


Every Some things you ought to know
about the Test of Masticating and
Swallowing Solids (TOMASS)

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Timed water swallowing test

- + Timed test of swallowing first published by Hughes & Wiles (1996)
- + Documentation of
 - + Number of swallows
 - + Time taken to swallow 150 ml
- + NOT the water swallowing test, a la Leder et al.



Timed water swallowing test


- + Calculation of three measures based on ingestion of 150 ml of water
 - + average volume per swallow (ml),
 - + average time (s) per swallow
 - + swallowing capacity (ml/s).
- + Validated on adults up to age 90+ and in 30 patients with Parkinson's disease and motor neurone disease.



*Hughes & Wiles, 1996

How to do it...

- + 150 ml of water from open cup
 - + Amount can be titrated if high risk patient
 - + "Drink as quickly as is comfortably possible"
 - + Begin timing with stop watch when cup touches bottom lip, stop when larynx returns to rest after last swallow
 - + Count number of swallows to consume full amount
 - + If patient fails to ingest full amount, subtract residual from initial amount and base calculations on total consumed.



Normative data

+ Hughes & Wiles, 1996

+ 181 healthy subjects (aged 18-91 yrs)

- + Volume per swallow
- + Time per swallow
- + Swallowing capacity (7.5 – 31.9 mL/sec)

+ Volume/swallow and swallowing capacity

- + Greater in men
- + Reduced with age



TWST normative data

Table 1 Median plus first and third quartiles (Q1, Q3) for average volume per swallow (V/S), and average time per swallow (T/S), and mean \pm SD swallowing capacity (V/T) in MND patients and normal subjects

Sex	Normal subjects Age group	Age (years) Median (range)	n	V/S (ml)	Q1	Q3	T/S (s)	Q1	Q3	V/T (ml/s)
Male	1	25.7 (18.9–34.1)	27	37.5	25.0	50.0	1.2	1.0	1.3	31.9 \pm 9.5
	2	44.6 (35.6–54.6)	25	30.0	21.4	37.5	1.2	1.0	1.4	24.8 \pm 7.8
	3	66.6 (56.5–73.0)	26	23.2	20.8	30.0	1.3	1.2	1.4	18.7 \pm 5.2
	4	77.3 (75.7–87.6)	12	20.0	15.7	25.0	1.5	1.3	1.8	14.6 \pm 5.9
Female	1	25.8 (18.9–34.1)	23	18.8	15.0	30.0	1.1	1.0	1.3	18.7 \pm 6.0
	2	44.0 (35.5–54.7)	22	16.7	13.6	21.4	1.3	1.1	1.7	13.6 \pm 4.8
	3	64.5 (55.4–74.9)	35	16.7	13.6	21.4	1.5	1.1	2.1	12.3 \pm 4.9
	4	79.9 (75.4–91.3)	10	10.6	9.1	13.0	1.5	1.4	1.8	7.5 \pm 3.3



Reliability & validity

+ Wu et al. (2004)

- + Is abnormal speed on 100 mL timed water swallowing test (<10 mL/s) associated with swallowing dysfunction on VFSS?
- + Sensitivity: 85.5% and specificity: 50%

+ Nathadwarala et al. (1992)

- + High inter-rater reliability
- + Individuals performed consistently on delayed repetitions
- + No effect of temperature or taste on swallowing speed



TWST in motor neurone disease

- + 30 patients with MND, 16 self-reported having problems with swallowing
- + Those who reported problems with swallowing had smaller volumes per swallow, longer time per swallow and reduced swallowing capacity than age and gender matched groups.



TWST in Parkinson's Disease

- + Miller et al. (2009)
 - + 150ml timed water swallowing test on 137 individuals with Parkinson's
 - + Over 80% of patients have a swallowing rate slower than published norms provided by Hughes and Wiles (1996)



Clinical advantages of TWST

- + Quantitative assessment of swallowing with norms
- + Standardized procedure with objective measures allowing for high inter- and intra-rater reliability
- + Easy to administer at bedside
- + Consistency of performance displayed on test re-test by norms may assist in identifying changes in an individual's swallowing function



Clinical limitations of TWST

- + No visualisation of pharyngeal physiology – they may be slow but you won't know why
- + Not appropriate for every patient, i.e. those known to aspirate or with compromised pulmonary function



TOMASS

TOMASS

- + Developed specifically as an outcome measure for a treatment study in Parkinson's disease (Athukorala, 2014)
 - + Correlate to the Timed Test of Swallowing
 - + Measure of oral pharyngeal efficiency for solid bolus intake: high level screening for mild impairment
 - + Theorised to be sensitive to detecting functional change in swallowing behaviour



The challenge...

- + Water is the same (viscosity) everywhere
 - + Solids are not
- + Prior attempts to quantify oral phase
 - + Peanuts
 - + Banana
 - + Bread square
- + Needed to find something that was available worldwide (mostly)
 - + Salada, Saltine, Gran Parvesi, Wasa Crack & Taste



How we do it...

- + Determine if the test is appropriate for patient
- + "Eat this as quickly as is comfortably possible. When you have finished, say your name out loud"
- + Using a stop watch begin timing as soon as cracker touches bottom lip, stop when participant says their name after last swallow



TOMASS

- + Documentation of
 - + Number of bites per cracker was determined by counting how many discrete segments of cracker the participant placed in their mouth.
 - + Number of masticatory cycles per cracker was counted through observation of jaw movements.
 - + Number of swallows per cracker.
 - + Duration of ingestion was timed from the moment the cracker passed the lips until they indicated that they had completely finished by stating their name out loud.



TOMASS: Norms

- + The Kiwi Group
 - + Arnotts Salada + USA Saltine
- + 80 participants per cracker
 - + Equal balance M/F
 - + 20-40, 40-60, 60-80, 80+



TOMASS: Norms

- + What we learned:
 - + Cracker matters!
 - + What looks the same doesn't eat the same.
 - + Trial matters
 - + Use only first trial in clinical use
 - + Gender matters
 - + Age matters
 - + Go Raw...
 - + Calculated measures washout group differences



TOMASS: Normative data

TABLE 2: TOMASS normative data consisting of mean and 95% confidence intervals by age and gender for Arnott's Salada™ cracker.

TEST OF MASTICATING AND SWALLOWING SOLIDS: Arnott's Salada™ cracker																			
Sex	Age	Discrete bites per cracker		Masticatory cycles per cracker		Swallows per cracker		Total time (in sec)		Masticatory cycles per bite		Swallows per bite		Time per bite (in sec)		Time per masticatory cycle (in sec)		Time per swallow (in sec)	
		Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Males	20-40	1.76	1.30-2.23	36.53	30.36-42.70	2.35	1.87-2.83	29.22	24.70-33.74	25.13	18.78-31.49	1.54	1.10-2.0	19.63	15.21-24.06	0.82	0.76-0.88	15.08	10.37-19.79
	40-60	1.93	1.44-2.42	41.40	34.60-48.60	3.00	2.11-3.89	34.49	30.74-38.24	23.87	18.93-28.81	1.89	1.15-2.64	21.10	17.09-25.11	0.90	0.85-0.98	13.01	10.75-15.28
	60-80	2.33	1.79-2.87	60.67	50.51-70.82	3.20	2.41-3.99	51.28	40.53-61.99	28.87	21.09-36.65	1.44	1.13-1.76	24.06	17.69-30.43	0.84	0.77-0.92	16.99	14.46-19.52
Females	20-40	3.40	2.65-4.15	89.73	70.52-108.94	4.00	2.73-5.27	84.76	63.13-106.39	28.99	23.04-34.95	1.27	0.88-1.66	28.79	19.33-38.24	0.95	0.80-1.11	24.12	17.15-31.09
	40-60	2.71	2.11-3.10	45.94	38.72-53.16	3.18	2.65-3.70	40.84	33.68-49.01	18.37	14.54-22.21	1.30	0.91-1.70	16.44	12.85-20.42	0.89	0.79-0.99	13.62	11.87-15.36
	60-80	3.13	2.55-3.72	52.93	45.10-60.77	3.53	2.91-4.16	46.79	36.75-56.83	18.10	15.08-21.13	1.17	1.06-1.27	15.70	13.53-17.88	0.89	0.78-1.00	13.79	11.62-15.97
80+	20-40	3.27	2.94-3.60	63.33	53.21-73.46	4.07	3.15-4.94	60.37	49.24-71.51	19.89	16.05-23.73	1.28	0.97-1.38	18.04	14.84-23.25	0.95	0.85-1.05	14.70	12.59-16.82
	40-60	4.33	3.75-4.91	104.33	81.85-126.82	4.67	3.79-5.55	90.68	70.11-110.06	24.51	20.26-28.74	1.09	0.83-1.25	20.92	17.87-23.97	0.85	0.78-0.93	19.44	15.97-23.21



TOMASS: Reliability

- + 40 healthy adults
 - + Two raters during execution of test
 - + Two repetitions, separated by 24 hours
- + Test re-test reliability high
 - + >.90 for all measures
- + Inter-rater reliability, also high
 - + >.90 for all measures except # swallows; slightly lower



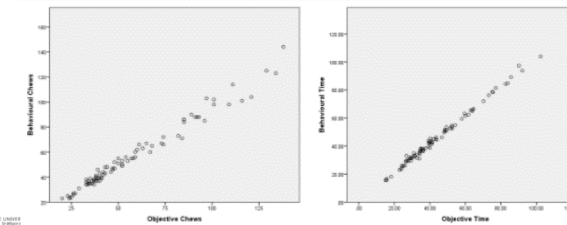
TOMASS: Convergent Validity

- + 22 healthy participants
 - + Recorded TOMASS with simultaneous
 - + sEMG of masseters and submental muscles
 - + Swallowing acoustics and nasal airflow
 - + Physiologic data analysed by two clinicians trained to analysis but blind to task
 - + Videorecorded TOMASS also rated by two clinicians for reliability analysis



TOMASS: Validity

Validity	Intraclass correlation coefficients
Chews	.987
Swallows	.851
Time	.997



TOMASS: Validity

- + Inter-rater reliability
 - + Masticatory Cycles ICC = .973
 - + Swallows ICC = .811
 - + Time ICC = .965
- + Inter-rater reliability for physiologic measures
 - + Masticatory Cycles ICC = .974
 - + Swallows ICC = .816
 - + Time ICC = .993

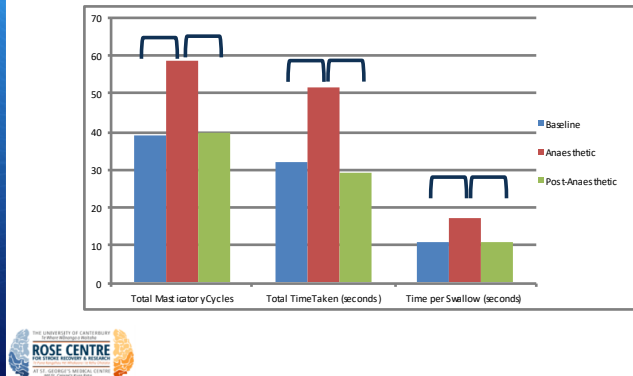


TOMASS: Construct Validity

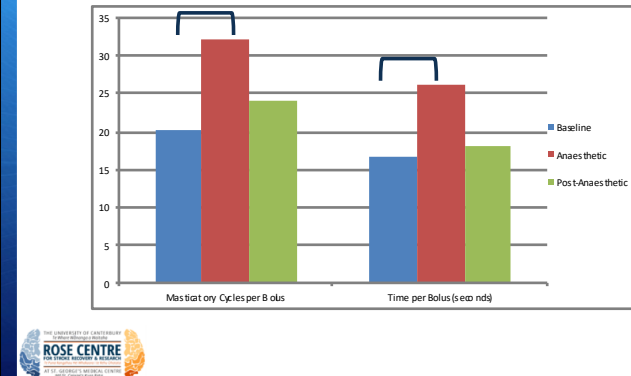
- + Gozdzikowska, et al (2016)
 - + 10 Adults
- + Method:
 - + Baseline TOMASS
 - + Oral cavity anaesthetised with topical anaesthetic gel ZAP™ (up to 0.8 ml)
 - + Anaesthesia TOMASS
 - + Wait two hours
 - + Post-anaesthesia TOMASS



TOMASS: Validation



TOMASS: Validation



TOMASS: Parkinson's disease

- + Battel et al. (subm)
 - + 68 adults (PD=23, MS=23, HC=22) approximately matched for age and sex.
- + Results:
 - + TOMASS: PD and MS patients performed poorer than HC for # of masticatory cycles, # of swallows and total time ($p < .01$) but did not differ from each other ($p > .05$).
 - + TWST: PD patients differentiated from MS and HC, ($p < .01$) but no difference between MS and HC on any measure.

TOMASS: in PD on - off drugs

- + Battel et al. (manuscript in prep)
 - + TOMASS & TWST in 38 patients with PD (19 male)
 - + 'On' drug testing was completed in the morning;
 - + 'Off' drug testing was completed at the same time of day, 48 hours after the last drug dose.
- + No significant differences were detected for any measure of swallowing efficiency as an effect of drug state, although statistical power was low.
- + Lack of effect consistent with some literature

TOMASS: in PD by severity

- + Emslie & Huckabee
 - + TOMASS in 40 patients with diagnosed PD
 - + Mild to moderate: 20
 - + Moderate to severe: 20
 - + Age and gender matched controls
 - + Completed:
 - + EATS 10
 - + TWST
 - + TOMASS



TOMASS in PD by severity

- + Results : Mixed Bag!
 - + Mild-moderate PD = advanced PD
 - + However, significant positive correlation between MDS-UPDRS scores and increasing number of masticatory cycles.
 - + Total time to ingest cracker was longer for both PD groups compared to their control groups.
 - + Number of swallows, masticatory cycles, and bites was also increased in the advanced PD group compared to the control group, but not mild to moderate group.
 - + Positive correlations were found between TOMASS and TWST for total time and number of swallows.



TOMASS in H&N Cancer

- + Apperley & Huckabee
 - + Focus of study to evaluate influence of 3 conditions of saliva substitute on a number of clinical factors, incl. TOMASS
 - + Recruited 40 patients with radiotherapy for H&N cancer; all non-surgical
 - + Only 29 (72%) could complete the TOMASS
 - + Results:
 - + No immediate or long-term difference in outcome measure – including TOMASS – as a function of the type of saliva substitute: methylcellulose, novel emulsion and water.



TOMASS in H&N Cancer

Measure	Group	Mean (95% CI)	F	Sig
# discrete bites	H&N Ca	5.58 (4.51-6.66)	25.49	<.001
	Control	2.69 (2.22-3.16)		
# masticatory cycles	H&N Ca	157.21 (93.1-192.65)	34.53	<.001
	Control	53.17 (45.49-60.85)		
# swallows	H&N Ca	9.07 (6.89-11.25)	26.23	<.001
	Control	3.34 (2.64-4.05)		
Total time (sec)	H&N Ca	186.55 (152.82-220.29)	66.86	<.001
	Control	117.33 (92.45-142.22)		

+ *H&N group: mean age 61, 74% male



WORLD DOMINATION!!

- + Australasia: Arnotts Salada™
- + USA: Nabisco Saltine™
- + Italy/Portugal: Gran Pavezi™
- + Ireland: Carr's water cracker™
- + German: ~~Crack and Taste~~ Tucs™
- + The Netherlands: Heijn Basic™
- + Israel: Golden cracker™



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Research Report

The Test of Masticating and Swallowing Solids (TOMASS): reliability, validity and international normative data

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Abstract

Background: Clinical swallowing assessment is largely limited to qualitative assessment of behavioural observations. There are limited quantitative data that can be compared with a healthy population for identification of impairment. The Test of Masticating and Swallowing Solids (TOMASS) was developed as a quantitative assessment of solid bolus ingestion.

Aims: This research programme investigated test development indices and established normative data for the TOMASS to support translation to clinical dysphagia assessment.

Method & Procedures: A total of 228 healthy adults (ages 20-80+ years) stratified by age and sex participated in one or more of four consecutive studies evaluating test-retest and interrater reliability and validity to instrumental assessment. For each study the test required participants to ingest a commercially available cracker with instructions to 'eat this as quickly as is comfortably possible'. Further averaged measures were derived including the number of masticatory cycles and swallows per bite, and time per bite, masticatory cycle and swallow. Initial analyses identified significant differences on salient measures between two commercially available crackers that are nearly identical in shape, size and ingredients, suggesting the need for separate normative samples for specific regional products. Additional analyses on a single cracker identified that the TOMASS was sensitive to detecting changes in performance based on age and sex. Test-retest reliability across days and interrater reliability between clinicians was high, as was validation of observational measures to instrumental correlates of the same behaviours. Therefore, normative data are provided for the TOMASS from a minimum of 80 healthy controls, stratified by age and sex, for each of seven commercially available crackers from broad regions worldwide.

Outcomes & Results: Analyses on a single cracker identified Arnott's Salada, and that TOMASS measures were sensitive for detecting changes in performance based on age and sex. Interrater and test-retest reliability across days were high, as was validation of observational measures to instrumental correlates of the same behaviours. Significant differences were identified between two commercially available crackers, nearly identical in shape, size and ingredients, thus normative samples for specific regional products were required. Normative data were then acquired for the TOMASS from a minimum of 80 healthy controls, stratified by age and sex, for each of seven commercially available crackers from broad regions worldwide.

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ORIGINAL ARTICLE

International standardisation of the test of masticating and swallowing solids in children

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Summary
The Test of Masticating and Swallowing Solids (TOMASS) is a validated assessment tool measuring the efficiency of solid bolus intake by four quantitative parameters: discrete bites, masticatory cycles, swallows and time to ingest a single cracker. A normative database for adults (20-80+ years) has previously been established. The objective of this study was to investigate the applicability and reliability of the TOMASS in children and adolescents (TOMASS-C) and to establish the normative database for this younger population. We collected data from 638 participants (male: 311, female: 327) in five age groups (4-18 years) with five different but very similar test crackers in four countries. Significant effects of bolus type (cracker), age group and gender on the TOMASS parameters were identified, requiring stratification of the TOMASS-C database by these variables. Intra-rater reliability was excellent (ICC = 0.94) for all parameters; inter-rater reliability was moderate for 'number of swallows' (ICC = 0.54), good for 'bites' (ICC = 0.78) and 'time' (ICC = 0.82), and excellent for 'masticatory cycles' (ICC = 0.96). The 'Test of Masticating and Swallowing Solids in Children (TOMASS-C)' was identified to be a reliable diagnostic tool for the comprehensive measurement of discrete oral stage components of solid bolus ingestion, standardised by a large normative database that covers age groups from pre-schoolers to young adults. While differences between gender groups were less pronounced than in the adult population, previous results relating to changes in masticatory and swallowing as a function of age are confirmed by our data.



TOMASS

- + **Limitations:**
 - + No visualisation of oral or pharyngeal physiology...they may be slow and inefficient, but you won't know why
 - + May be difficult for those known to aspirate; patients at very high risk
- + **Benefits:**
 - + Easily done at bedside
 - + Quantitative measure of swallowing
 - + Appears particularly sensitive for picking up high level dysphagia; PD



Questions ??

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