Effects of Sucking Exercise using Straws on Mouth Rinsing Ability in Children with Down syndrome

Megananda Hiranya Putri[1], Susi Sukmasari[2]*, Eliza Herijulianti[1], Hetty Anggrawati[1], Neneng Nurjanah[1], Arlette Suzy Setiawan[3]

1. Dental Health Department, Politeknik Kesehatan Kementerian Kesehatan Bandung, Indonesia.
2. Paediatric Dentistry and Dental Public Health Department, Kulliyyah of Dentistry, International Islamic University Malaysia.
3. Paediatric Dentistry Department, Faculty of Dentistry, Universitas Padjadjaran, Bandung, Indonesia.

Abstract

Down syndrome (DS) children with facial hypotonus need muscle exercise to improve oral hygiene. Aim:

To investigate the effect of sucking exercises using different shaped straws in Down syndrome children.

The study in 41 DS children at DS Parents Association in Bandung. They scored using the Mouth Rinsing Test Function (MRT-F) scale and taught how to suck water using the straw, then performed at home. Wilcoxon Signed Ranks were used to assess MRT-F scores before and after sucking exercises and Mann-Whitney U test to determine the differences between two different shaped of straws.

The first day of MRF-T scores in circular straws group were 1(30%), 2(35%), 3(20%) and 4(15%), while in straight straws were 1(38.2%), 2(19%), 3(42.9%) and 4(0%) respectively. At the end of the third week the scores were 1(25%),2(25%),3(15%), 4(20%), and 5(15%), while in straight straws were 1(33%),2(19%),3(28.6%), 4(14.3%), and 5(4.8%). The significant difference of MRFT scores before and after exercises were $p<0.05$, while the differences between circular and straight straws were $p>0.05$.

The ability to mouth rinse in DS children was improved after performing water sucking exercises in both groups. However, no significant differences between the straight and circular straw exercises.

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Introduction

Children with DS differ from children without DS by having a third copy of chromosome 21. The condition is known as trisomy 21. This caused by non-disjunction of the chromosome and is the most common genetic cause for mental retardation [1]. The incidence of DS is approximately 1/732 new-borns in the United States [2] and has been reported in people of all races[3]. Live births of children with DS in Georgia in 2012-2016 was highest in Hispanics, followed by whites, blacks and Asian[4]. The excess chromosome 21 alters the genetic balance of the body, causing changes in physical characteristics, intellectual ability, physiological function and neurobiological function from childhood till adult life [5].

Children with DS often exhibit systemic disorders, such as cardiovascular, neurological, immunological, musculoskeletal, and orofacial anomalies [5–7]. One-third of the mid-face is sometimes undeveloped, resulting in class 3 malocclusion, open bite, narrow palate and some dental anomalies [8,9]. Orofacial dysfunction is on account of poor neuromotor control, muscle weakness, dysmorphology and intercurrent illness. In particular, feeding and swallowing are impaired. The functional and anatomical characteristics of DS children as described above have a direct impact on oral health [10].

*Corresponding author:
Susi Sukmasari,
Department of Paediatric Dentistry and Dental Public Health, Kulliyyah of Dentistry, International Islamic University Malaysia.
E-mail: sukmasari@iium.edu.my

Hypotonus or muscle tone weakness is a condition that occurs in the muscles of the body, including the facial muscles. Hypotonus in the facial muscles and lips requires attention and should be an important consideration in oral health. Hypotonia is reduced muscle tone in muscles innervated by facial nerves[11]. This condition is associated with a habit of mouth breathing as a consequence of small nasal cavity size or because of continuous infection in the upper respiratory tract. Mouth breathing causes halitosis (bad breath), mouth dryness (xerostomia), angular cheilitis and/or hypersalivation [8]. Muscle hypotonus generally affects manual movement ability, including movements required in the self-hygiene activities, including bathing and brushing teeth. Restrictions in movement often can cause poor oral hygiene levels. Plaque and food remaining in the oral cavity supports the occurrence of gingivitis and periodontal disease [12]. During tooth brushing, mouth rinsing to thoroughly remove leftover food and plaque is needed. Facial muscle tone weakness in individuals with DS generally causes difficulties with speaking, sucking, swallowing, and mouth rinsing activities [8]. These limitations also cause individuals with DS to have poor access to antiseptic treatment by mouth rinsing. The increased prevalence and severity of periodontal disease in individuals with DS has pushed many researchers to investigate the various factors that are responsible for this disadvantage.

Sucking water through a straw and swallowing produces similar functional patterns to thumb sucking including lip, mentalis and buccinator activity[13] EMGs examination recorded activity of the temporalis (TM), masseter (MM), orbicularis oris (OM), and suprahyoid (SM) muscle groups during these functions. These findings suggest that the active tongue- and jaw-lowering movement may play a primary role in increasing sucking strength during the suckle-feeding period in infants[14]. Sucking deficiency in individuals with DS may result not only from the hypotonicity of the perioral muscles, lips and masticatory muscles, but also a deficiency in smooth tongue movement[15].

The aim of myofunctional therapy as a part of oral motor therapy is to ameliorate muscle tone condition around the oral cavity, especially the muscles involved in nose breathing, chewing food, swallowing, strengthening of the soft palate and the orbicularis muscle tone. Myofunctional therapy consists of techniques performed over time to strengthen the muscles. The techniques used vary, and can include using a labial button, whistle blowing and straw sucking. A research conducted by Saccomanno (2018) on 10 children with DS requiring the children to place a pencil between the nostril and upper lips showed significant improvement in the oral and nasal functions, improved facial appearance, increased lip tone and improved balance coordination [9]. Following the therapy, the children were able to close their lips, showed improvement in swallowing ability, had reinforced nose breathing, and had reduced drooling and angular cheilitis.

Previous studies under the POTADS Foundation (Parents' Association for Children with DS) regarding the effect of oral health education modules on the knowledge and skills of 32 parents with DS children showed increased parent understanding about the teeth and oral condition of their child and improved parental skills in managing the child's oral health[16] . Out of the 32 children with DS, approximately 20% showed characteristics of facial hypotonus, including open mouth and mouth breathing, thus indicating that the child had sucking difficulties. Based on the above reasons, we sought to investigate the effect of sucking exercises using different shaped straws in DS children with hypotonus on improved oral health through the improvement of sucking and mouth-rinsing ability.

Materials and methods

Ethical approval

Ethical approval was obtained from the Tasikmalaya Health Research Ethics Committee under the Indonesian Ministry of Health (number 3278012P). Before commencement of the study, permission was obtained from POTADS. Written informed consent from the parents/caregivers of eligible Down syndrome children was obtained.

Data collection

Participants

The study was conducted at POTADS. Out of 97 children with Down syndrome who were member of POTADS, 46 children are sought who are included in the inclusion criteria. The inclusion criteria are as follows: a. Children diagnosed with Down Syndrome aged 3 to 9 years, b. Clinically the child has hypotonia

characterized by a closed upper lip, tends to breathe through the mouth, dry lips or children with Down Syndrome with a habit of cleating, c. Children's mouth rinsing score at score 1 - 3 (MRT-F scale). The exclusion criteria were uncooperative children and parents and children with MRT-F's score at 4-5. The participants were randomly divided into 2 groups; one group consisting of 20 participants were designated the circular group and 21 participants were designated the straight group. Calibration process between 6(six) investigator using MRT-F scale was done prior study commencement.

Sucking exercises

Preliminary data was retrieved by observing how the participants rinsed; the activity was scored and recorded in the observation sheet. Parents and their children were taught how to suck plain water using straight straws. The amount of water to be sucked was 150 ml. The duration provided for completion of the sucking activity was about 1 hour to allow more time for children who were unable to finish sucking in a single activity. The investigators explained how to fill the observation sheet to the parents.

After ensuring that the parents understood their duties at home i.e., monitoring and supporting the child during the sucking exercises performed 3 times a day for 21 days, parents were given the observation sheets and were instructed to continue the exercises at home. The tools and materials provided in this study were straight stainless-steel straws and circular stainless-steel straws, a plastic mouthwash bowl, a mirror, and the observation sheet to record outcomes of the sucking exercises. Researchers also provided parents with observation sheets for mouth rinsing activities. The parents were supervised on how to fill the observation sheet with data on their child's oral exercise at home.

Home observation:

Children in the control group practiced sucking water using straight straws, while children in the intervention group practiced sucking water using circular straws. The parents supervised the children's rinsing in the morning and evening after brushing the child's teeth. Then, the parents filled up the observation form for their child's mouth-rinsing ability scores. Investigators and parents met up on day 7, 14 and day 21 after the start of the home exercise to compile the observation forms. All the data collected and kept by investigator, the data key in and analyse without patient's name.

Instrument fabrication

Straight and rotating straw models were produced under consultation of the Bandung Manufacturing Polytechnic Department of Metal Casting Engineering. Straws were produced from food-grade stainless steel that was safe for use in food and beverage. The final length of both straws was kept the same, i.e., 20 cm (Figure. 1).

Figure 1. Straight and Circular Stainless-Steel Straws.

Scoring of mouth rinsing ability

Mouth Rinsing Test Function scale (MRT-F scale)

The participants' mouth rinsing ability before and after the sucking exercises was observed and scored by investigators using the MRT-F Scale. The child was asked to sit in an anteflexion position and instructed to imitate the investigator's mouth rinsing demonstration. The mouth rinsing demonstration was given as follows: a) Transferring 10 ml of water from the bowl into the mouth, b) Closing the lips and holding the water in his/her mouth, c) Moving both cheeks symmetrically, d) Moving the cheeks alternately, and e) Discarding the water into the sink.

The children were observed and assessed for their abilities from putting water in their mouths to discarding the water. The MRT-F scale was scored as follows: Score 1: Can't put water into the mouth; Score 2: Water may be put into the mouth, but the child swallows or spits out the water; Score 3: Water is stored in the mouth, and can only be snuffed out symmetrically; Score 4: Water can be snuffed out throughout the oral cavity asymmetrically but wasted out, or can be snuffed out asymmetrically but slowly, Score 5: Water can be thoroughly snuffed out asymmetrically throughout the oral cavity. According to the MRT-F scale scores, the children were categorized into 2 groups: children with scores of 1-3 were referred to as the symmetry group, and those with scores 4-5 were included in the asymmetry group[17].

Statistical analysis

The Wilcoxon Signed Ranks Test was used to assess mouth rinsing ability before and after being given water sucking exercises. The differences in mouth rinsing ability between children who were given water sucking exercises with straight straws and circular straws was analysed using Mann-Whitney U test.

Results

Out of 46 selected children who had score of less than 4 on the MRT-F scale, 5 participants did not continue the study because 1 was on surgery waiting schedule, 2 were exposed to Varicella (chickenpox), 1 refused to suck using the stainless-steel straw, and 1 was found to have a level 5 mouth rinsing score. 41 participants consisted of 26 children between 3 - 6 years of age and 15 children between 7-9 years of age. The participants were 22 boys and 19 girls.

Table 1 shows scores for mouth rinsing ability of the participants as measured by the MRT-F scale at the beginning of the experiment. Most of the children scored 1 on the MRT-F scale, with average scores ranging between 1s-3.

		Groups N (%)		
		Circular straw	Straight straw	Total N (%)
MRT-F-scores	1.00	10 (50.0)	14 (66.7)	24 (58.5)
	2.00	5 (25.0)	3 (14.3)	8 (19.5)
	3.00	5 (25.0)	4 (19.0)	9 (22.0)
Total		20 (100.0)	21 (100.0)	41 (100.0)

Table1. Participants' mouth rinsing ability before water sucking exercises**.**

Table 2 shows scores for mouth rinsing ability of the participants in both groups as measured by the MRT-F scale at the end of the first week. Scores were in the range of 1-3. The scores for treatment group were relatively improved; four children who scored one at the beginning of the experiment scored higher to 2 and 3. For the control group, two children had score improvements from their initial scores of 1.

		Groups N (%)		
		Circular straw	Straight straw	Total N (%)
MRT-F scores	1.00	6 (30.0)	12 (57.1)	18 (43.9)
	2.00	7 (35.0)	2 (9.5)	9 (22.0)
	3.00	7 (35.0)	7 (33.3)	14 (34.1)
Total		20 (100.0)	21 (100.0)	41 (100.0)

Table 2. Participants' mouth rinsing ability after 1week of water sucking exercises.

Table 3 shows scores for mouth rinsing ability of the participants as measured by the MRT-F scale at the end of the second week. Children in the treatment group scored between 1-4 on the MRT-F scale. For the control group, the children still scored in the range of 1-3 on the MRT-F scale. However, an improvement in scores from 1 to 2 and 3 was observed in the control group.

		Groups N (%)		
		Circular straw	Straight straw	Total N (%)
MRT-F scores	1.00	6 (30.0)	8 (38.1)	14 (34.1)
	2.00	7 (35.0)	4 (19.0)	11 (26.8)
	3.00	4 (20.0)	9 (42.9)	13 (31.7)
	4.00	3 (15.0)	0 (0.0)	3 (7.3)
Total		20 (100.0)	21 (100.0)	41 (100.0)

Table 3. Participants' mouth rinsing ability after 2 weeks of water sucking exercises.

Table 4 shows scores for mouth rinsing ability of the participants as measured by the MRT-F scale at the end of the third week. The participants' mouth rinsing score fell between 1-5 on the MRT-F scale for both groups.

		Groups N(%)		
		Circular straw	Straight straw	Total
MRT-F scores	1.00	5 (25.0%)	7 (33.3%)	12 (29.3%)
	2.00	5 (25.0%)	4 (19.0%)	9 (22.0%)
	3.00	3 (15.0%)	6 (28.6%)	9 (22.0%)
	4.00	4 (20.0%)	3 (14.3%)	7 (17.1%)
	5.00	3 (15.0%)	1 (4.8%)	4 (9.8%)
Total		20 (100.0%)	21 (100.0%)	41 (100.0%)

Table 4. Participants' mouth rinsing ability after 3 weeks of water sucking exercises.

	Numbers of participants with improved mouth rinsing ability	Z	Sig. (P)
End of 1st week	6	-2.449	0.014
End of 2nd week	8	-2.714	0.007
End of 3rd week	14	-3.407	0.001

Table 5. Differences in mouth rinsing ability before and after water sucking exercise using circular straw.

Figure 2 shows that 7 (seven) participants in the treatment group and 3 (three) children in the control group achieved scores 4-5 on the MRT-F scale. MRT-F scores of 4-5 indicated that the participants were able to hold the water in their mouths and asymmetrically snuffed.

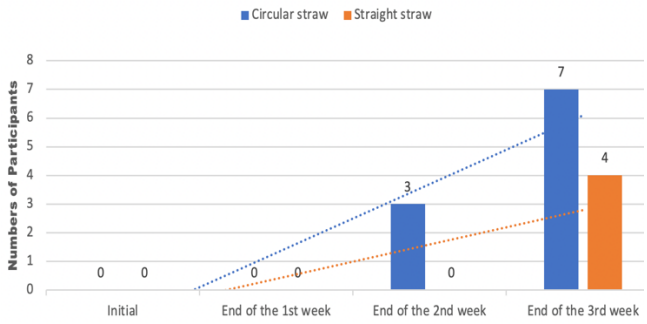

Figure 2. The numbers of Down syndrome children scoring 4-5 for mouth rinsing ability.

The Wilcoxon Signed Ranks test results in Table 5 shows that there is a significant difference ($p < 0.05$) in mouth rinsing ability before and after water sucking exercises using circular straws at the end of each week.

From the Wilcoxon Signed Ranks Test results in Table 6 , it can be concluded that at the end of week 1, there was no significance improvement in mouth rinsing ability ($p>0.05$); however, at the end of weeks 2 and 3, significant differences in mouth rinsing ability were observed in the participants after performing sucking exercises using the straight straw ($p<0.05$).

	Numbers of participants with improved mouth rinsing ability	Z	Sig. (P)
End of 1st week	4	-1.890	0.059
End of 2nd week	8	-2.598	0.009
End of 3rd week	13	-3.307	0.001

Table 6. Differences in mouth rinsing ability before and after water sucking exercise using straight straw.

Based on the results of Mann-Whitney test calculations in Table 7, overall test results showed p-value >0.05, indicating no differences in mouth rinsing ability between the participants who used circular straws compared to participants who used straight straws in the sucking exercises at the beginning of the study, end of week 1, end of week 2 and end of week 3.

Groups		N	Mean Rank	Z	Asymp. Sig. (2-Tailed)
Initial mouth rinsing ability	Circular straw	20	22.63	-0.959	0.338
	Straight straw	21	19.45		
End of 1st week	Circular straw	20	22.98	-1.107	0.268
	Straight straw	21	19.12		
End of 2nd week	Circular straw	20	21.65	-0.356	0.722
	Straight straw	21	20.38		
End of 3rd week	Circular straw	20	22.50	-0.803	0.422
	Straight straw	21	19.57		

Table 7. Differences in mouth rinsing ability of participants after water sucking exercise using circular vs straight straws.

Discussion

Regular toothbrushing and flossing has been proven globally to prevent oral diseases such as dental caries and gingivitis. Besides toothbrushing and flossing, mouth rinsing can be used to complete the measures needed to maintain good oral hygiene and prevent oral diseases. In Japan, about 30% of all children currently practice fluoride mouth rinsing [18].

Mouth rinsing using plain water can expel food remains, dirt and plaque after toothbrushing. Mouth rinsing with mouth-rinse containing antimicrobials can help prevent bad breath and reduce plaque and gingivitis, reducing the incidence of tooth decay in children. Mouth rinsing can also improve visual attention in

children[19] and improve endurance in athletes when coupled with a carbohydrate-based mouthwash agent [20,21]. It can also be used as a method for the delivery of pain relief drugs and management of xerostomia when coupled with fluoride containing mouthwash[22] Based on these benefits, mouth rinsing ability is important for children with DS who commonly encounter problems such as xerostomia due to mouth breathing[8] and are at a higher risk of developing caries and periodontal disease[12,23]. However, due to their predisposition to hypotonia in the facial muscles and tongue[8,14,24] larger tongue size[25,26], posterior open bite [27] and borderline or low IQ [2], children with DS often have difficulties in their ability to mouth rinse thoroughly. Difficulty in mouth rinsing and swallowing is associated with poor chewing ability, which reduces the natural teeth cleaning processes. Consequently, patients with this syndrome suffer from halitosis, discomfort during chewing and early loss of permanent teeth [3,8].

The muscles involved during sucking activity and mouth rinsing are the temporalis, masseter, orbicularis oris and suprahyoid muscle groups. Hypotonus in the orbicularis oris muscle of children with DS makes it difficult for them to close their mouths and difficult to perform the necessary push and pull movements during mouth rinsing activity[24]. Active tongue and jaw movement play an important role in increasing sucking strength during the suckle-feeding period in infants. However, the tongue and jaw functions in DS children are impaired during feeding action. The results of our study indicate that most DS children score 1 on the MRT-F scale before starting on any straw sucking exercises [17]. Score 1 indicates that the child was unable to hold water in their mouth; the water was immediately wasted out of the mouth or swallowed in less than 10 seconds. Therefore, this anomaly pathway needs to be monitored and treated as early as possible. Fortunately, total muscle activity, especially the suprahyoid muscles increase with age[28]

Muscle strength can be increased with regular and measurable exercise [17,29]. Sucking exercise as a myofunctional therapy improves facial muscle function around the oral cavity [9,29]. In this study, sucking exercises applied to DS subjects showed improved mouth rinsing ability in both groups. Although scores for mouth rinsing ability remained between 1-3 at the end of week 1, the number of subjects capable of score 3 mouth rinsing ability had increased, indicating improvement in mouth rinsing ability compared to the initial of the experiment. At the end of week 2, three subjects in the circular group were able to achieve score 4, while participants in the control group still scored 1-3. Three participants in the circular group and one participant in the control group were able to successfully achieve score 5 by the end of week 5.

Although there is no clear link proving that sucking exercises using a circular straw improves facial muscle performance, significant improvement in mouth rinsing ability was recorded every week compared to the initial ability in both groups. The results show that sucking exercises can be used as part of myofunctional therapy to strengthen the facial muscles that support the ability to mouth rinse. The exercises allowed the child to be able to close his mouth and perform the necessary pushing and pulling movements with their lips to perform the mouth rinsing activity. Besides improving mouth rinsing ability, the exercise may help children with DS to hold in saliva in the oral cavity and minimize drooling. Although the American Dental Association (ADA)[22] does not recommend the use of mouth rinsing agents that contain antimicrobial ingredients in children below 6 years-old, strengthening the facial muscles at a younger age can prepare the child for their future oral hygiene practice needs. In this study, sucking exercise followed by retaining water in the mouth and moving the cheeks asymmetrically to improve mouth rinsing ability in DS children showed promising results.

In this study, the participants achieved good sucking habits via performing the routine exercises under the supervision of their parents or guardians. In athletes, muscle strength improvement is observed after training 3 times a week for up to 8 weeks. Although muscle training duration in our study was performed in 3 weeks/21 days; in children with Down's Syndrome, early intervention is the most important factor for success [15]. Stimulation to strengthen the muscle tone needs to start from the first 1-year period of the child's life, followed by a period span of 1-5 years. Compared to infants without DS, infants with DS need more time to acquire certain motor development skills [30]. This stage can be assumed as initiation phase when new habit attempt starting to be formed. It

seems the instruction was simple, and the participants could understand and performed willingly. However, to culminate the stability phase, the training should be continued under parents supervision and review by investigator.[31]

The findings of our study can be extended to other aspects of children's skills requiring facial muscle strength. For example, the sucking exercise may help prepare children for better gargling skills, which is recommended for clearing out the oral cavity and can prevent microorganisms from reaching the respiratory track, causing diseases. This is an important skill especially now in the COVID-19 pandemic to prevent infection. However, need more specific training to reach the gargling skill in children with DS to prevent choking.

For future studies, we suggest increasing study group size and analysing the effect that intellectual ability, hypotonus severity as measured by muscle tone and sensorimotor stimulation [29], access to orthodontic treatment [10] and parent-child interaction[32] has on outcomes of the sucking exercise.

Conclusions

The ability to mouth rinse in DS children was improved after performing water sucking exercises in both groups. However, no significant differences between the straight and circular straws exercises.

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Declaration of Interest

The authors report no conflict of interest.

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