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Research Article

A Comparison of Viscosity Classifications Between the Japanese Dysphagia Diet 2013 Criteria and the International Dysphagia Diet Standardisation Initiative

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Abstract

The aim of this study is to classify thickened liquids into the International Dysphagia Diet Standardisation Initiative (IDDSI) framework by IDDSI flow test and compare the results to Japanese Dysphagia Diet 2013 criteria (JDD2013). We used five different types of thickeners and solvents. JDD2013 is constructed in Mildly Thick, Moderately Thick and Extremely Thick. For the IDDSI flow test, a syringe was filled up to the 10 ml mark and allowed to flow for 10s and judged by 5 criteria. The Mildly Thick liquids in JDD2013 that corresponded as 55% were level 1 in IDDSI and those corresponded as 43% were level 2. The Moderately Thick liquids that corresponded 71% were level 2. The Extremely Thick liquids that corresponded 94% were level 3. None of the liquids corresponded to level 4.

Keywords: *Dysphagia Diet; Thickened Liquid; Deglutition; Deglutition Disorders; Swallowing*

Introduction

In recent years, developed countries around the world have been facing an aging population problem. In 2015, the number of people worldwide aged sixty or over was 900 million [1], this is about 12.3% of the world's total population. It is estimated that people over 65 years old comprised 7.6% of the world population in 2010 and this population will expect to rise to 9.3% in 2020 [2]. Dysphagia is especially related to aging and is more frequent among elderly people [3], meaning instances will increase as the number of elderly people increases. Stroke risk increases with age [4]. Dysphagia is estimated to occur in 29% to 64% of stroke patients [5].

Dysphagia is caused by not only stroke but also Parkinson's disease and inflammation of the tongue and esophagus and so on. Dysphagia is associated with a high risk of malnutrition and dehydration.

The practice of altering food texture to make it easier to eat is adopted by hospitals, nursing homes, and other medical/care institutions, as well as by households that care for dysphagia patients. Demand for dysphagia foods is likely to increase over time. Currently, the United States [6], Australia [7], Japan, and several other countries have a standard framework for classifying dysphagia diets, but each categorizes the liquids by viscosity value differently. The language used to describe dysphagia diets also differs. For example, words like "nectar" are neither used nor understood in Asia. In response to this, the International Dysphagia Diet Standardisation Initiative (IDDSI) was established in 2013 to create a common terminology for dysphagia diets and to create a unified standard framework for worldwide use [8]. Representatives from Europe, North America, South America, Asia, Oceania and Africa constitute the IDDSI. These representatives proposed the IDDSI framework, which is a classification table of dysphagia foods and liquids. In it, dysphagia foods and liquids are categorized into eight levels. Levels 0 - 4 represent liquids and levels 3 - 7 represent foods. Levels 3 and 4 apply to both liquids and foods.

The purpose of the IDDSI is to cross language barriers by using labels, colors, and numbers to enable a common understanding across different cultures. The IDDSI framework describes characteristics, physiological rationales, and testing methods for levels 0 - 4 and proposes the IDDSI flow test. This test is an easy method that utilizes syringes to estimate viscosity.

Many viscosity tests already exist. They focus on measuring viscosity by using viscometers, but are cost-prohibitive. Thus, they are not available to many medical and research institutions. Therefore, developing a simple, readily available measuring method is crucial for a universal measurement method to be adopted worldwide.

In 2013, the Japanese Dysphagia Diet 2013 (JDD2013) was created in Japan. Until then, there was no unified guideline of dysphagia foods in Japan. Many different names and stages existed in different areas and facilities. It was disadvantageous for people with dysphagia and related persons. Therefore, in order to be used commonly by hospitals, facilities, and home, the standardized stage classification was developed for dysphagia diets and thickened liquids. The aim of this study was to compare differences in viscosity ranges between the JDD2013 and the IDDSI framework. We collected thickened liquids from the three JDD2013 levels and classified them according to the IDDSI framework levels by measuring their viscosities by using a flow test.

Materials and Methods

We used five thickeners. three were xanthan gum-based products called Tsururinko-Quickly (Clinico Co., Ltd., Tokyo, Japan), Softia-S (Nutri Co., Ltd., Mie, Japan) and Neo-hightoromeal-Ⅲ (Food Care Co., Ltd., Kanagawa, Japan), one was a guar gum-based product called Hightoromeal (Food Care Co., Ltd., Kanagawa, Japan), and one was a starch-based product called Tromelin-granules (Sanwa Kagaku Kenkyusho Co., Ltd., Aichi, Japan). Five types of solvents were used: distilled water, 1% salt water, a green tea called Oi Ocha Ryokucha (Itoen Co., Ltd., Tokyo, Japan), an orange juice called Bireley's (Asahi Soft Drinks Co., Ltd., Tokyo, Japan), and an enteral nutrient called Ensure Liquid (Abbott Japan Co., Ltd., Tokyo, Japan). Hereafter, the following abbreviations will be used: Tsururinko-Quickly will be X-1, Softia-S will be X-2, Neo-hightoromeal-Ⅲ will be X-3, Hightoromeal will be G, and Tromelin-granules will be S.

Sample Preparation

The solvents were divided into 100 ml batches and the thickening agents were added. The solutions were mixed for 1 min at a rate of 3 rotations/s. Afterward, the solutions were left for 30 min at 20°C. All solutions were mixed once except the enteral nutrient, which received a second mixing in order to stabilize the physical properties (30s mixing → left for 5 min at 20°C → 30s mixing → left for 30 min at 20°C). The thickeners were mixed to 50 mPa·s, 150 mPa·s, 300 mPa·s, and 500 mPa·s (the values according to JDD2013). Average viscosities were within ±5% of each of the target values. If there was more than 5% difference, the solution which was closest to 5% was adopted and the others were not used.

Measurement of Viscosity

All thickened liquids were measured using a rheometer (Rheo Stress 6000; Thermo Fisher Scientific, Germany). The parameters were set to a cone diameter of 35 mm, a cone angle of 1°, and a truncation gap of 52 μm. The temperature of each sample was 20 ± 2°C. Shear rate was adjusted to 50 s^{-1}. Viscosity measurements were repeated three times per sample.

IDDSI Flow Test

The flow test was carried out according to IDDSI guidelines [8]. The syringe (slip tip, 10 ml, diameter of 15.3 mm, length of from 0 line to 10 line is 50.6 mm: Terumo Co., Ltd., Tokyo, Japan) had its plunger removed and was filled to the 10 ml mark. The tip of the syringe was closed with a finger to prevent the sample from leaking out (Figure 1). The syringe was placed perpendicular to the floor. The finger blocking the tip was removed. The liquid was allowed to flow for 10s before the tip of the syringe was closed with a finger again. We recorded the amount of remaining sample in the syringe. Three measurements were recorded per sample, and the average results were classified according to table 1.

Figure 1: *Implementation of IDDSI flow test.*

Level	State
0	All liquid has flowed through syringe.
1	There is between 1 and 4 ml remaining.
2	There is between 4 and 8 ml remaining.
3	There is more than 8 ml remaining, but some liquid still flows through.
4	If no liquid flows at all, the category is Level 4 or above.

Table 1: *Result classification table of IDDSI flow test.*

Results

Table 2 shows thickened additive concentration for all kinds of liquids investigated. From these results, it was found that each thickener needed to be added at different concentrations to reach the same viscosity. Using the results in table 2, syringe residual amounts that JDD2013 criteria were measured and are shown in table 3. The results obtained from table 3 were classified into the IDDSI level (Table 4). The JDD2013 viscosities were classified as follows: Mildly Thick liquids were classified into levels 1 and 2, Moderately Thick liquids were levels 2 and 3, and Extremely Thick liquids were level 3. No solution had a viscosity that corresponded to level 4 of IDDSI. The guar gum thickening agent resulted in lower IDDSI level in the results of water, green tea, orange juice and 1% salt water compared to the other two kinds of the thickening agent, although the viscosity was the same.

	Drink	Thickener	Viscosity (mPa･s)			
			50	150	300	500
Addition Concentration (%)	Water	X-1	0.75	1.55	2.50	3.55
		X-2	0.75	1.55	2.35	3.40
		X-3	0.35	0.80	1.40	2.05
		G	0.75	1.15	1.50	1.85
		S	2.60	3.35	3.90	4.30
	1% Salt Water	X-1	1.25	2.15	2.95	3.75
		X-2	0.95	1.70	2.45	3.25
		X-3	0.65	1.10	1.60	2.05
		G	0.75	1.20	1.55	1.90
		S	—	—	—	—
	Green Tea	X-1	0.70	1.40	2.15	3.30
		X-2	0.75	1.50	2.30	3.25
		X-3	0.40	0.80	1.30	1.85
		G	0.75	1.15	1.55	1.85
		S	3.40	4.50	5.25	5.75
	Orange Juice	X-1	0.75	1.35	2.05	2.85
		X-2	0.70	1.35	2.10	2.95
		X-3	0.40	0.75	1.15	1.60
		G	0.70	1.10	1.45	1.75
		S	2.80	3.85	4.55	5.20
	Enteral Nutrient	X-1	0.90	2.00	3.05	4.05
		X-2	0.80	1.70	2.50	3.30
		X-3	0.55	1.25	1.80	2.20
		G	1.65	3.35	4.55	5.55
		S	1.85	3.25	4.35	5.20

Table 2: *Thickened additive concentration (g/100 ml) for all of the liquids investigated.*

	Drink	Thickener	JDD2013		
			Mildly Thick (50~150 mPa·s)	Moderately Thick (150~300 mPa·s)	Extremely Thick (300~500 mPa·s)
IDDSI Flow Test (ml)	Water	X-1	1.7 - 6.7	6.7 - 9.4	9.4 - 9.9
		X-2	2.1 - 7.1	7.1 - 9.5	9.5 - 9.9
		X-3	1.8 - 7.2	7.2 - 9.4	9.4 - 9.9
		G	1.1 - 4.9	4.9 - 7.8	7.8 - 9.4
		S	3.0 - 7.1	7.1 - 9.1	9.1 - 9.6
	1% Salt Water	X-1	0.5 - 5.4	5.4 - 8.8	8.8 - 9.9
		X-2	1.1 - 6.2	6.2 - 9.2	9.2 - 9.9
		X-3	0.2 - 5.1	5.1 - 9.2	9.2 - 9.9
		G	0.7 - 4.6	4.6 - 7.6	7.6 - 9.3
		S	—	—	—
	Green Tea	X-1	2.4 - 6.9	6.9 - 9.3	9.3 - 9.9
		X-2	2.3 - 6.8	6.8 - 9.4	9.4 - 9.9
		X-3	1.6 - 6.8	6.8 - 9.4	9.4 - 9.9
		G	1.1 - 4.2	4.2 - 7.6	7.6 - 9.2
		S	1.5 - 6.6	6.6 - 9.0	9.0 - 9.7
	Orange Juice	X-1	1.1 - 6.1	6.1 - 9.2	9.2 - 9.9
		X-2	1.6 - 6.3	6.3 - 9.4	9.4 - 9.9
		X-3	1.2 - 6.0	6.0 - 9.4	9.4 - 9.9
		G	1.5 - 5.3	5.3 - 7.8	7.8 - 9.2
		S	1.4 - 5.9	5.9 - 8.9	8.9 - 9.8
	Enteral Nutrient	X-1	1.3 - 4.5	4.5 - 8.3	8.3 - 9.8
		X-2	2.1 - 6.2	6.2 - 7.9	7.9 - 9.7
		X-3	1.2 - 5.4	5.4 - 8.3	8.3 - 9.6
		G	1.5 - 6.4	6.4 - 8.5	8.5 - 9.4
		S	1.1 - 5.1	5.1 - 8.1	8.1 - 9.2

Table 3: *Range of the respective syringes residual amounts.*

	Drink	Thickener	JDD2013		
			Mildly Thick (50~150 mPa·s)	Moderately Thick (150~300 mPa·s)	Extremely Thick (300~500 mPa·s)
IDDSI Framework (Level)	Water	X-1	1,2	2,3	3
		X-2	1,2	2,3	3
		X-3	1,2	2,3	3
		G	1,2	2	2,3
		S	1,2	2,3	3
	1% Salt Water	X-1	0,1,2	2,3	3
		X-2	1,2	2,3	3
		X-3	0,1,2	2,3	3
		G	0,1,2	2	2,3
		S	—	—	—
	Green Tea	X-1	1,2	2,3	3
		X-2	1,2	2,3	3
		X-3	1,2	2,3	3
		G	1,2	2	2,3
		S	1,2	2,3	3
	Orange Juice	X-1	1,2	2,3	3
		X-2	1,2	2,3	3
		X-3	1,2	2,3	3
		G	1,2	2	2,3
		S	1,2	2,3	3
	Enteral Nutrient	X-1	1,2	2,3	3
		X-2	1,2	2	2,3
		X-3	1,2	2,3	3
		G	1,2	2,3	3
		S	1,2	2,3	3

Table 4: *Results from Table 3 categorized into IDDSI levels.*

The results of table 3 were categorized by IDDSI levels into 1 ml, 4 ml, and 8 ml. For example, water X-1, which was Mildly Thick, was 1.7 - 6.7 ml (Table 3). This result is both less than 4 (making 1.7 - 4 level 1 in the IDDSI Framework) and greater than 4 (making 4-6.7 level 2). In other words, water X-1 comprised 46% level 1 and 54% level 2. Details are shown in figure 2.

Table 5 shows that 2% of Mildly Thick liquids were classified into level 0, 55% were level 1, and 43% were level 2. 71% of Moderately Thick liquids were level 2, and 29% were level 3. 6% of Extremely Thick liquids were level 2, and 94% were level 3.

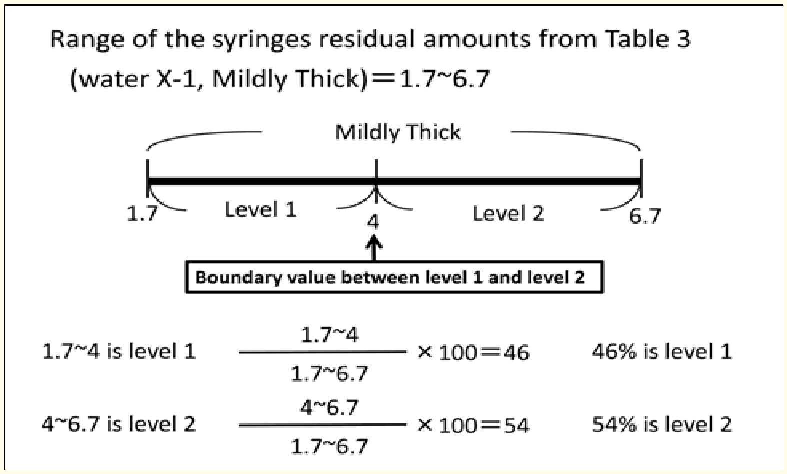

Figure 2: *Method of calculation.*

Mildly Thick		JDD 2013		
		Moderately Thick	Extremely Thick	
IDDSI	Level 0	2	0	0
	Level 1	55	0	0
	Level 2	43	71	6
	Level 3	0	29	94
	Level 4	0	0	0
Total		100	100	100

Table 5: *JDD2013 levels for all thickened liquids categorized into the IDDSI levels.*

Discussion

Fluid thickening is a standard and important technique for dysphagia treatment [9,10]. Thickened liquids are frequently used in the management of oropharyngeal dysphagia because thickening a liquid slows down the rate at which the liquid flows through the oropharynx and reduces the risk of aspiration. Leonard., *et al*. also recorded statistically significant results whereby gum thicken barium liquid (150~170mPas) was lower aspiration rate than liquid barium (4~5mPas) [11].

When we thickened fluids, we consulted the classification of JDD2013, which divides thickened liquids into the categories. We created a total of four types of viscosities at the boundary values of JDD2013's Mildly Thick, Moderately Thick, and Extremely Thick categories. The IDDSI framework classifies viscosities into 5 levels. The entire JDD2013 range nearly exactly corresponds to the IDDSI framework levels 1, 2, and 3. The liquids we created at the boundaries of JDD2013's Mildly Thick category were also classified into the IDDSI framework. 55% were measured as level 1 and 43% were level 2. 71% of our Moderately Thick liquids were classified as level 2. 94% of our Extremely Thick liquids were level 3. The IDDSI framework also contains clear descriptions of the viscosity of each level, which enables comparisons with the JDD2013 categories. Level 1 of the IDDSI framework is described as being able to flow through a straw. Level 2 is described as being able to flow off spoons and to be drunk through a standard bore straw. It is suggested that both of these levels correspond to JDD2013's Mildly Thick category. 71% of our Moderately Thick liquids were classified into level 2. Moderately Thick is denoted as difficult to suck through a standard or wide straw, but level 2 is labeled as being able to be drink through standard straw. Although most of our Moderately Thick liquids corresponded to level 2, they were considered close to level 3.94% of Extremely Thick liquids were classified into level 3. Both Extremely Thick and level 3 liquids start to hold a form. Extremely Thick is described as not being able to flow out from between the teeth of a fork, but level 3 is described as not being able to be eaten with a fork because it drops through the prongs. Extremely Thick corresponds to level 3. However, our results indicate that Extremely Thick is thicker than level 3. In other words, we think that Extremely Thick is closer to level 4. But, the size of the gap of fork tooth is different because JDD 2013 uses disposable forks to judge thicken level, but IDDSI uses metal forks. In this study, none of the liquids corresponded to level 4. Level 4 is described as "The prongs of a fork can make a clear pattern on the surface" of the liquid and the liquid "Holds shape on spoon." It is the thickest category of liquids. The percentage of our results corresponding to the level 0 was very small, only 2% of our Mildly Thick liquids. Level 0 is described as when a liquid "Flows like water," almost the same as unthickened liquid. Therefore, there is a range of viscosity not in JDD2013 that is covered in the range of the IDDSI framework. It was found that the range of thickened liquid used internationally is wider than that of JDD2013.

Measurement of viscosity was performed at a shear rate of 50 s^{-1} to compare around the world. This is based on the research of the NDD [6], Wood [12] and Shama and Shaman [13]. The Japanese Society of Dysphagia Rehabilitation also decided on a shear rate of 50 s^{-1}, based on the research of the Yamagata [14]. Cichero., *et al*. showed that it would be possible to compare data between countries if they utilized a shear rate of 50 s^{-1} [9].

In this study, we used five different types of thickeners and five different solvents. In Japan, xanthan gum-based products are mainstream. However, we used xanthan gum, guar gum, and starch-based products because many different products are used around the world. After the flow test was performed, we found that when we mixed guar gum with water, salt water, green tea, and orange juice, less of the liquid remained in the syringe than when compared to when those solvents were mixed with other thickeners to the same viscosity (Table 3). Namely, despite having the same viscosity, the guar gum sample tended to be lower on the IDDSI scale than the other samples. This is presumed to be due to the tendency that guar gum has closer shear thinning than xanthan gum. The viscosities of xanthan gum sample and guar gum sample were the same value when measuring 50 s^{-1} of viscometer, but we think the IDDSI flow test showed lower shear rate than 50 s^{-1} of viscometer. It is presumed that the viscosity of the guar gum sample is lower than that of the xanthan gum, the flowing down quickly, and the IDDSI level was lowered.

The solvents were water, 1% salt water, green tea, orange juice, and enteral nutrient. The 1% salt water solvent was chosen because 1% salinity is the recommended level for miso soup. We had to do experiments using other solvents in order to achieve results that are useful internationally. When we started the experiment, we thought that the results for mixtures of enteral nutrient would show less liquid remaining in the syringe than those of other solvents, as enteral nutrient slipped quickly because of the high lipid content. However, from our results it was found that all of the solvents left comparable amounts of liquid. The IDDSI method allowed measurement of enteral nutrient almost as accurately as other solvents. This suggests that the IDDSI flow test may have less solvent dependence.

The study began by examining the required amount of thickeners that needed to be added to solutions in order to reach the boundary value viscosities of JDD2013. Table 2 shows the required concentration for each of the solvents. It was found that the amount of added thickener necessary to obtain the same viscosity varies depending on the solvent and the thickener. When someone uses thickeners, it is necessary for them to grasp that the viscosities and properties are different depending on the products [15,16]. We felt that thickener S was the hardest to thicken among the thickeners used. Especially when we added it to the 1% salt water, the viscosity was not stable. Hamlet., *et al*. reported that a starch thickener continues to rise in viscosity even after 30 minutes or more and is not stable [17]. This report is based on apple juice, but even in salt water this property may exist and the viscosity may have varied. Due to the above reasons, thickener S is difficult to handle. Because of their low reproducibility, the solutions made from combining salt water and thickener S were excluded.

In addition to the IDDSI flow test, the line spread test (LST) [18], fork test, and spoon test are used as the simple measurement methods of thickened liquid. LST can evaluate viscosity easily and inexpensively compared to a viscometer. The usefulness of LST has been demonstrated [19], and it is especially excellent in the measurement of xanthan gum-based thickeners [20]. However, high lipid thickened liquids (for example, enteral nutrient) cannot be measured accurately by the LST. In Australia, the fork test is used for classification of thickened liquid. The fork test is a simple measurement method that can be performed with only a fork. However, judgment is made only by visual observation. It is impossible to classify it numerically or objectively, and results may change depending on the fork material. The same can be said for the spoon test. On the other hand, the IDDSI flow test is an inexpensive measurement system. This method uses only syringes, and it is possible to classify the results numerically and objectively. We found the IDDSI flow test to be useful.

In this study, the IDDSI flow test was conducted by only one person. There may have been minor variations in the results owing to human error during stages such as reading the syringe scale and the timing of stopping the stopwatch. Even if the same 10 ml syringes were used, the length may differ depending on the company manufacturing them. We recommend having more consideration about variation of falling speed and residual amounts. Actually, when we tested with syringes of different shapes (length of from 0 to 10 line or nozzle size of the syringes), residual amounts were varied in Mildly Thick but they almost same in Extremely Thick. Currently, IDDSI is studying the detailed shape of syringe.

The thickened liquid easily changes its viscosity depending on how thickeners are put in and mixed and so on. In table 2, thickened additive concentration for all of the liquids is shown, but these results are for reference only. It is desirable for the measurer to measure additive concentrations again each time the liquids are mixed.

The temperature of all thickened liquids was set at 20°C. It is also necessary to study the viscosity of thickened liquids at different temperatures, because there are many types of drinks around the world that served at different temperatures. IDDSI flow test has been proved to categorize a wide range of liquids and It has been found to cope small changes in thickness associated with change in serving temperature [21].

Food and beverages are diversifying day by day, so it is difficult to investigate everything. More and more types of thickeners will also be developed in the future. According to Roger., *et al*. new thickeners should be developed that avoid the adverse effects of fluid thickening [22]. As countermeasures for dysphagia are established with evidence, more detailed research on the IDDSI flow test will proceed, and it is necessary to make a simple method for the test which can be performed with equal accuracy worldwide.

Conclusion

We created thickened liquids of JDD2013's boundary viscosities using 5 types of thickeners and solvents and carried out the IDDSI flow test. As a result, the liquids we created at the boundaries of JDD2013's Mildly Thick category were also classified into the IDDSI framework. 55% were measured as level 1 and 43% were level 2. 71% of our Moderately Thick liquids were classified as level 2. 94% of our Extremely Thick liquids were level 3. In this study, none of the liquids corresponded to level 4. We would like to continue experiments under different circumstances in the future.

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