

Two mastication tests used in children with Down Syndrome: a feasibility study

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Nederlandse samenvatting

Titel: Twee kauwtesten bij kinderen met Down Syndroom: een haalbaarheidsstudie.

Achtergrond: Kinderen met Down Syndroom (DS) hebben grote kans op problemen bij het kauwen en slikken. Voor kinderen met DS zijn er geen objectieve tests beschikbaar die kijken naar de functie van en het uithoudingsvermogen tijdens het kauwen. In deze studie is de haalbaarheid van twee kauwtesten bekeken. De Test of Mastication and Swallowing of Solids-Children (TOMASS-C) geeft informatie over de kauwfunctie. De 6-minuten kauwtest (6MKT) geeft informatie over het volhouden van de kauwbewegingen.

Onderzoeksvragen: Ten eerste: zijn de TOMASS-C en de 6MKT geschikt om af te nemen bij kinderen met DS? Daarnaast: geven deze testen informatie over de kauwfunctie en het volhouden van de kauwbewegingen bij deze kinderen?

Methode: Een groep van 24 kinderen (4-18 jaar) met DS participeerde in de studie. De volgende variabelen zijn gemeten in de TOMASS-C: totale kauwtijd, het aantal happen (AH), aantal kauwbewegingen (AKB) en het aantal slikinzetten (ASI). De interbeoordelaarsbetrouwbaarheid van de variabelen AH, AKB en ASI is berekend om de betrouwbaarheid te beschrijven. De volgende variabelen zijn gemeten in de 6MKT: het totaal aantal kauwbewegingen en het percentageverschil tussen minuut 1 en 6. Daarnaast is er een kwalitatieve beoordeling van de kauwbewegingen gedaan. Participanten hebben een visueel analoge schaal ingevuld voor pijn en vermoeidheid. In beide testen is er een vergelijking gemaakt met een normaal ontwikkelende groep. De variabelen zijn verzameld door middel van video-opnamen tijdens de afname van beide testen.

Resultaten: TOMASS-C: 83.3% van de participanten slaagde er in de test te voltooien. 6MKT: 87.5% van de participanten slaagde er in de test te voltooien.

Conclusie: Beide testen zijn geschikt voor kinderen met DS. De testen geven informatie over de functie en het volhouden van het kauwen bij kinderen met DS. Kinderen met DS hebben geen problemen met het volhouden van het kauwen. De kauwproblemen komen voort uit problemen in de efficiëntie van het kauwen.

Aanbevelingen: In tegenstelling tot TD kinderen, kost het de logopedist veel energie om de testen af te nemen. De logopedist moet hier goed op voorbereid zijn.

English Abstract

Title: Two mastication tests used in children with Down Syndrome: a feasibility study.

Background: Children with Down Syndrome (DS) can have problems with chewing and swallowing. However, no objective tests are available which give information about the function and endurance of mastication. In this study, the feasibility of two mastication tests is measured.

Research questions (RQ): Are the Test of Mastication and Swallowing of Solids-Children (TOMASS-C) and the 6-Minute Mastication Test (6MMT) feasible to use in children with DS? Do these tests give information about the function (efficiency) and mastication endurance in these children?

Method: A total of 24 (4 – 18 years) children with DS participated. The collected variables in the TOMASS-C were masticatory time (MT), number of bites (NB), masticatory cycles (MC) and number of swallow acts (NSA). The interrater correlation coefficient (ICC) of NB, MC and NSA were calculated to measure the reliability. Collected variables in the 6MMT were total masticatory cycles (TMC) and percentage difference between minute 1 and 6 (DMC). Furthermore, qualitative ratings of masticatory movements were made. Participants completed a visual analogue scale. In both tests, a comparison to a typically developing (TD) group was made. The variables were generated through video recordings during both tests.

Results: TOMASS-C: a total of 83.3% completed the test. 6MMT: a total of 87.5% completed the test.

Conclusion: Both tests are feasible for children with DS. Both tests give information about the function and endurance during mastication in children with DS. Children with DS do not have problems in endurance during mastication. Their problems in eating are caused by an ineffective way of mastication.

Recommendations: The speech- and language therapist (SLT) needs to be extra prepared to complete both tests in children with DS.

Keywords: children, Down Syndrome, mastication, Test of Mastication and Swallowing of Solids-Children, 6-minute Mastication Test

Introduction

In children with feeding and swallowing problems, to date, the clinical assessment mainly consists of observations with subjective scores. There are no objective tests available which give information about the function and endurance of mastication. Recently, two mastication tests are developed. The first test measures the function of mastication, the second measures the endurance of mastication. For the first test, Maggie-Lee Huckabee developed an easy to administer mastication test for adults which is easy to perform: the Test of Mastication and Swallowing of Solids (TOMASS) (article in preparation). This test gives information about the masticatory function (masticatory performance). Masticatory performance is defined as objective masticatory function: the capacity of a person to fragment solid food (1). In the TOMASS the participant is asked to eat a cracker twice and to do so as fast as possible. The department of speech- and language therapy for children of the Radboudumc in Nijmegen, the Netherlands, obtained permission to adapt this test especially for children: the Test of Mastication and Swallowing of Solids-Children (TOMASS-C). For typically developing (TD) children, the standard scores for this test were collected in the spring of 2015 (Registration CMO 2015-1652). The second test for mastication is the 6-Minute Mastication Test (6MMT). During this test, the participant is asked to chew for 6 minutes on a chewing tube, on one side of the mouth. This test gives information about the endurance of mastication. For TD children aged between 7 and 11 years old, the standard scores for this test were collected in December 2014 (2) and until December 2015 for TD children aged between 5 and 18 years old (3).

In the clinical assessment of children with mastication and swallowing problems attending the department of speech and language therapy for children of the Radboudumc, these tests are part of the standard test set. With these tests, the speech and language therapist (SLT) can give a quantitative and objective judgment. Moreover, the oral motor problems can be explained and the SLT can propose therapy. However, to assess the mastication performance and endurance in children with Down Syndrome (DS), no objective tests are available.

In the Netherlands, the birth prevalence of DS is estimated to be 10 to 14 per 10.000 live births and it is the most common genetic disorder among new-borns (4). The syndrome is associated with intellectual disability (4). Because of appropriate health and social care, the life expectancy of children with DS has increased intensively over the last century (5).

Apart from having a syndrome which causes delayed psychomotor development, children with DS can have problems with chewing, drinking and swallowing due to impaired oral-motor function

(4). This dysfunction includes dental anomalies, deminished neuromotor control and orofacial dysmorphology (6). The mid-third part of the face is underdeveloped, but the mandible has a normal development (7). Due to overall hypotonia, the tongue and lips are hypotonic. The tongue has inefficient lingual lateralization and takes up a low and anterior resting position in the mouth. This makes the tongue seems abnormally large (7). The temporomandibular joints are reported to be lax (6).

For children growing up with DS, it may be difficult to achieve a mature mastication and swallowing function (8,9). In TD children, the mouth is closed before mastication, so food is held in the mouth (10). Mastication consists of a lateral and rotating movement of the tongue and mandible: the masticatory cycle (10). Total time needed for mastication during the formation of the food bolus, is defined as masticatory time. For adults with DS, the masticatory time is increased. Allison et al. (2004) described observations about masticatory time and masticatory cycles of some foods. The mean masticatory time for healthy adults (mean age = 22,9 ± 6.6 years) of 12.92 seconds when eating a sausage. In contrast, adults with DS (mean age = 31.6, ± 8,5 years) have a mean masticatory time of 18,49 seconds during eating a sausage (11).

In persons with DS, masticatory time is increased by insufficient oromotor coordination due to small and arrhythmic jaw movements (7-9). Besides, Spender et al. (9) noted frequent pauses within the masticatory cycle. In addition, due to an excessive vertical opening the occlusal contact area is reduced (7,12), which negatively affects masticatory time and efficiency as well. Moreover, reports have shown that tongue lateralization and collecting food into a bolus are inefficient (11,13). Controlling the food bolus from the lips to the pharynx may be difficult due to poor coordination (8,9). At the same time, silent aspiration is shown to be a problem in children with DS, with liquid and semi liquid food reaching the bronchi (8).

In 4-to 5-year-old children with DS, video recordings showed that tongue protrusion during eating in this population is marked (14). Food is held in the mouth longer than in control participants, whether the food is solid, semi-solid or pureed. Young adults with DS have a significantly lower mean mastication frequency, a significantly higher number of masticatory cycles with open mouth and refused more food types compared to controls (11,13,15). In other words, the masticatory performance of children with DS is limited. However, no objective mastication tests in children with DS are available.

Problem statement

It is essential to determine quantitative measures of the mastication performance and endurance to give a clear diagnosis and direction to the therapy. At the moment, the mastication tests are being developed for children with problems in oral-motor functioning. In children with DS, the standard values for mastication performance and endurance are unknown. Therefore, it is necessary to investigate if it is possible to use the 6MMT and the TOMASS-C in children with DS. The purpose of this study is to explore whether these tests are suitable for children with DS with sufficient language comprehension to understand the tasks.

Aim

The primary objective was to determine if it is feasible to use the TOMASS-C and 6MMT in children with DS between 4 – 18 years old.

The secondary objective was to determine if both tests give information about the function (efficiency) and endurance during mastication in these children.

Research Questions

1. Are the TOMASS-C and the 6MMT feasible to use in children with Down Syndrome between 4 – 18 years old?*
2. Do these tests give information about the function (efficiency) and endurance in mastication in these children based on a comparison to a typically developing group?

Additional, the intraclass correlation coefficient of the TOMASS-C is computed.

* Both tests are feasible when 80% of the participants is able to complete the test.

Method

Design

The study was a feasibility study.

Population and Domain

Children with DS were approached by their own SLT to participate in the study in their practice. The participants were all aged between 4 – 18 years and, because they had to understand the tasks, had a minimum language comprehension of 3;0 – 3;6 years of age. They have received or still are receiving speech and language therapy for problems in oral-motor functioning. Children with a feeding tube or gluten allergy were excluded. In addition, children who were at risk of choking or children who were only allowed to eat thick liquid food, were excluded. In both tests, the participants were compared to a TD group (3) (16).

Procedures

In both tests, the own SLT gave the instructions to the participant following a standardized protocol. In the TOMASS-C, the participant was asked to drink 100 millilitres of water. Then, the participant was asked to eat a cracker twice and to do this as quickly as comfortably possible and to say his own name when he had finished. In the 6MMT, the participant was asked to chew for six minutes on a chewing tube, on one side of the mouth. The participant could hold the chewing tube with his hand if he wanted to. The SLT sat behind the child and held the chewing tube during six minutes. After every minute, the SLT gave information about the remaining time. If needed, a time-timer was used for visual support. During the test, the participant was allowed to watch a short movie. After the 6MMT, the participant filled in a face scale for masticatory pain and fatigue, see figure 1. The face scale score was converted to a visual analogue scale (VAS) score. In contrast to the standard VAS scores after the 6MMT (Van den Engel-Hoek et al., article in preparation), the participants did not fill in the VAS score after 5 minutes. These scores appeared to be unreliable in children with DS because in TD children these scores appeared unreliable too (Van den Engel-Hoek et al., article in preparation).

In a short structured questionnaire, general information about gender, age and mastication skills was collected from the participants' parents.

Materials

The chewing tube, used in the 6-minute Mastication Test, was 12 – 15 centimetres long, 1 centimetre thick and had a resistance level 3 (Theratube©). After chewing, the tube was boiled for 5 minutes in water with lemon juice. In the TOMASS-C, 5x5 centimetre crackers of the brand LU were used.

Variables

The main study parameter was the ability for the participants to perform the TOMASS-C and the 6MMT.

Data collected from the TOMASS-C included the total time needed to eat a cracker (mastication time, MT), number of bites needed for eating a cracker (NB), number of masticatory cycles (MC – number of closing masticatory actions during the MT period) and the number of swallowing acts needed for eating the cracker (NSA). In addition, data about the total time needed (TT) and the number of swallow acts (NSAW) needed for drinking 100 millilitres of water was measured as well.

The variables collected from the 6MMT included the total masticatory cycles in 6 minutes (TMC) and the percentage difference in masticatory cycles between minute one and minute six (DMC). There was a qualitative rating of the masticatory movements in rhythm and size of the movements. Moreover, VAS-scores for pain and fatigue were collected.

Data collection

Both tests were video recorded in high definition by a Canon Eos 1100D digital SLR camera by the first author. The mastication movements were videotaped laterally with a good view on the mandibular movements. When the researcher was not able to count one of the parameters in regular motion, the videos were played back in slow motion using Windows Movie Maker.

Reliability

Both authors scored the first video. When discrepancies existed, the authors reached consensus after deliberation. The first author scored the other 23 videotapes. In the TOMASS-C, a second reviewer scored four cases (16,7%) to test the interrater reliability.

Statistical analysis

First, the percentage of completed tests was computed. Descriptive statistics were used to document the general characteristics of the participants.

In the TOMASS-C, the participants were divided into five age groups to make a comparison with the TD group: 4:0 – 5:11 years old (group 1); 6:0 – 7:11 years old (group 2); 8:0 – 9:11 years old (group 3), 10:0 – 13:11 years old (group 4) and 14:0 – 17:11 years old (group 5). The DS groups were compared to the TD groups using an one sample T-test. The intraclass correlation coefficient (ICC) of the first and second reviewer were computed.

In the 6MMT, the participants were divided into two age groups to compare the DS group with the TD group: 4:0 – 8:11 years old (group A) and 9:0 – 17:11 years old (group B). For both groups, the TMC and DMC scores were converted into z-scores using the equation below table 5. Mean and standard deviation of the z-scores were computed. A qualitative rating of the masticatory movements based on rhythm and size was made. Descriptive statistics were used to document the numeric VAS scores.

Ethical issues

This study was approved by the Committee on Research Involving Human Subjects of Arnhem and Nijmegen. Informed consent was obtained from the parents of the participants. Both tests were fulfilled during a regular visit to the SLT.

Results

Participants

The study group consisted of 24 children with DS, age range (years : months) 4:7 – 17:11 (mean age $9:7 \pm 3:9$ years), 13 females and 11 males. The characteristics of the participants are shown in table 1. All the participants lived at home.

Fourteen participants had swallowing problems in the past, seven participants still experience swallowing problems. All participants received speech and language therapy for oral motor skills in the past. Ten participants suffered recurrent respiratory infections or pneumonia regularly. For all data of the questionnaire, see table 2.

Feasibility

In the TOMASS-C, a total of 20 participants could complete the test (83.3%). In the 6MMT, a total of 21 participants could complete the test (87.5%).

Results of the TOMASS-C

In a total of 4 randomly selected cases (16.6%), a second reviewer scored the number of bites, mastication cycles and number of swallowing acts in both crackers to compute the intraclass correlation coefficient (ICC). MC (ICC = .989 – .996) and NB (ICC = .933 - .995) have an almost perfect correlation (ICC \geq .81). NSA (ICC = -.421 - -.179) has a poor effect (ICC \leq .0) (17). A total of 3 participants could not completely eat the first cracker in the TOMASS-C; two in group 3 and one in group 4. A total of 4 participants could not finish the second cracker in the TOMASS-C; one in group 2 and the same participants who failed to eat the first cracker completely. Descriptive statistics are shown in table 3.

Using an one-sample T-test, all of the parameters (cracker 1 and 2) from the DS groups were compared with the TD groups. As shown in table 4, MT in cracker 1 in the DS group differed significantly from the TD group in groups one, four and five. NB did not differ in all of the groups. MC in the DS group differed significantly from the TD group in groups one, four and five. NSA differed in all groups except group 1. In cracker 2, fewer significant differences were found. MT in the DS group differed significantly from the TD group in groups one and four. NB did not differ in any of the groups. MC in the DS group differed significantly from the TD group in group four. NSA differed significantly from the TD group in groups one, two and four.

Results of the 6MMT

Three participants could not complete the 6MMT; two in group A and one in group B (12.5%). One of them underwent the test until minute five. Two others did not start. In both groups, the z-scores were calculated. The mean and standard deviation of the z-scores are displayed in table 6. The number and percentage of total N of z-scores out of normal distribution per group are displayed in table 7.

From a total of 21 participants, a qualitative rating of the masticatory movements was made. A distinction in rhythm and size was made as shown in table 6.

Nine participants gave a face score for pain and fatigue. In one participant, the results seemed unreliable. Therefore, these scores were excluded from the results. As shown in table 8, in a total of eight participants the VAS-pain scores were computed. In a total of 7 participants the VAS-fatigue scores were computed.

Discussion

In this study, the TOMASS-C and 6MMT were tested for the first time in children with DS. The primary objective of this study was to determine if it is feasible to use the TOMASS-C and the 6MMT in children with DS. The data reported that twenty out of twenty-four participants (83.3%) could complete the TOMASS-C. Twenty-one out of twenty-four participants (87.5%) could complete the 6MMT. Concluding, both tests are feasible to use with children with DS (% complete the test > 80%).

The secondary objective of this study was to determine if these tests give information about the function and endurance in mastication in children with DS based on a comparison with typically developing children. Both tests give relevant information about the function and endurance during mastication in children with DS. In the TOMASS-C, comparisons with the TD group during the first cracker shows significant differences in the parameters MT, MC and NSA. Most of the significant differences are found in the youngest and two oldest age groups. In the present study, children with DS older than 10;0 years need more time, have more mastication cycles and swallowing acts than TD children of this age. In children with DS, it takes a longer time to acquire a mature way of mastication (18). Hennequin et al. (15) found a longer MT in an adult group DS than a healthy reference group. The adult DS group had a higher mean number of MC than the reference group for peanuts and bread; these results are in accordance with the results of the present study. In younger children, both TD and DS groups are developing their mastication skills. At the age of three to four years, most TD children have acquired a mature way of mastication (10). Gisel (18) found no significant effect of age in TD children (5 – 8 years old) on MT for graham crackers. This indicates that mastication skills mature earlier than an age of 5 years. In this study, the youngest DS group shows significant differences in comparison with the TD group in the parameter MT. This is in accordance to the literature (Gisel, 1988).

It is remarkable that when eating the second cracker, the oldest DS groups show no significant differences anymore compared to the TD group. It is the author's hypothesis that there is a learning effect in this group. In the parameter MC, the same phenomenon appears in the youngest age group, presumably caused by a learning effect.

The TOMASS-C is a reliable test in the parameters NB and MC. However, the parameter NSA scored a poor ICC. We hypothesized, the scoring of the NSA was being complicated because of the unrest of the participants during the test.

Results of the 6MMT suggest that the total masticatory cycles during six minutes in both age groups are within the standard range in comparison with TD children (z-score group A= -1.7; group B= -1.3). However, the difference in percentages between minute one and six in both groups is wide off the normal distribution (z-score group A = 4.9; group B = 6.3). The number of mastication cycles in minute one was generally low; it is the author's hypothesis that DS children need more time to get used to the chewing tube. However, the DS children do not have problems in endurance in mastication. The problems in mastication can be attributed to the effectiveness of mastication. The qualitative ratings show a difference in comparison with the TD group. In DS children, jaw control was found to be limited (9). Jaw control is necessary for rhythmic and constant chewing (19). This could be an explanation for the differences found between the DS and TD group.

In the current study, the children were asked to describe the intensity of pain and fatigue using a face scale after the 6MMT. Self-reports of children's pain intensity are a valuable source of information, but their interpretation must be considered together with observation of behavior (20). Therefore, the parents and the SLT noted whether if the given score was reliable. One participant who completed the face scale, scored a 10. Many TD children younger than five years old have a marked tendency to use only the extremes of scales (20). Tsze et al. (21) found that convergent validity of the visual analogue scale (VAS) for describing pain was questionable in children <7 years old without a developmental delay. In this study, only participants older than 9 years old completed the VAS directly after the 6MMT. Due to their developmental delay, the interpretation must be tentative.

We have some recommendations for these tests in children with DS. Children with DS and problems in oral sensitivity or behavioral problems are not suitable for these tests. To complete both tests in children with DS, the SLT is needed to be well-prepared. In contrast to the TD groups, it took real effort for the SLT to complete both tests. Behavior played an important role. If the child does not cooperate, the test cannot be completed. Therefore, the SLT and the child with DS must know each other well. Take up to 45 minutes to complete both tests. Most of the children needed time between both tests to do something else. Otherwise, the child was not able to focus during the second test. During the TOMASS-C, it is recommended to make a competition out of eating a cracker as fast as possible. Most of the children would not eat as fast as possible without a competition. During the 6MMT, some children needed 'inner speech': they need the SLT to articulate their thoughts to continue mastication. For example, the SLT was constantly saying "bite, bite, bite" during 6 minutes. It

is expected that this has influenced the results in TMC and DMC. Without watching a movie, it would be complicated to complete the 6MMT for children with DS.

A limitation of the study is the scoring of the NSA in the TOMASS-C. Due to the unrest of the participants, it was difficult to score the NSA reliable. A strength of the study is that the participants live all over the Netherlands, which makes the group participants representative for the Netherlands. Moreover, computing the interrater reliability using the video recordings of the TOMASS-C is an added value.

Conclusion and Recommendations

Both tests are feasible for children with DS. Both tests give information about the endurance and function during mastication in children with DS. However, some adjustments need to be made. To complete both tests in children with DS, the SLT needed to be well-prepared. The SLT and the child with DS must know each other well. Because it takes a longer time to complete both tests, it is important to have enough time, about 45 minutes. Moreover, make it fun to do the tests. This study shows that children with DS, although they are known with hypotonia, do not have endurance problems during mastication, but their efficiency in mastication is reduced.

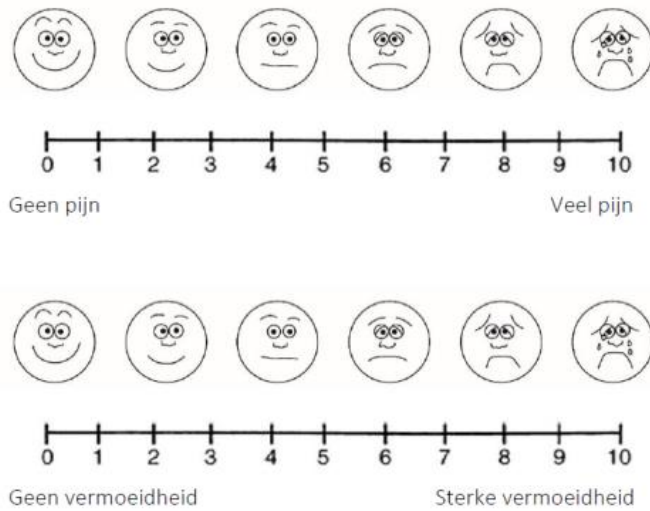
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Tables and figures

Figure 1. Face scale converted into VAS



Geen pijn = No pain; Veel pijn = A lot of pain; Geen vermoeidheid = No fatigue, Sterke vermoeidheid = Strong fatigue

Table 1. Participants

		N	Mean	Standard deviation	range
Gender	Male	11			
	Female	13			
Age (years : months)		24	9:7	3:9	4:7 – 17:11
Length (centimetres)		21	121	31	105 – 155
Weight (kilogram)		18	23	17	19 – 55

Table 2. Results of the questionnaire

	No (N %)	Yes (N %)	N Total
1. Respiratory infections or pneumonia	13 (56.5%)	10 (43.5%)	23
2. Swallowing problems in the past	10 (41.7%)	14 (58.3%)	24
3. Swallowing problems in the present	17 (70.8%)	7 (29.2%)	24
4. Look up to eating and/or drinking	21 (87.5%)	3 (12.5%)	24
5. Difficulties with chewing	17 (70.8%)	7 (29.2%)	24
6. Many choking	20 (83.3%)	4 (16.7%)	24
7. Coughing during a meal	22 (95.7%)	1 (4.3%)	23
8. Saliva loss or food loss during a meal	17 (70.8%)	7 (29.2%)	24
9. Cramming	11 (45.8%)	13 (54.2%)	24
10. Eating enough	2 (8.3%)	22 (91.7%)	24
11. Open mouth behavior	10 (41.7%)	14 (58.3%)	24
12. Drooling	17 (73.9%)	6 (26.1%)	23
13. Speech and language therapy for oral motor skills in past	0 (0%)	24 (100%)	24
14. Speech and language therapy for oral motor skills in present	4 (16.7%)	20 (83.3%)	24
15. Problems during tooth brushing	18 (81.8%)	4 (18.2%)	22

Table 3. Mean and SD per DS group per parameter for the TOMASS-C.

parameter	Group 1 4:0 – 5:11 years	Group 2 6:0 – 7:11 years	Group 3 8:0 – 9:11 years	Group 4 10:0 – 13;11 years	Group 5 14;0 – 17;11 years
Cracker 1	N = 5	N = 4	N = 4	N = 5	N = 3
MT (sec), mean (SD)	119.6 (14.2)	132.0 (41.5)	95.0 (21.0)	63.0 (6.5)	81.3 (5.0)
NB, mean (SD)	10.8 (2.8)	7.0 (2.1)	5.5 (1.4)	4.2 (1.4)	4.0 (2.1)
MC, mean (SD)	108.4 (17.0)	154.3 (74.9)	97.8 (18.2)	60.4 (6.8)	73.0 (7.1)
NSA, mean (SD)	13.4 (2.4)	12.8 (1.8)	9.8 (1.5)	8.6 (1.6)	11.7 (1.7)
Cracker 2	N = 5	N = 3	N = 4	N = 5	N = 3
MT (sec), mean (SD)	114.0 (22.3)	108.3 (27.8)	141.0 (43.1)	58.2 (6.5)	61.0 (5.5)
NB, mean (SD)	9.2 (3.0)	6.7 (1.7)	4.3 (0.9)	2.6 (0.9)	5.0 (1.0)
MC, mean (SD)	100.2 (21.0)	139.0 (97.6)	77.8 (16.3)	58.2 (7.1)	63.0 (11.0)
NSA, mean (SD)	10.8 (1.2)	10.7 (0.7)	17.0 (9.4)	7.8 (1.9)	8.0 (1.0)

DS = Down Syndrome; TOMASS-C = Test of Mastication and Swallowing of Solids-Children; MT = Mastication Time; NB = Number of Bites; MC = Masticatory cycles; NSA = Number of Swallow Acts

Table 4. Comparison DS groups with TD groups for the TOMASS-C

Parameter	Group 1 4:0 – 5:11 years		Group 2 6:0 – 7:11 years		Group 3 8:0 – 9:11 years		Group 4 10:0 – 13:11 years		Group 5 14:0 – 17:11 years	
Cracker 1										
MT (s), mean difference (95% CI)	71.8	(32.4 – 111.2)	97.0	(-35.2 – 229.2)	56.2	(-10.7 – 123.1)	28.4	(10.2 – 46.5)	47.5	(26.1 – 68.9)
p	.007**		.102		.075		.012*		.011*	
NB, mean difference (95% CI)	4.9	(-2.9 – 12.7)	3.9	(-2.9 – 10.6)	2.4	(-2.2 – 7.0)	1.2	(-2.6 – 5.1)	1.5	(-7.50 – 10.4)
p	.157		.166		.194		.424		.556	
MC, mean difference (95% CI)	62.4	(15.1 – 109.7)	114.2	(-124.4 – 352.7)	57.1	(-0.93 – 115.2)	22.9	(4.02 – 41.9)	37.2	(6.71 – 67.8)
p	.022*		.225		.052		.028*		.034*	
NSA, mean difference (95%CI)	5.9	(-0.38 – 12.1)	10.6	(4.9 – 16.3)	7.1	(2.2 – 12.0)	6.5	(1.92 – 11.0)	9.0	(1.9 – 16.2)
p	.059		.010**		.019*		.017*		.032*	
Cracker 2										
MT (s), mean difference (95% CI)	68.8	(6.9 – 130.7)	72.7	(-47.1 – 192.5)	105.3	(-31.8 – 242.4)	26.3	(8.5 – 44.6)	30.0	(-9.1 – 69.0)
p	.037*		.121		.092		.015*		.081	
NB, mean difference (95% CI)	3.5	(-4.8 – 11.9)	3.3	(-3.9 – 10.5)	0.9	(-1.9 – 3.6)	0.6	(-3.1 – 2.1)	3.3	(-0.45 – 7.1)
p	.304		.188		.388		.632		.063	
MC, mean difference (95% CI)	51.0	(-7.3 – 109.2)	101.1	(-189.9 – 392.2)	39.6	(-12.2 – 91.3)	20.4	(0.7 – 40.0)	29.0	(-110.8 – 168.8)
p	.072		.274		.093		.045*		.231	
NSA, mean difference (95%CI)	4.5	(5.3 – 11.7)	8.2	(5.4 – 11.1)	14.7	(-15.1 – 44.4)	5.8	(0.5 – 11.1)	5.7	(-7.1 – 18.4)
p	.002**		.006**		.215		.038*		.112	

DS = Down Syndrome; TD = Typically Developing; TOMASS-C = Test of Mastication and Swallowing of Solids-Children; CI = Confidence Interval; MT = Mastication Time; NB = Number of Bites; MC = Masticatory cycles; NSA = Number of Swallow Acts; * = significant difference, $p \leq 0.05$; * = significant, $p \leq 0.01$

Table 5. Mean and SD z-scores per group for TMC and DMC in the 6MMT

	Group A	Group B
	4:0 – 8:11 years	9:0 – 17:11 years
	N = 8	N = 13
TMC (SD)	-1.7 (0.9)	-1.3 (1.9)
DMC (SD)	4.9 (5.3)	6,3 (3.2)

SD = standard deviation; TMC = Total Masticatory Cycles; DMC = percentage difference between minute one and minute six; 6MMT = 6-Minute Mastication Test.

z-scores of the 6MMT are calculated using the equation*:
$$\frac{\text{measured value} - \text{normal value}}{\text{standard deviation of normal value}}$$

*equation from (3).

Table 6. Qualitative ratings of the masticatory movements on the 6MMT

Qualitative rating	Group A	Group B
	4:0 – 8:11 years	9:0 – 17:11 years
	N = 9	N = 13
Rhythm		
Rhythmic N (%)	0 (0.0%)	1 (7,7%)
Variable rhythmic N (%)	0 (0.0%)	0 (0.0%)
Not rhythmic N (%)	9 (100%)	12 (92.3%)
Movements		
Normal movements N (%)	5 (55.6%)	4 (30.8%)
Big movements N (%)	0 (0.0%)	1 (7.7%)
Small movements N (%)	0 (0.0%)	2 (15.4%)
Variable movements N (%)	4 (44.4%)	6 (46.1%)

6MMT = 6-Minute Mastication Test

Table 7. Number and percentage of total N of z-scores out of normal distribution per group for TMC and DMC in the 6MMT

	Group A	Group B
	4:0 – 8:11 years	9:0 – 17:11 years
TMC		
N z-score ≤ -2 z (%)	3 (37.5%)	7 (53.8%)
N z-score ≥ 2 z (%)	0 (0.0%)	2 (15.4%)
DMC		
N z-score ≤ -2 z (%)	0 (0.0%)	0 (0.0%)
N z-score ≥ 2 z (%)	5 (62.5%)	13 (100%)

TMC = Total Masticatory Cycles; DMC = percentage difference between minute one and minute six; 6MMT = 6-Minute Mastication Test.

Table 8. Mean VAS scores for pain and fatigue per group A and B, directly after the 6MMT

VAS scores	Group A	Group B
	4:0 – 8:11 years	9:0 – 17:11 years
VAS score pain (SD; range)	0 (0.0; 0 – 0)	N = 8 0.3 (0.7; 0 – 2)
VAS score fatigue (SD; range)	0 (0.0; 0 – 0)	N = 7: 0.9 (1.6; 0 – 4)

VAS = Visual Analogue Scale; 6MMT = 6-Minute Mastication Test