety and quality of care.

Nutrition in Infancy and Toddler Years

Eating a diet rich in variety is critical to achieving adequate nutrition and promoting appropriate growth (Nicklaus, 2009). The American Heart Association recommends that as children reach the age of two years, their diet should include and rely on fruits, vegetables, whole grains, low-fat and nonfat dairy, beans, fish, and lean meat. Children one year of age should be eating approximately 2 cups of dairy, 1 cup of fruit, ¾ cup of vegetables, 2 ounces of grains, and 1 ½ ounces of lean meat/beans, totaling 900 kilocalories per day (Gidding et al., 2005).

Dr. Toomey, a pediatric psychologist, states that a typical child should consume a minimum of 30 foods (10 proteins, 10 carbohydrates, and 10 fruits/vegetables), tolerate and experiment with new foods, and eat from most textures (Toomey and Nyhoff, 2007).

It is important to note that a gap exists between current practice and dietary recommendations for infants and children. The Feeding Infants and Toddler Study of 2004 found that commercial baby foods were the leading source of fruit and vegetable intake for infants up to 8-months old. As toddlers begin including solid foods in their regular diet, the amount of fruits and vegetables consumed decreases in both quality and quantity. For example, French fries are the third most commonly consumed vegetable at 9-months of age and rises to the number one most commonly consumed vegetable at 15-months of age. (Fox et al., 2004). Providing infants and toddlers with a variety of healthy foods seems to be the key to attaining long-term dietary variety (Nicklaus, 2009). Intake of healthy, minimally processed foods by mouth is only possible if children have the oral motor skills needed. These skills are developed and mastered in the first two years of life in healthy children that follow a typical developmental course. For those children that do not follow a typical developmental course and require swallowing and feeding therapy, knowledge of the thickness, cohesiveness, and adhesiveness of first foods will help guide the therapist's selections of food for teaching the oral motor skills necessary to progress through various textures of food.

STATEMENT OF THE PROBLEM

Pediatric dysphagia affects 30%-80% of children with developmental disorders, while 24%-40% of typically developing children demonstrate issues with feeding and swallowing at some point during their early development (Delaney and Arvedson, 2008.) Dysphagia can lead to malnutrition, dehydration, and even mortality.

Treatment of pediatric dysphagia necessitates the systematic introduction of foods along a gradient of increasing difficulty to facilitate the development of the necessary oral motor skills to support oral intake of a nutritionally sound and varied diet. Many children with dysphagia miss the developmental window to acquire these skills within the natural environment and therefore seek therapeutic services to help remediate oral feeding deficits. In the first year of life, infants transition through nutritional sources that initially are limited to a thin liquid consistency gradually progressing to thicker consistencies until they eventually eat solid foods by the end of their first year of life. Many parents choose to provide commercially marketed first foods and these foods differ in their manufacturing processes, presentation (by pouch or jar from spoon), and content. However, it is unknown how the different manufacturing processes and presentation affect the thickness, cohesiveness, and adhesiveness of the food.

To better understand the objective properties of the various, commercially available first foods, the specific aims of this project include:

1. Document the thickness, adhesiveness, and cohesiveness of stages 1, 2, 3, and 4 baby foods as marketed by Gerber & Beech-Nut.
2. Analyze the potential differences in thickness, adhesiveness, and cohesiveness between two common manufacturers of first foods (Beech-Nut and Geber).
    a. Hypothesis: There will be no significant differences in thickness, adhesiveness, and cohesiveness levels when comparing first foods from the two common manufacturers.
    b. Statistical analysis: The differences between brand and stage on the flow test were tested using a univariate ANOVA. The differences between brand and stage on the spoon test (cohesiveness and adhesiveness) were tested using a Kruskal Wallis test.

3. Compare the thickness, adhesiveness, and cohesiveness measures between foods packaged in jars and pouches.
    a. Hypothesis: There will be no significant differences in thickness, adhesiveness, and cohesiveness levels when comparing first foods packaged in jars (consumed with spoons) and in pouches.
    b. Statistical analysis: The differences between brand and stage on the flow test were tested using a univariate ANOVA. The differences between brand and stage on the spoon test (cohesiveness and adhesiveness) were tested using a Kruskal Wallis test.
4. Determine the relationship of the manufacturer's descriptions of Stage 1, Stage 2, Stage 3, and Stage 4 to the IDDSI framework.
    a. Hypothesis: There will be a direct, positive relationship between the manufacturer's staging of first foods developmental levels and the IDDSI's classification of first foods.
    b. Statistical analysis: The differences within and between each group was tested using a Spearman's rank-order correlation.

METHODS & PROCEDURES

Products

The author reviewed and then compiled a comprehensive list of baby foods locally available for both baby food brands of interest (Gerber and Beech Nut). The results of this analysis can be found in Appendix: Table 1 and Table 2.

A representative sample of 30% of the regionally available Gerber and Beech Nut baby foods in each of the categories of interest (presentation, ingredients, and manufacturer's categorization) was collected.

For the categories that contain 5 or fewer samples locally, all available products were collected. Ingredients for Stage 1, for both Gerber and Beech Nut, contain fruits flavors and vegetable flavors, with no blends or mixed consistencies. Single ingredients are also featured in stage 2 of Gerber and Beech Nut, with the addition of fruit and vegetable blends. Stage 3 of Gerber and Beech Nut consists only of blended fruits and vegetables with mixed consistencies of puree and bite sized particles.

Raters

Six research assistants were assigned specific roles within this project. Their roles included running tests, recording data, and cleaning up each day. They participated in a training period of three weeks in which they were taught how to conduct each test with greater than 95% intra and inter-rater reliability. Each data collection session was filmed and reviewed to ensure reliability.

Assessments & Measures

All tests were conducted in a double-blind fashion. The research assistants were blinded to the specific aims of the project and will be blinded to the brand, stage, presentation, and ingredients of the baby food samples that they are testing. The original packaging of each sample was completely covered and labeled with a number that corresponded to the sample and was included in a master list. The samples were tested in a random order. Each test was scored as performed and the test was video recorded for reassessment at a later date to establish intra-rater reliability.

Flow Test

To evaluate the thickness of the food samples, the IDDSI flow test was performed using a 10-mL reference syringe with a measured length of 61.5 mm from the from the zero line to the 10-mL line.

Exactly 10-mL of puréed baby food was filled into the syringe while the nozzle was plugged with a finger. A timer was set to 10 seconds as the nozzle was released and the substance was allowed to flow freely. After the 10 seconds came to an end, the nozzle was once again plugged, and the remaining milliliters of puree food was recorded. Water was flushed through the syringe and paper towel was used to dry it between each trial. This test was done ten times per sample. All samples were tested with the flow test. The results were recorded and the corresponding IDDSI framework category was assigned. If 1-4 mL of fluid remained in the syringe it was considered to be Level 1, a slightly thick fluid. If 4-8 mL of fluid remain, the substance was categorized as Level 2, a mildly thick fluid. If 8-10 mL remained the substance is Level 3, a moderately thick fluid or liquidized food. If nothing dripped from the syringe, leaving the full 10 mL of fluid, the substance is Level 4, an extremely thick fluid or puréed food.

Spoon Tilt Test

For samples, in both jars and pouches, that were categorized as IDDSI Level 3 and 4 by the IDDSI Drip Test, the spoon tilt test was performed to determine the cohesiveness and adhesiveness of the sample. To conduct the spoon tilt test, a 10-mL syringe of pureed food was used to fill the bowl of a standard metal teaspoon that has a length of 2 inches and width of 1 $^{1}/_{6}$ inches. The spoon was tilted with a slight turn of the wrist and the judges answered the following yes/no questions listed on their rating sheets:

1. Did the sample hold its shape on the spoon?
2. Did the sample slide off with just a turn to the wrist?
3. Did the sample slide off in one piece?
4. Did the sample leave little to no residue?

To improve the consistency and validity of responses, the judges were provided with pictures of a sample answering each question.

The raters were required to reference these pictures throughout the test. The spoon tilt test was done 10 times for each sample tested. The spoon was rinsed with water and dried with a paper towel between each trial. Cohesiveness can be determined by the shape the sample holds on the spoon and if it slides off in just one piece. Adhesiveness was observed if the sample slides off with a light turn of the wrist, leaving little to no residue behind.

A scoring system was implemented to quantify the adhesiveness and cohesiveness of each sample. A score of 0 was assigned to the answers “no” and a score of 1 was assigned to answers “yes.” The cohesion and adhesion score possibilities ranged from 0-2 per sample. Each sample was tested 10 times, and the average score of the sums was used for statistical testing below to determine overall cohesiveness and adhesiveness.

Fork Pressure Test

For the level 3 and 4 Gerber and Beech-Nut foods, in jars and pouches, that contain potentially greater texture and larger food particles, the fork pressure test was also conducted. The average size of a child’s trachea, under the age of 2 years is 5.3 mm. Therefore, any texture increasing particle added to infant and toddler purées must be a maximum of 4 mm for a safe swallow (Griscom and Wohl, 1986). The amount of tongue force in a successful swallow is on average 17 kPa (Steele et al., 2014). The creators of IDDSI determined that 17 kPa is about the same amount of pressure it takes for the thumbnail to noticeably blanch to white (Lam et al., 2017). For the purpose of keeping this study objective, an Iowa Oral Performance Instrument (IOPI), a tool for measuring tongue pressure, was used instead of the blanching fingernail method. All particles were differentiated and counted in each sample. The particle size was measured prior to testing, and then placed on the bulb of the IOPI.

A standard metal fork, with 4 mm between each prong, was used to apply less than 17 kPa of pressure onto the sample. The particle sizes after the test were measured and noted.

The raters answered the following Yes/No questions:

1. When pressed, did the particles easily separate and come through the prongs
2. Was it easily mashed with little pressure (less than 17 kPa)?

If the answer to questions above was no, the testers applied 17 kPa of pressure, and slowly increased the amount of pressure, until the sample mashed and protruded through the prongs of the fork. The amount of pressure required to mash the sample was recorded. A scoring system was implemented to quantify the results from the qualitative questions above, and the results were used to categorize the food according to IDDSI's framework. This test was performed ten times per particle type and the mean scores, pressure, and sizes were determined. IDDSI states that if a food intended for pediatric populations has particles 2 mm in size, is easily mashed with a fork, and protrudes through the prongs of a fork with less than 17 kPa of pressure, it is considered to be a Level 5 Minced and Moist. If the particle sizes are approximately 8 mm in size and requires 17 kPa of pressure or more to be mashed and protrude through prongs, the sample is considered to be a Sample 6 Soft and Bite Sized.

Post Testing Reliability

After all tests were completed and results recorded, raters watched 25% of the test films again and recorded responses to establish intra-rater reliability. The results were compiled into a database and uploaded to SPSS for analysis.

RESULTS

The first aim of this study was to document the thickness, adhesiveness, and cohesiveness of marketed stages by Gerber & Beech-Nut. Descriptions of food properties in manufactured stages are listed in Appendix: Tables 4-6.

Analysis of Variance (ANOVA) was used to determine the relationship of thickness to brands (Gerber and Beechnut), marketed stages (one through four), and packaging (jar or pouch).

To analyze the relationship of cohesiveness and adhesiveness to brands, marketed stages, and packaging, the Kruskal Wallis test was conducted. The Kruskal Wallis Test is an analysis parallel to ANOVA for non-parametric data.

This analysis was chosen due to the abnormal distribution of data violating the normality assumption of ANOVA.

Food Property Differences in Gerber & Beech-Nut Brands and Stages

The second aim of this study was to analyze the potential differences in thickness, adhesiveness, and cohesiveness between two common manufacturers of first foods (Beech-Nut and Geber).

A one-way, univariate ANOVA was conducted to compare the effect of (a) brand, Gerber and Beech-Nut, (b) marketed stages, and (c) brand and marketed stages to the thickness of developmental first foods. Thickness is determined by measuring the substance with the IDDSI flow test which provides a measurement from zero to 10. There was no significant relationship between (a) brand and thickness, $F\ (1,33) = 3.271$, $p = .080$; (b) marketed stage and thickness, $F\ (3, 33) = 0.736$, $p = .538$; or (c) brand and marketed stages to thickness, $F\ (2, 33) = 0.651$, $p = .528$.

The Kruskal-Wallis test was conducted to determine the cohesiveness and adhesiveness of foods according to brand, Gerber and Beech-Nut. Cohesiveness and adhesiveness of foods is measured via the spoon tilt test that is scored by answering a series of binary questions about the foods interaction with the spoon.

The Kruskal-Wallis test was conducted to determine if there were significant differences in cohesiveness and adhesiveness of foods by brand.

Spoon tilt test scores were not significantly different for measures of cohesiveness (X^2 (1) = 0.610, p = .435) or adhesiveness (X^2 (1) = 0.265, p = .607) when comparing samples from Beech Nut and Gerber.

The Kruskal-Wallis test was conducted to determine if there were significant differences in cohesiveness and adhesiveness of foods according to their marketed stage.
Median brand category scores were not statistically different with respect to cohesiveness (X^2 (3) = 1.640, p = .650) or adhesiveness (X^2 (3) = 3.371, p = .338).

Food Property Differences in Packaging

The third aim of this study was to compare the thickness, adhesiveness, and cohesiveness measures between foods packaged in jars and pouches.

A descriptive analysis was conducted to determine the mean differences between glass jars, plastic jars, and pouches. The plastic jars (*M* = 9.8106) and the glass jars (*M* = 9.5469) fell within the same IDDSI category and were consequently consolidated into one category and compared to the pouches. A one-way, univariate ANOVA was conducted to determine if thickness of developmental first foods was different according to packaging and no statistical difference was found, F (1, 38) = 4.047, p = .051.

The Kruskal-Wallis test was conducted to determine the cohesiveness and adhesiveness of foods according to packaging, following the spoon tilt test. The difference in cohesiveness was not statistically significant in pouches versus jars, X^2 (1) = 0.726, p = .394. However, the difference in adhesiveness was statistically significant in pouches versus jars, X^2 (1) = 5.966, p = .015. The food packaged in pouches (*M* = 1.0, *SD* = 0.0) was determined to be less adhesive than the food packaged in jars (*M* = 1.4, *SD* = 0.525).

Relationship of the Manufacturer's Stages & IDDSI Stages

The final aim of this study was to determine the relationship of the manufacturer's descriptions of Stage 1, Stage 2, Stage 3, and Stage 4 to the IDDSI framework.

To perform this comparison, the particles in two of the food samples had to be removed. Their corresponding IDDSI level was determined according to the guidelines set by IDDSI and included for review in Tables 4-6.

To assess the relationship between marketed stage and IDDSI category due, a Spearman's rank-order correlation was performed. Spearman's rank-order correlation was the preferred choice due to the abnormal distribution and ordinal nature of the data. There was no significant correlation between marketed stage and IDDSI category $r_S = .094$, $p = .575$.

Reliability

The raters in this study re-watched 25% of the test films and re-recorded responses once testing was complete. Raters obtained a score of 97% intra-rater agreement on their Flow Test measures, with 99% inter-rater agreement. An intra-rater agreement of 96% and an inter-rater agreement of 99% was achieved on the Spoon Tilt Test. There was 100% intra and inter-rater agreement on the Fork Pressure Test, with the exception of identifying the particle size, which had 50% inter-rater agreement. Particle size scores differed at most by 1 mm. It is possible that film quality impacted the reliability of measuring particles.

DISCUSSION

Food Property Differences in Gerber & Beech-Nut Brands and Stages

The results of this study determined that the thickness, cohesiveness, and adhesiveness of developmental first foods are not related to the brand, Gerber and Beech-Nut, the marketed stage, or brand by marketed stage.

This suggests that the assigned stages by Gerber and Beech-Nut are for marketing purposes, and do not follow the hierarchy of difficulty as proposed by the International Dysphagia Diet Standardization Initiative (IDDSI). The stages proposed by Gerber are advertised to correlate with developmental gross motor milestones such as supported sitting, unsupported sitting, crawling, and toddling, while Beech-Nut correlates their food with chronological age. However, there is not sufficient evidence to determine a correlation between the difficulty of these foods and the marketed recommended time of consumption.

This finding also demonstrates that, despite Beech-Nut's strong promotion of organic products, the thickness, cohesiveness, or adhesiveness is not impacted by the "natural ingredients" used. No significant difference was found between Gerber's standard line and Beech-Nut's organic line.

Food Property Differences in Packaging

There is not a statistically significant difference in the thickness or cohesiveness of the foods tested, based on the type of packaging (pouch or jar) the manufacturers used. However, the food in pouches were less adhesive than the food packaged in jars. Therefore, the food packaged in pouches is less likely to stick to the sides of the container, like the food in jars. Adhesiveness is one of the 8 food properties that affects texture and the management of dysphagia. It is conceivable that the food packaged in pouches is slightly easier to consume and requires less oral motor skill as compared to the baby foods from a jar.

Relationship of the Manufacturer's Stages & IDDSI Stages

This study did not find a significant correlation between Gerber and Beech-Nut's marketed stages (one through four) and their IDDSI category (two through five). These results suggest that clinicians cannot base their selection of commercially available baby foods for pediatric patients with dysphagia based solely on the marketed stage.

The incongruence between marketed stage and IDDSI category creates challenges for clinicians and parents in managing children with dysphagia.

Overall Implications

Based on the conclusion that difficulty of developmental first foods is not dependent on marketed stage, brand, or packaging, with the exception of pouches being less adhesive, there is not a clear justification for choosing one brand or stage over another when working with pediatric patients with dysphagia. Gerber level one foods are sold in a pack of two, with a volume of 2 oz per jar, and cost $1.50 ($0.375/ounce).

Level two foods by Gerber can be purchased in packs of two, 4 oz jars for $1.75 ($0.219/ounce), and Gerber's level three foods are sold for $1.99 and contain two, 5 oz jars ($0.199/ounce). Beech-Nut does not increase price or volume as the marketed stage increases. However, presumably due to their use of organic ingredients, one 4.25 oz jar is $1.39 ($0.327/ounce), which is more expensive per ounce, than Gerber's level two and three baby foods. Gerber's line of pouched foods, regardless of stage, contain 3.5 oz of food and are typically $1.49 ($0.426/ounce), while organic pouches contain the same volume and are $1.69 ($0.482/ounce). Price and volume seem to be the only quantifiable differences between the Gerber and Beech-Nut lines of baby foods. Due to the known importance of food difficulty (thickness, adhesiveness, and cohesiveness) in managing and rehabilitating dysphagia in pediatric populations (Garcia and Chambers, 2008), it is suggested that parents of children with dysphagia and clinicians working with children with dysphagia make food selections based on cultural preferences (organic vs regular component ingredients) and cost efficiency and not assume differences in food difficulty/texture based on the individual brand's marketing schema.

The lack of significant difference in food difficulty across brand or marketed stage is likely due to the frequent variation within each stage and brand.

For example, Gerber level one green beans are characterized as an IDDSI level four, but Gerber level one carrots are categorized as an IDDSI level three. More variations can be clearly seen in Tables 4, 5, and 6.

Therefore, due to these inconsistencies, it is proposed that parents and clinicians test foods to determine their IDDSI category before serving them to children with dysphagia that have specific IDDSI level diet recommendations.

The results of this study bring attention to the need for clinician and parent vigilance when choosing commercially available baby foods appropriate for children with dysphagia. Additionally, it is also important for baby food manufacturers to be aware of the IDDSI framework and the incongruence between the IDDSI framework and their current marketing schema.

Awareness of this difference may lead to restructuring of their marketing schema in light of the many inconsistencies found in thickness, adhesiveness, and cohesiveness of foods marketed within the same levels. Gerber made great strides in promoting a spirit of inclusion for children with disabilities, when selecting a child with Down Syndrome to be the new face of their company. However, children with Down Syndrome are often at risk for feeding and swallowing complications and further consideration of the impact of their products on children with dysphagia would encourage a larger conversation among commercial distributors of food for kids. That type of conversation and consideration among developmental first food companies, such as Gerber and Beech-Nut, could lead to the use of a standardized hierarchy of food difficulty to label their foods, in order to accommodate and account for the needs of all of their consumers.

Limitations of the Present Study

The world of developmental first foods is relentlessly changing and growing. Throughout the process of this study Gerber re-branded their marketed stages 1, 2, 3, and 4, to clearly correlate to developmental gross motor milestones. The results of this study were not impacted by the change in branding. However, it is important to note that current flavors may no longer read "Stage 1, 2, 3, or 4" and will now read "Supported Sitter, Unsupported Sitter, Crawler, & Toddler."

Gerber and Beech-Nut introduced several flavors and discontinued many flavors throughout this process as well. Originally, all samples were purchased regionally. However, as local stores discontinued specific flavors, Amazon was used to order samples that were low in stock. Gerber also created an "organic" line after samples had already been chosen for this study.

Conclusions and Future Prospects

Future investigations should compare Gerber's new organic line to its standard line to determine if there is a difference in thickness, cohesiveness, or adhesiveness amongst the two. Prospective studies should also expand on these results to include the effects of heating and cooling on thickness, cohesiveness, and adhesiveness. It is important that subsequent reports also include data from prominent companies aside from Gerber and Beech Nut.

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APPENDIX

Table 1:

Commercially available baby foods locally available by brand, presentation (jar or pouch), and ingredients in stage 1

Baby Food Name	Brand	Presentation	Marketed Stage	Ingredients
Green Bean	Gerber	Jar	1	Vegetable
Peas	Gerber	Jar	1	Vegetable
Carrot	Gerber	Jar	1	Vegetable
Apple	Gerber	Jar	1	Fruit
Banana	Gerber	Jar	1	Fruit
Pear	Gerber	Jar	1	Fruit
Peach	Gerber	Jar	1	Fruit
Prune	Gerber	Jar	1	Fruit
Sweet Potato	Gerber	Jar	1	Vegetable
Butternut Squash	Gerber	Jar	1	Vegetable
Chicken & Broth	Beech Nut	Jar	1	Meat
Turkey & Broth	Beech Nut	Jar	1	Meat
Sweet Potatoes	Beech Nut	Jar	1	Vegetable

Table 2: Commercially available baby foods locally available by brand, presentation (jar or pouch), and ingredients in stage 2

Baby Food Name	Brand	Presentation	Marketed Stage	Ingredients
Carrot	Gerber	Jar	2	Vegetable
Apples	Gerber	Jar	2	Fruit
Sweet Potato Turkey	Gerber	Jar	2	Meat w/ Fruit/Vegetable
Sweet Potato Mango Kale	Gerber	Jar	2	Mixed Fruit & Vegetable
Carrot Mango Pineapple	Gerber	Jar	2	Mixed Fruit & Vegetable
Apple Chicken	Gerber	Jar	2	Meat w/ Fruit/Vegetable
Vegetable Chicken	Gerber	Jar	2	Meat w/ Fruit/Vegetable
Pea Carrot Spinach	Gerber	Jar	2	Mixed Vegetables
Green Bean	Gerber	Jar	2	Vegetable
Apricot Mixed Fruit	Gerber	Jar	2	Mixed Fruit
Peach	Gerber	Jar	2	Fruit
Apple Avocado	Gerber	Jar	2	Mixed Fruit
Pear Zucchini Corn	Gerber	Jar	2	Mixed Fruit & Vegetable
Mac + Cheese	Gerber	Jar	2	Vegetable, Grain, & Dairy
Pear Cinnamon & Oatmeal	Gerber	Jar	2	Mixed Fruit/Vegetable w/ Grain
Chicken Noodle	Gerber	Jar	2	Meat w/Fruit/Vegetable & Grain
Turkey Rice	Gerber	Jar	2	Meat w/Fruit/Vegetable & Grain
Turkey & Gravy	Gerber	Jar	2	Meat
Chicken & Gravy	Gerber	Jar	2	Meat
Bananas	Gerber	Jar	2	Fruit
Pear	Gerber	Jar	2	Fruit
Apple Banana & Oatmeal Cereal	Gerber	Jar	2	Mixed Fruit & Grain
Apple Banana Strawberry	Gerber	Jar	2	Mixed Fruit
Carrot Sweet Potato Pea	Gerber	Jar	2	Mixed Vegetable
Apple Mango & Rice Cereal	Gerber	Jar	2	Mixed Fruit & Grain
Sweet Potato	Gerber	Jar	2	Vegetable
Banana Apple Pear	Gerber	Jar	2	Mixed Fruit
Butternut Squash	Gerber	Jar	2	Vegetable
Pear Pineapple	Gerber	Jar	2	Mixed Fruit
Chicken Rice Dinner	Gerber	Jar	2	Meat w/ Fruit/Vegetable & Grain
Peas	Gerber	Jar	2	Vegetable

Baby Food Name	Brand	Presentation	Marketed Stage	Ingredients
Banana Carrot Mango	Gerber	Jar	2	Mixed Fruit & Vegetable
Pumpkin Banana	Gerber	Jar	2	Mixed Fruit
Sweet Potato Corn	Gerber	Jar	2	Mixed Vegetable
Pear Squash	Gerber	Pouch	2	Mixed Fruit & Vegetable
Apple Blueberry Spinach	Gerber	Pouch	2	Mixed Fruit & Vegetable
Banana Blueberry Blackberry Oatmeal	Gerber	Pouch	2	Mixed Fruit/Vegetable w/ Grain
Peach Pear Strawberry	Gerber	Pouch	2	Mixed Fruit
Pear Spinach	Gerber	Pouch	2	Mixed Fruit & Vegetable
Carrot Apple Mango	Gerber	Pouch	2	Mixed Fruit & Vegetable
Pear Blueberry Apple Avocado	Gerber	Pouch	2	Mixed Fruit
Banana Cinnamon Granola	Beech Nut	Jar	2	Mixed Fruit/Vegetable w/ Grain
Peaches	Beech Nut	Jar	2	Fruit
Apple	Beech Nut	Jar	2	Fruit
Sweet Carrots	Beech Nut	Jar	2	Vegetable
Green Beans	Beech Nut	Jar	2	Vegetable
Banana Blueberry Avocado	Beech Nut	Pouch	2	Mixed Fruit
Apple Sweet Potatoes Pineapple w/ Oats	Beech Nut	Pouch	2	Mixed Fruit/Vegetable w/ Grain

Table 3: Commercially available baby foods locally available by brand, presentation (jar or pouch), and ingredients in stages 3 and 4

Baby Food Name	Brand	Presentation	Marketed Stage	Ingredients
Vegetable Beef	Gerber	Jar	3	Meat w/ Fruit/Vegetable
Vegetable Turkey	Gerber	Jar	3	Meat w/ Fruit/Vegetable
Chicken Itty Bitty Noodle	Gerber	Jar	3	Meat w/ Fruit/Vegetable
JUST Sweet Potatoes Squash & Peas	Gerber	Jar	3	Mixed Vegetable
JUST Apple & Zucchini	Gerber	Jar	3	Mixed Fruit &Vegetable
Banana Raspberry & Yogurt	Beech Nut	Jar	3	Mixed Fruit/Vegetable & Dairy
Apple Mango Strawberry	Beech Nut	Jar	3	Mixed Fruit
Apple Sweet Potato & Cinnamon	Gerber	Pouch	4	Mixed Fruit & Vegetable
Banana Blueberry	Gerber	Pouch	4	Mixed Fruit
Peach Apricot Carrot w/ Yogurt	Gerber	Pouch	4	Mixed Fruit/Vegetable & Dairy
Pear Peach Oatmeal	Gerber	Pouch	4	Mixed Fruit & Grain
Banana Pear Zucchini	Gerber	Pouch	4	Mixed Fruit & Vegetable
Fruit + Yogurt: Very Berry	Gerber	Pouch	4	Mixed Fruit & Dairy
Fruit + Yogurt: Strawberry Banana	Gerber	Pouch	4	Mixed Fruit & Dairy

Table 4:

Thickness, adhesiveness, and cohesiveness in stage 1 baby foods marketed by Gerber and Beech Nut (BN)

Sample	Brand	Packaging	Manufactured Stage	IDDSI Category	Flow Test Mean	Flow Test Standard Deviation	Cohesive Mean	Cohesive Standard Deviation	Adhesive Mean	Adhesive Standard Deviation
Green Bean	Gerber	Plastic	1	4	10	0	1.8	0.42	2	0
Carrot	Gerber	Plastic	1	3	9.77	0.09	0	0	1.7	0.48
Apple	Gerber	Plastic	1	3	9.85	0.08	0	0	1.9	0.32
Peach	Gerber	Plastic	1	3	9.82	0.04	1	0	1	0
Carrots	BN	Glass	1	3	9.19	0.58	0	0	2	0
Apples	BN	Glass	1	3	9.55	0.08	0	0	2	0
Sweet Potatoes	BN	Glass	1	3	8.64	0.64	0	0	1	0
Chicken & Broth	BN	Glass	1	3	9.76	1	0	0	0	0.26
Turkey & Broth	BN	Glass	1	3	9.88	1.2	0.42	1.9	0.32	0.21

Table 5: Thickness, adhesiveness, and cohesiveness in stage 2 baby foods marketed by Gerber and Beech Nut (BN)

Sample	Brand	Packaging	Manufactured Stage	IDDSI Category	Flow Test Mean	Flow Test Standard Deviation	Cohesive Mean	Cohesive Standard Deviation	Adhesive Mean	Adhesive Standard Deviation
Carrot	Gerber	Plastic	2	3	9.68	0.29	0	0	1	0
Apples	Gerber	Plastic	2	3	9.78	0.06	1	0	2	0
Carrot Mango Pineapple	Gerber	Plastic	2	3	8.78	0.32	0	0	2	0
Vegetable Chicken	Gerber	Plastic	2	3	9.94	0.096	0	0	1	0
Pea Carrot Spinach	Gerber	Plastic	2	3	9.86	0.096	1	0	1	0
Green Bean	Gerber	Plastic	2	4	10	0	1.9	0.32	1.5	0.53
Apricot Mixed Fruit	Gerber	Plastic	2	3	9.98	0.063	1	0	1.9	0.32
Peach	Gerber	Plastic	2	4	10	0	0	0	1	0
Apple Avocado	Gerber	Plastic	2	3	9.98	0.06	1	0	1.5	0.53
Pear Zucchini Corn	Gerber	Plastic	2	3	9.26	0.11	0	0	2	0
Mac + Cheese	Gerber	Plastic	2	3	9.99	0.11	1	0	1	0
Pear Cinnamon & Oatmeal	Gerber	Plastic	2	3	9.92	0.03	1	0	1	0
Pear Squash	Gerber	Pouch	2	4	10	0	1	0	1	0
Apple Blueberry Spinach	Gerber	Pouch	2	3	9.94	0.096	1	0	1	0
Banana Blueberry Blackberry Oatmeal	Gerber	Pouch	2	4	10	0	1.4	0.52	1	0

Sample	Brand	Packaging	Manufactured Stage	IDDSI Category	Flow Test Mean	Flow Test Standard Deviation	Cohesive Mean	Cohesive Standard Deviation	Adhesive Mean	Adhesive Standard Deviation
Peach Pear Strawberry	Gerber	Pouch	2	3	9.99	0.03	0	0	1	0
Banana Blueberry Avocado	BN	Pouch	2	3	9.87	0.04	1	0	1	0
Banana Cinnamon Granola	BN	Glass	2	4	10	0	1	0	1	0
Apple Sweet Potato Pineapple w/ Oats	BN	Pouch	2	3	9.96	0.08	0.1	0.32	1	0
Pear Kale Cucumber	BN	Glass	2	3	9.98	0.04	0	0	1	0
Peaches	BN	Glass	2	3	9.4	0	0	1	0	0.16
Apple	BN	Glass	2	3	9.6	0.2	0.42	1	0	0.16
Sweet Carrots	BN	Glass	2	3	9.16	0	0	2	0	0.43
Green Beans	BN	Glass	2	3	9.26	0	0	2	0	0.13

Table 6: Thickness, adhesiveness, and cohesiveness in stages 3 and 4 baby foods marketed by Gerber and Beech Nut (BN)

Sample	Brand	Packaging	Manufactured Stage	IDDSI Category	Flow Test Mean	Flow Test Standard Deviation	Cohesive Mean	Cohesive Standard Deviation	Adhesive Mean	Adhesive Standard Deviation
Banana Apple Strawberry	Gerber	Plastic	3	5	9.98	0.06	0	0	1	0
Roasted Vegetable Chicken & Lil Bits	Gerber	Plastic	3	5	10	0	0	0	1	0
JUST Sweet Potatoes Squash & Peas	BN	Glass	3	3	9.7	0	0	1.1	0.32	0.24
JUST Apple & Zucchini	BN	Glass	3	3	9.99	1	0	1.9	0.32	0.03
Banana Blueberry	Gerber	Pouch	4	3	9.96	0.08	1	0	1	0
Peach Apricot Carrot w/ Yogurt	Gerber	Pouch	4	3	9.86	0.24	0	0	1	0
Banana Pear Zucchini	Gerber	Pouch	4	4	10	0	0	0	1	0