

Tongue strength: why? how?

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Brugmann Dysphagia Symposium
October 2017

Usage scenario's

- screening
- pathophysiologic diagnosis
- follow-up
- therapy

Usage scenario's

- **screening**
- pathophysiologic diagnosis
- follow-up
- therapy

screening

- sarcopenia: “generalized muscle weakness”

- *European Working Groups on Sarcopenia in Older People (EWGSOP)*

must 1. low *skeletal muscle mass* index (kg/m^2) by bioelectrical impedance analysis (BIA)

and 2a. low handgrip **strength** or

2b. slow walking *speed*

REPORT

Sarcopenia: European consensus on definition and diagnosis

Report of the European Working Group on Sarcopenia in Older People

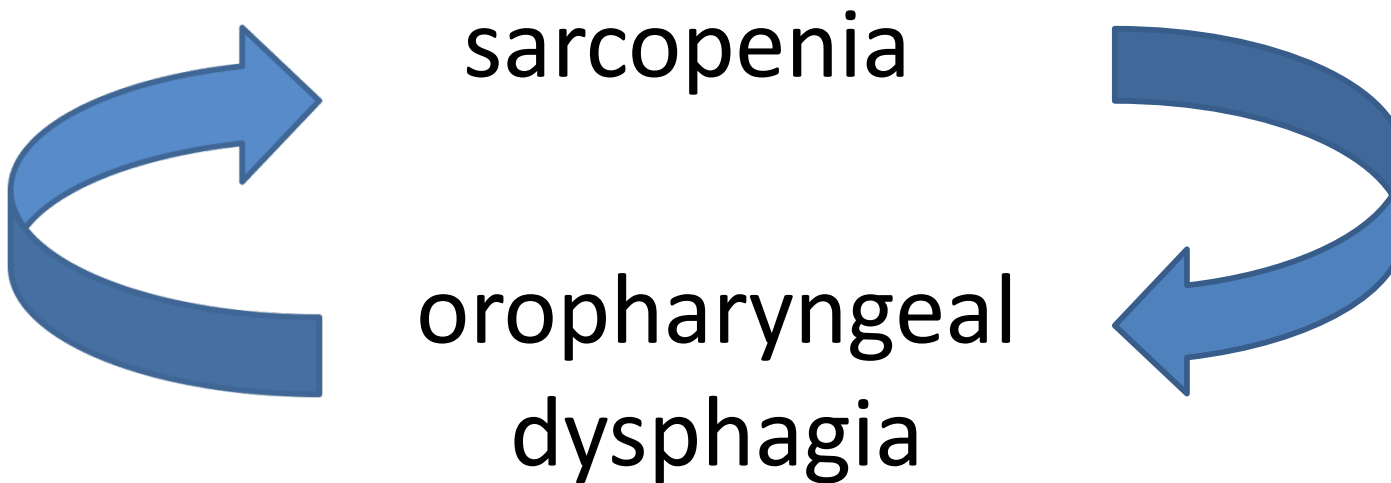
Age and Ageing 2010; **39**: 412–423
doi: 10.1093/ageing/afq034
Published electronically 13 April 2010

screening

- sarcopenia is common in *elderly*!
 - nursing home residents: overall 38%
 - 50% in frail subjects (1/4 of population)
 - hospitalized patients
 - hip fracture: 17% - 34%
 - acute care wards: 17%
- associated with *hospitalization* and *mortality*!
 - often co-etiology & important recovery-predictor

screening

- sarcopenia
 - may involve *swallowing* muscles!
 - clear links in literature



screening

- hand grip strength
 - measurable and indicative for tongue strength ($r = .33$; Sakai, Dysphagia 2017)
 - especially in men (Wakasugi, Gerodontology 2017)



screening

- measuring **tongue strength** is more function-specific
- how? are there many options?!

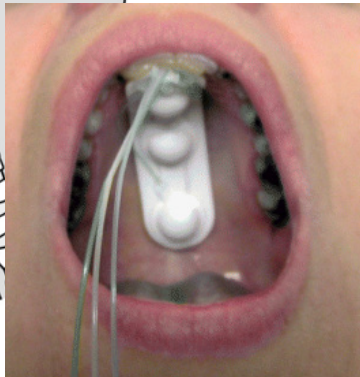
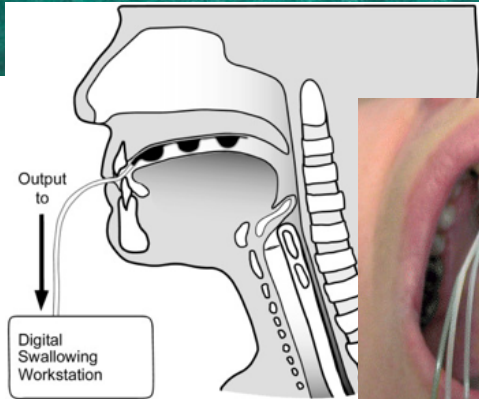
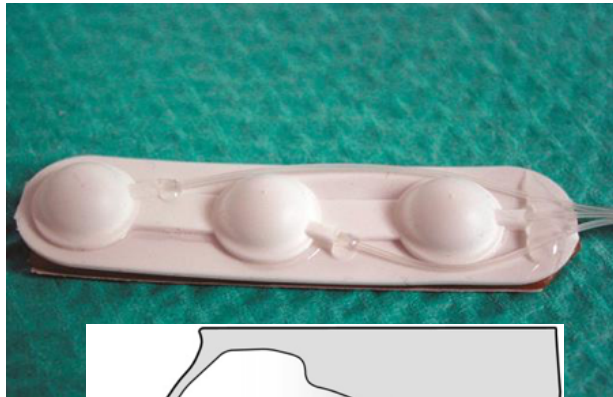


tongue - strength

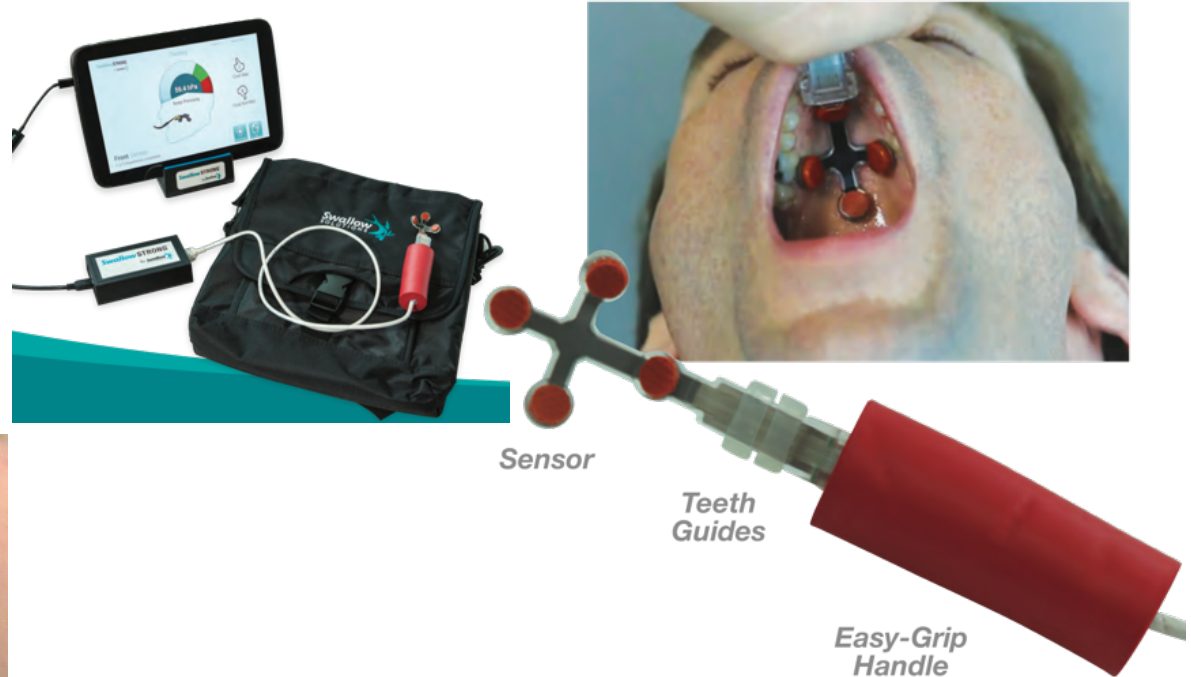
- Iowa Oral Performance Instrument (IOPI)
 - Erich Luschei, 1988
- ‘alternatives’
 - KayPentax Signals Lab (USA)
 - SwallowSTRONG (USA)
 - JMS/‘Handy probe’ (Japan)
 - Oropress (Ireland)



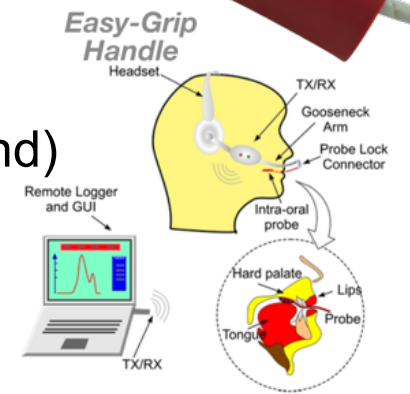
KayPentax Signals Lab



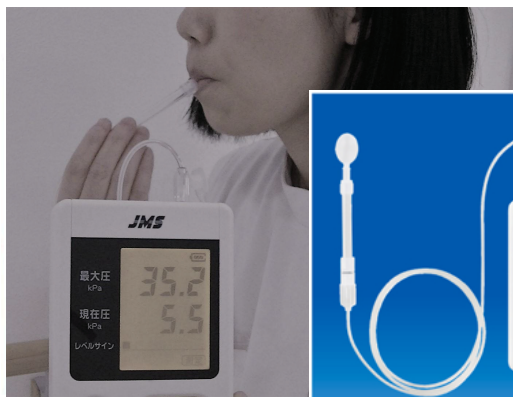
SwallowSTRONG (JoAnn Robbins - USA)



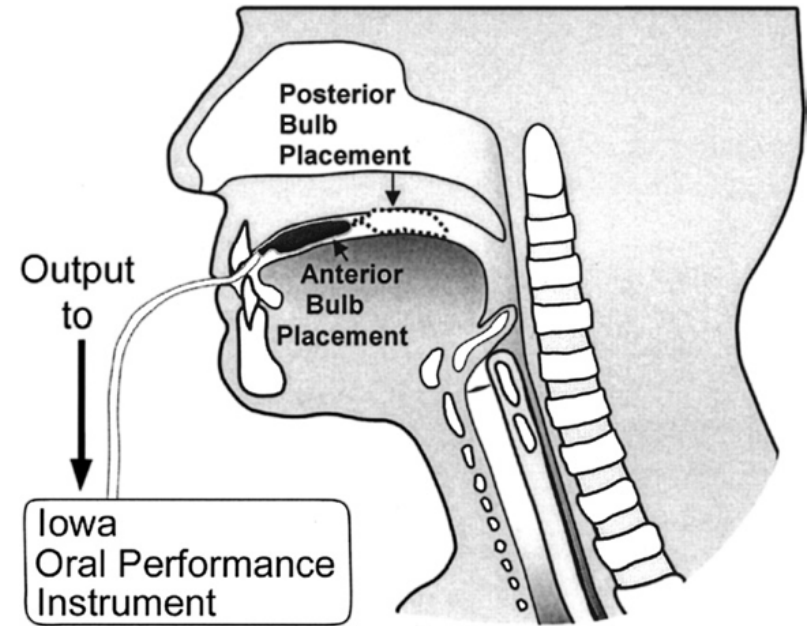
Oropress (Perry - Ireland)



JMS/Handy probe (Utanohara - Japan)

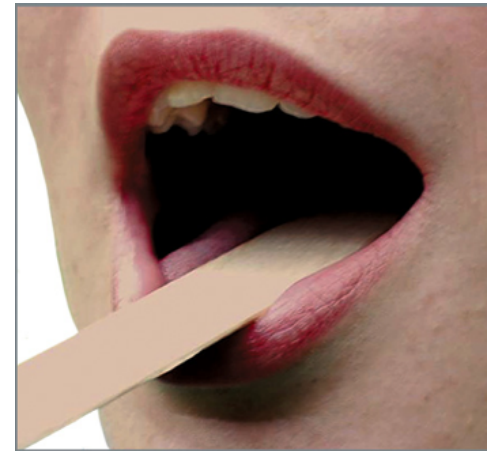


IOPI



really?

- Comments on IOPI:
 - why do I need expensive equipment?
 - I'm an experienced clinician!
- Scientific question:
 - how reliable are subjective measurements?
 - does experience make you more reliable?



Clark HM et al. Relationships among subjective and objective measures of tongue strength and oral phase swallowing impairments.

Am J Speech Lang Pathol. 2003

- subjective vs objective measurements of tongue strength
 - impact of experience clinician
 - experienced: 2 SLPs (8 & 14 years of experience in oral motor examinations)
 - inexperienced: 9 SLP students (without prior experience)
- $n = 63$
 - variety of patients in age, etiology, and moment of evaluation
- objective strength: IOPI
- subjective strength: tongue spatula
 - estimation of *protrusion* force required to overcome resistance by clinician

Clark 2003

- relation subjective – objective tongue strength

correlation	P_{maximaal}
global	$r = .541$
inexperienced	$r = .696$
experienced	$r = .395$

- only** reliable differentiation were extremes: normal <> very weak

screening

- what are cut-offs?
 - unanswered question...
- but we have normative data! (see later)

Usage scenario's

- screening
- **pathophysiologic diagnosis**
- follow-up
- therapy

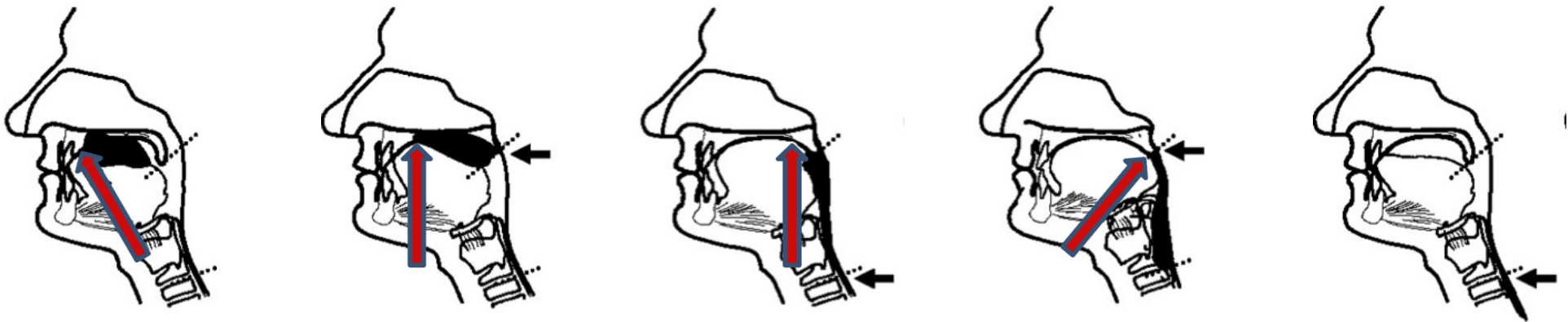


stages of deglutition

- oral phase
 - oral preparatory: mastication and bolus formation
 - oral transport ←
- pharyngeal phase
- esophageal phase

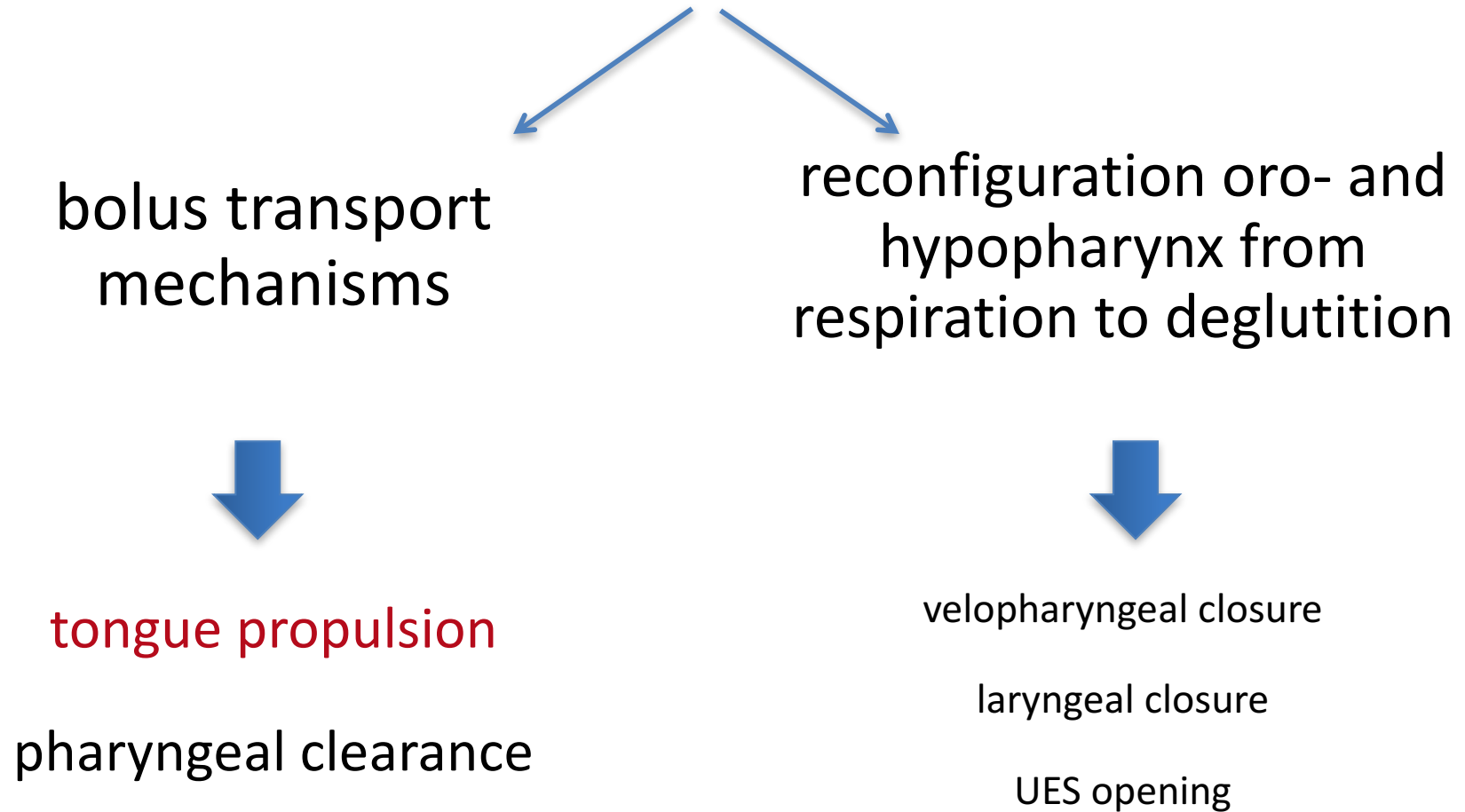
Oral Transport Phase – Kahrilas '93

1. bolus on midline tongue groove (end oral preparation)
2. upward movement of tongue to hard palate
from tongue tip to base-of-tongue
→ anterior & posterior tongue strength

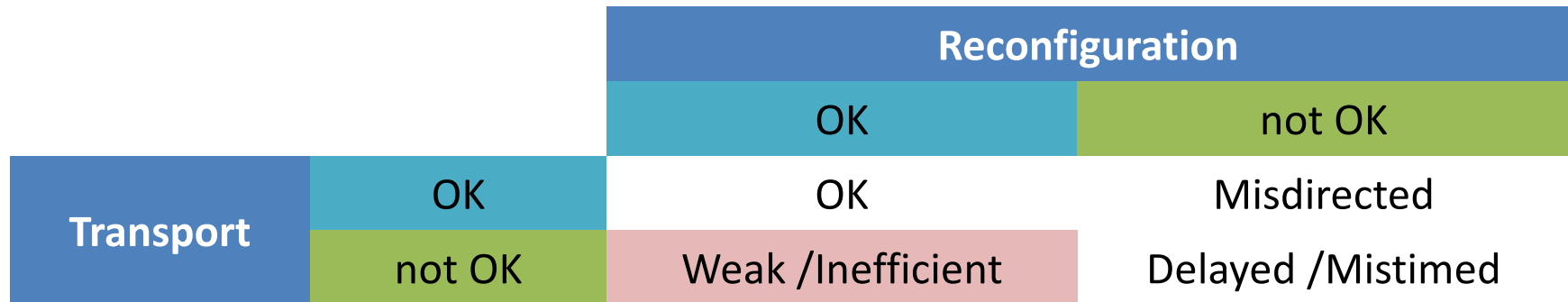


Concept of Dysphagia - Kahrilas, Logemann '93

transition from respiratory oropharynx to deglutative oropharynx



Dysphagia-concept



Weak / Inefficient Swallow

- etiology: deficient bolus driving forces
 - tongue strength = most important but also others...
 - pharyngeal contraction and elevation
 - hyolaryngeal elevation
 - UES opening



Weak / Inefficient Swallow

- etiology: deficient bolus driving forces
 - tongue strength = most important but also others...
 - pharyngeal contraction and elevation
 - hyolaryngeal elevation
 - UES opening
- results in **residue** → which movement(s) is subnormal?
- difficult to ascertain on clinical basis...



Weak / Inefficient Swallow

- etiology: deficient bolus driving forces
 - tongue strength = most important but also others...
 - pharyngeal contraction and elevation
 - hyolaryngeal elevation
 - UES opening
- results in **residue** → which movement(s) is subnormal?
- difficult to ascertain on clinical basis...
- make an educated guess using the **location** of **residue**



Weak / Inefficient Swallow



- make an educated guess using the **location** of **residue**

Residue

location	etiology	confirmation
base of tongue	↓ tongue driving force	IOPI
valleculae	↓ tongue driving force / hyoid-elevation	IOPI
lateral channels	↓ / delayed laryngeal elevation	palpation / sEMG
	↓ pharyngeal action	FEES / VFES / manometry
larynx	↓ / delayed laryngeal closure	FEES
piriform sinuses	↓ pharyngeal squeeze	FEES
	UES mistiming	FEES / VFES / manometry
postcricoid	inadequate UES opening	FEES / VFES / manometry
diffuse	combination	IOPI/FEES / VFES / manometry

pathophysiology

- “patho-”
 - what defines “patho-”?
 - normative data!



Dysphagia

DOI 10.1007/s00455-012-9425-x

ORIGINAL ARTICLE

The Influence of Age, Sex, Bulb Position, Visual Feedback, and the Order of Testing on Maximum Anterior and Posterior Tongue Strength and Endurance in Healthy Belgian Adults

**Jan Vanderwegen · Cindy Guns · Gwen Van Nuffelen ·
Rik Elen · Marc De Bodt**

Dysphagia

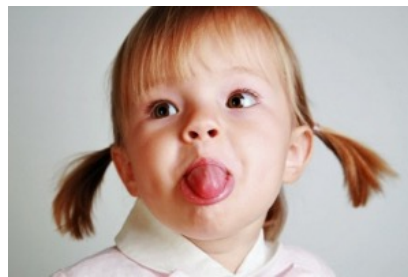
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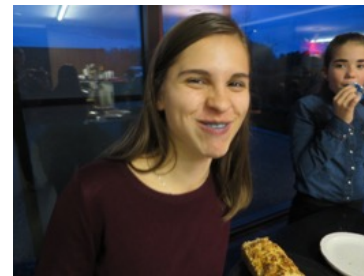
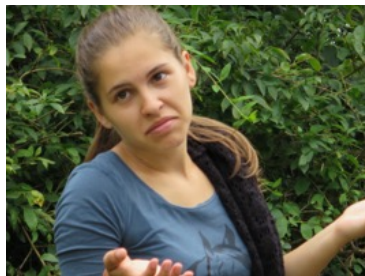
and children



The Influence of Age, Sex, Bulb Position, Visual Feedback, and the Order of Testing on Maximum Anterior and Posterior Tongue Strength and Endurance in Healthy Belgian Adults

Jan Vanderwegen · Cindy Guns · Gwen Van Nuffelen ·
Rik Elen · Marc De Bodt

and children
and teenagers



Normative data

- available

Jan Vanderwegen et al. The influence of age, sex, bulb position, visual feedback, and the order of testing on maximum anterior and posterior tongue strength and endurance in healthy belgian adults. *Dysphagia*. 2013 Jun;28(2):159-66. doi: 10.1007/s00455-012-9425-x.

Tongue strength & endurance – Belgian normative dataset

MALES

MIP_{ant} (kPa)

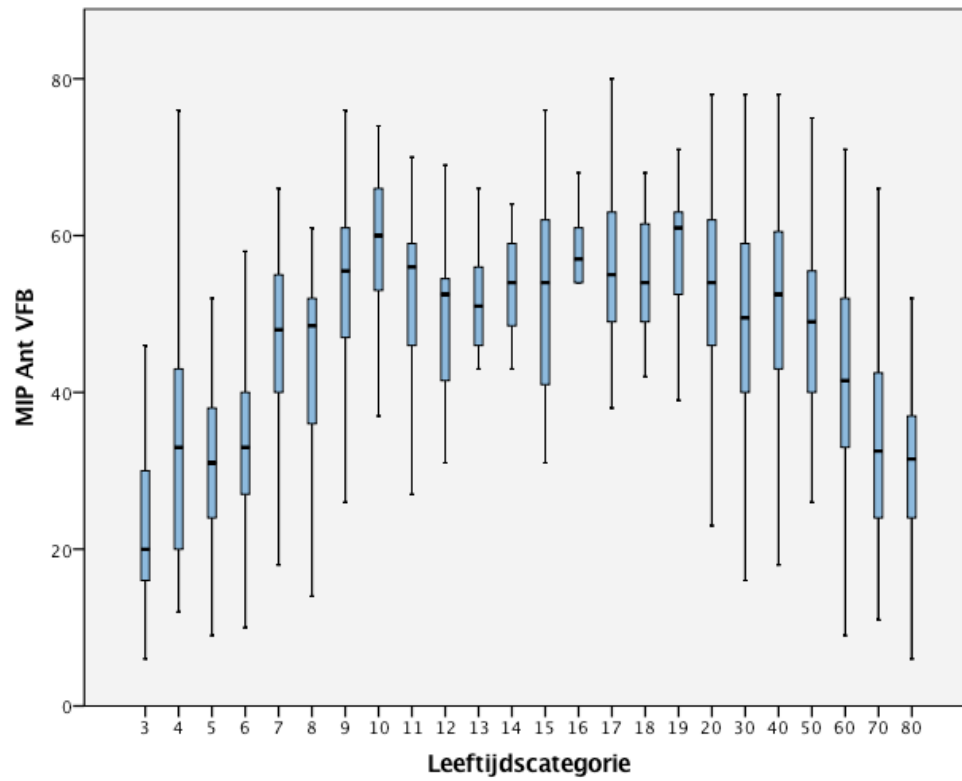
age	P5	P10	P25	P50	P75	P90	P95
20-30	33	43	51	60	64	73	85
31-40	38	40	46	57	63	75	77
41-50	27	38	47	57	67	73	76
51-60	30	38	42	49	58	67	68
61-70	12	19	33	42	56	62	65
71-80	15	17	23	35	44	54	60
80+	14	17	28	34	40	50	56

MIP_{post} (kPa)

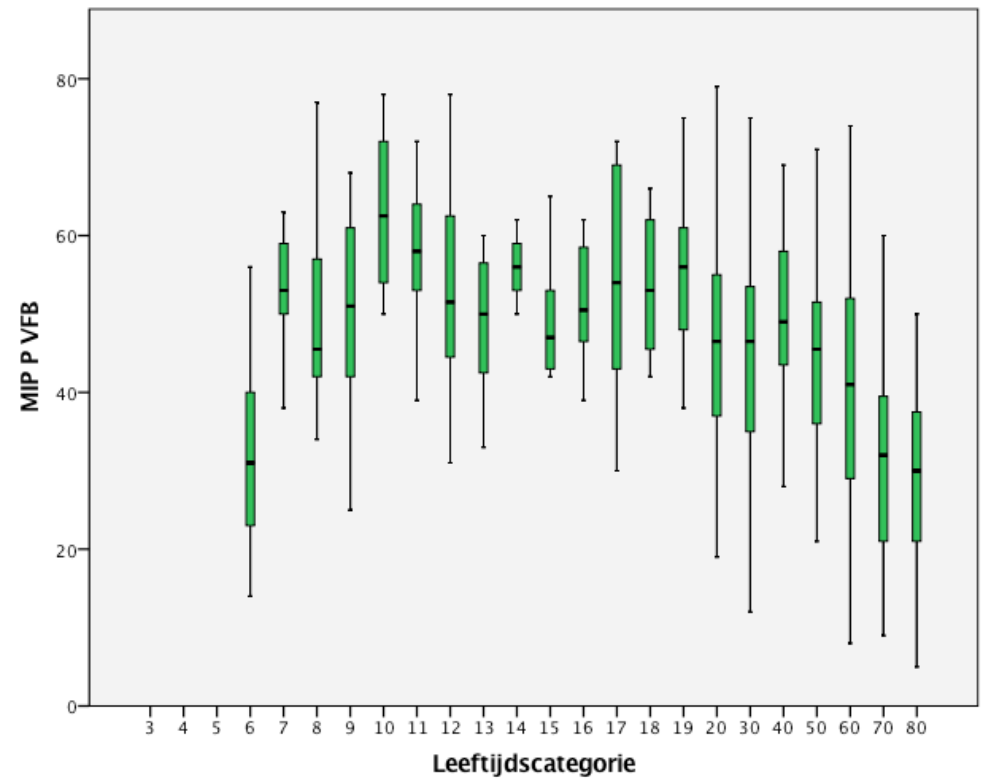
age	P5	P10	P25	P50	P75	P90	P95
20-30	27	29	37	49	58	72	77
31-40	23	32	37	48	56	71	73
41-50	25	36	46	52	62	69	69
51-60	25	33	36	47	53	64	68
61-70	11	13	29	44	54	65	67
71-80	12	14	21	34	41	47	48
80+	9	13	23	32	39	46	48

Results – *age all*

MIP anterior



MIP posterior



Usage scenario's

- screening
- pathophysiologic diagnosis
- **follow-up**
- therapy

follow-up

- negative direction
 - progressive decrease of tongue strength
 - reduction of oral feeding capabilities
 - associated with death

NM diseases: ALS

J Neurol (2012) 259:2360–2365

DOI 10.1007/s00415-012-6503-9

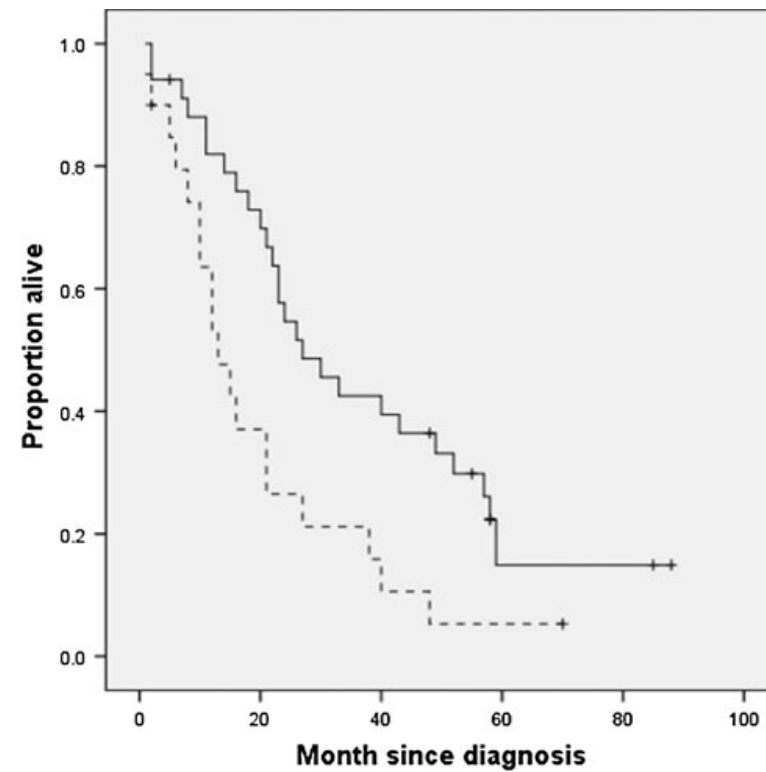
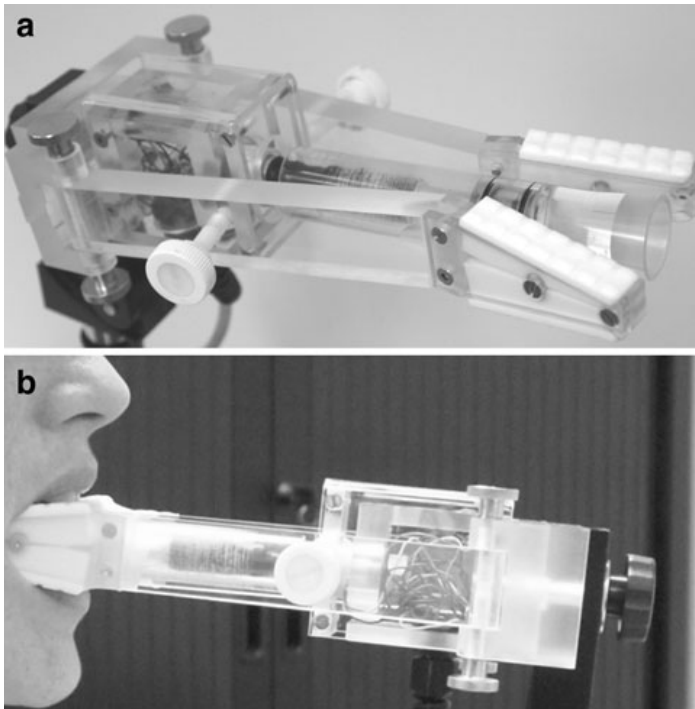
ORIGINAL COMMUNICATION

Prognostic value of decreased tongue strength on survival time in patients with amyotrophic lateral sclerosis

**J. G. Weikamp · H. J. Schelhaas · J. C. M. Hendriks ·
B. J. M. de Swart · A. C. H. Geurts**

NM diseases: ALS

- decreased tongue strength might herald bulbar involvement in ALS well *before* dysarthria or dysphagia occur...



follow-up

- positive direction
 - increased gain in tongue strength is possible due to scientific exercise construction
 - hugely motivating for patients
 - “What’s my number today?”
 - Forget your tongue spatula and saying: “I think it’s better...”



Usage scenario's

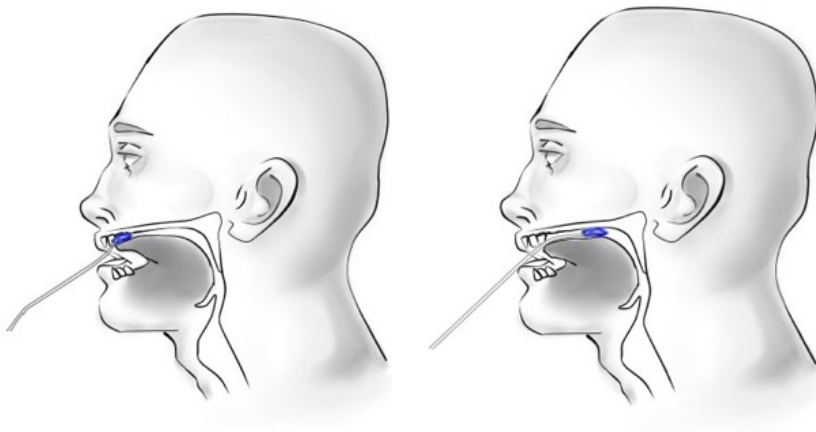
- screening
- pathophysiologic diagnosis
- follow-up
- **therapy**

Tongue strengthening exercises (TSE)

Aim to ...

1. increase tongue-palate pressures

- anterior and posterior part of the body of the tongue



Tongue strengthening exercises (TSE)

Aim to ...

1. increase tongue-palate pressures
2. improve P_{swal} → improved bolus propulsion
3. **improve swallowing function** (↓ residue & penetration/aspiration)

Growing evidence for TSE

Table 1 Literature overview of efficacy studies on tongue strengthening exercises

Author	N	Subjects	Therapy-protocol	Exercises	Target level	Device	Results MIP _A	MIP _P
Lazarus et al (2003) [12]	31	young healthy adults	50 repetitions 5x/week 4 weeks	ATSE	100% MIP	IOPI	+10kPa	n/a
Robbins et al (2005) [26]	10	healthy elderly	90 repetitions 3x/week 8 weeks	ATSE	week 1: 60% MIP week 2-8: 80% MIP	IOPI	+7kPa	n/a
Robbins et al (2007) [27]	10	stroke patients	30 repetitions 3x/week 8 weeks	ATSE PTSE	week 1: 60% MIP week 2-8: 80% MIP	IOPI	+16kPa	+24kPa
Yeates et al (2004) [28]	3	elderly with dysphagia	60 repetitions 2-3x/week 8-30 weeks	ATSE PTSE	50, 75, 100% MIP	IOPI	unsp ↑	unsp ↑
Clark et al (2009) [25]	39	healthy adults	30 repetitions 7x/week 9 weeks	ATSE	100% MIP	TD	+6kPa	n/a
Lazarus et al (2013) [29]	31	patients with head and neck cancer	50 repetitions 5x/week 6 weeks	ATSE +TST	100% MIP	TD	+2kPa	n/a
Steele et al (2013) [30]	6	patients with acquired brain injury & dysphagia	60 repetitions 2x/week 11-12 weeks	ATSE PTSE	20-90% MIP	IOPI	unsp ↑	unsp ↑
Oh et al (2015) [31]	10	healthy adults	30min/day 3x/week 8 weeks	ATSE PTSE	week 1: 60% MIP week 2-8: 80% MIP	IOPI	+16kPa	+16kPa
Park et al (2015) [32]	15	stroke patients	100 repetitions 5x/week 6 weeks	ATSE PTSE +TST	80% MIP	IOPI	+19kPa	+17kPa
Steele et al (2016) [33]	11	stroke patients	60 repetitions 2-3x/week 6-12 weeks	ATSE PTSE	25-85% MIP	IOPI	n/a	+19kPa
Rogus-Pulia et al (2016) [34]	34	elderly with dysphagia	30 repetitions 3x/week 8 weeks	ATSE PTSE	week 1: 60% MIP week 2-8: 80% MIP	MOST	unsp ↑	unsp ↑

How to make TSE effective and efficient?



Overload

- principles of exercise
- sport sciences
- ‘force the neuromuscular system beyond the level of usual activity’

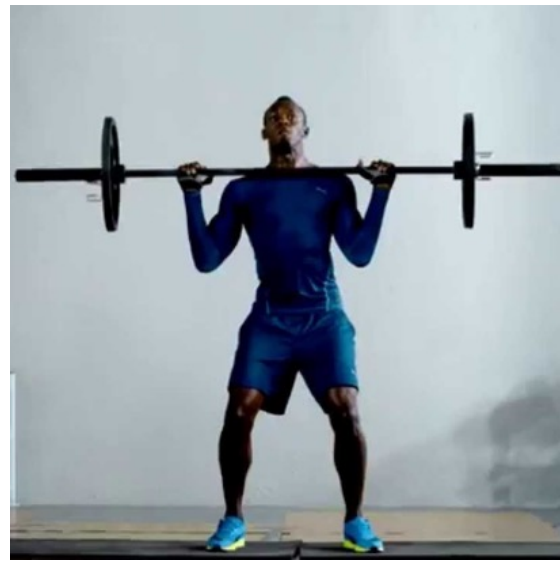
How to make TSE effective and efficient?



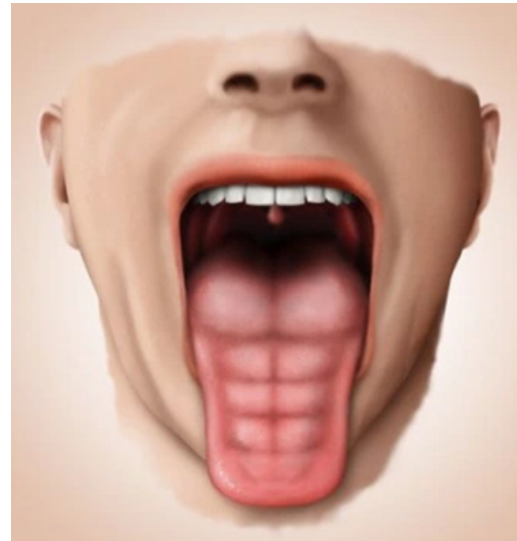
Overload

- ✓ resistance
- ✓ # repetitions
- ✓ frequency of practice
- ✓ duration

What is enough?



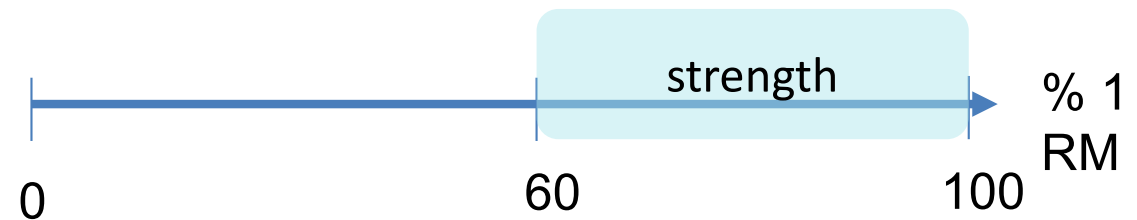
Can we simply use the knowledge of sports science?



Can it be too much?



Resistance



- 1 Repetition Maximum
- evidence based international guidelines (American College Sports Medicine)
- > 80% 1RM might cause injuries

Literature

- **60 % → 80 % 1 RM**
- **80 % 1 RM**
- **100 % 1 RM**
- **wide range (20-90% 1RM)**

Author	N	Subjects	Target level
Lazarus et al (2003) [12]	31	young healthy adults	100% MIP
Robbins et al (2005) [26]	10	healthy elderly	week 1: 60% MIP week 2-8: 80% MIP
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Resistance in TSE

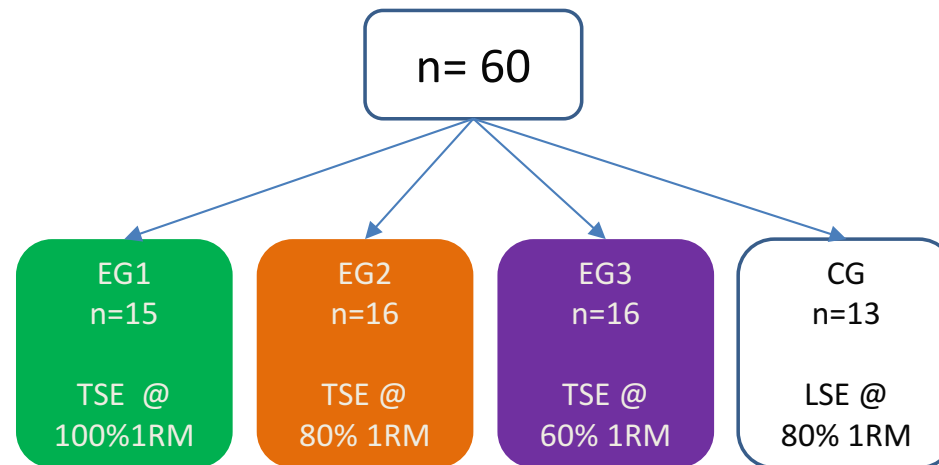
- what is the most effective resistance in TSE?
- 100 % > 80 % > 60 %?
- is 60 % more feasible?

Randomized controlled trial (Van Nuffelen et al)

Inclusion criteria

1. 70+ y.o.
2. MMSE >24
3. No history of pathology with possible influence on TS and swallowing
4. Passed Yale swallow protocol
5. TS-values within normal limits

Randomization

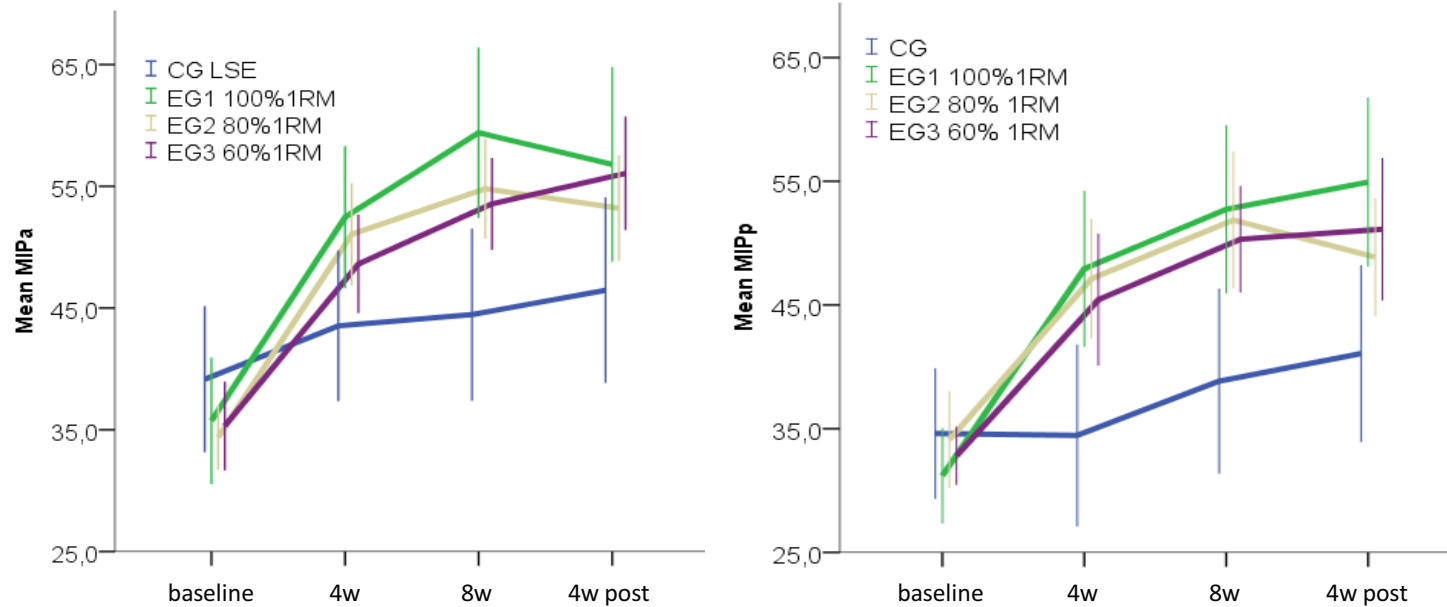


Randomized controlled trial (Van Nuffelen et al)

- ✓ 8 weeks TSE
- ✓ 3 nonconsecutive days/week
- ✓ EGs: 120 tongue presses/session (60 ant, 60 post; alternating order)
- ✓ CG: 120 lip presses/session
- ✓ Instruction: press until target level is reached → keep for 3 seconds
- ✓ Progressive overload: new 1 RM every 2 weeks



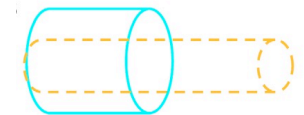
Effect on maximum tongue-palate pressures



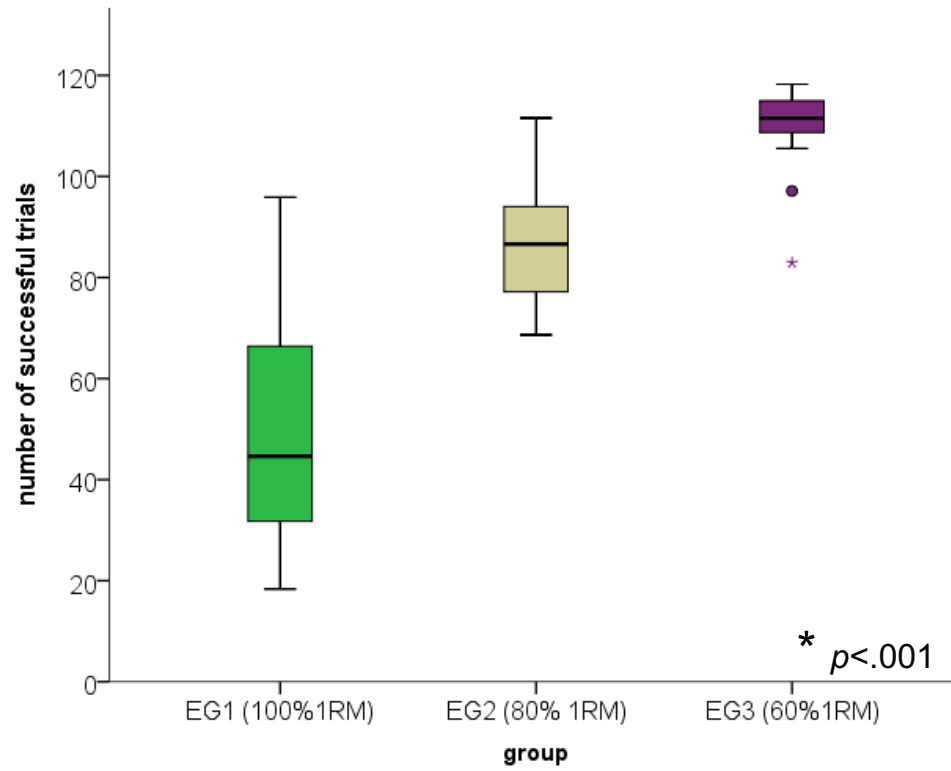
- significant difference between **control group** & all TSE-groups @ 4 & 8 weeks
- **no** significant differences between the TSE-groups
 - MIP anterior (8 weeks) : +24 kPa (100%) - + 21 kPa (80%) - + 17 kPa (60%)

Can it be too much?

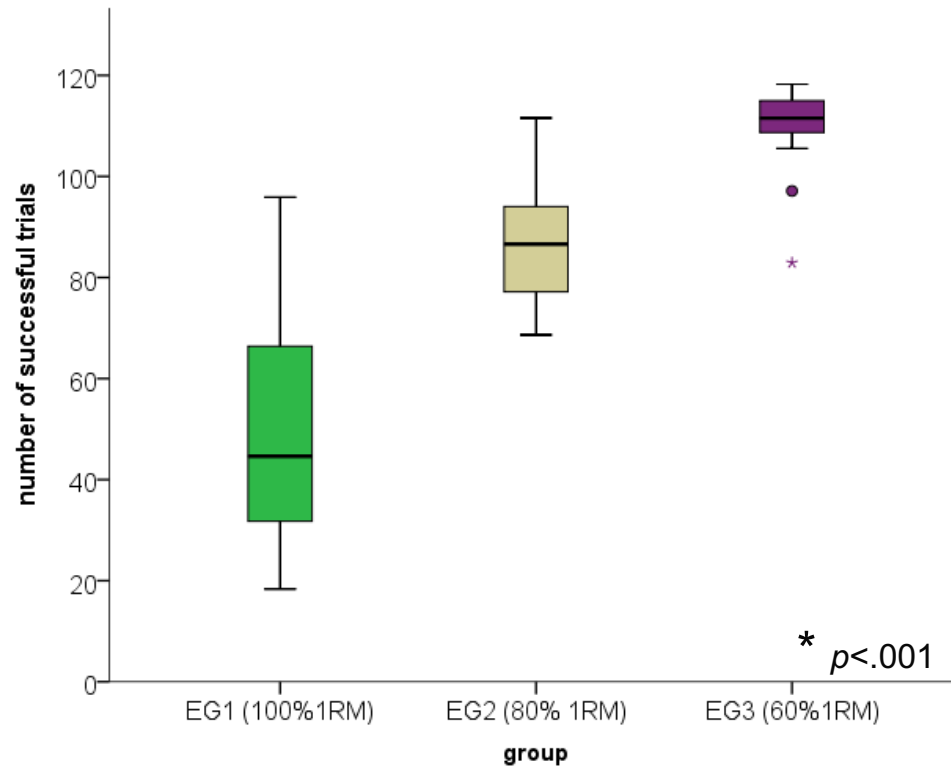
- no complaints about muscle fatigue or pain
- no drop-outs due to pain or muscle fatigue
- not mentioned in TSE-literature
- tongue = muscle hydrostat
 - no skeletal support
 - constant muscle volume during contraction
- high proportion of type II muscle fibres (fatigue resistant)
- tongue fatigue resistant ?



Number of successful repetitions



Number of successful repetitions



- positive feedback on performance
- adds to intrinsic motivation
- 'Yes you can'


Preliminary conclusions...

Van Nuffelen *et al. Trials* (2015) 16:395
DOI 10.1186/s13063-015-0889-5



STUDY PROTOCOL

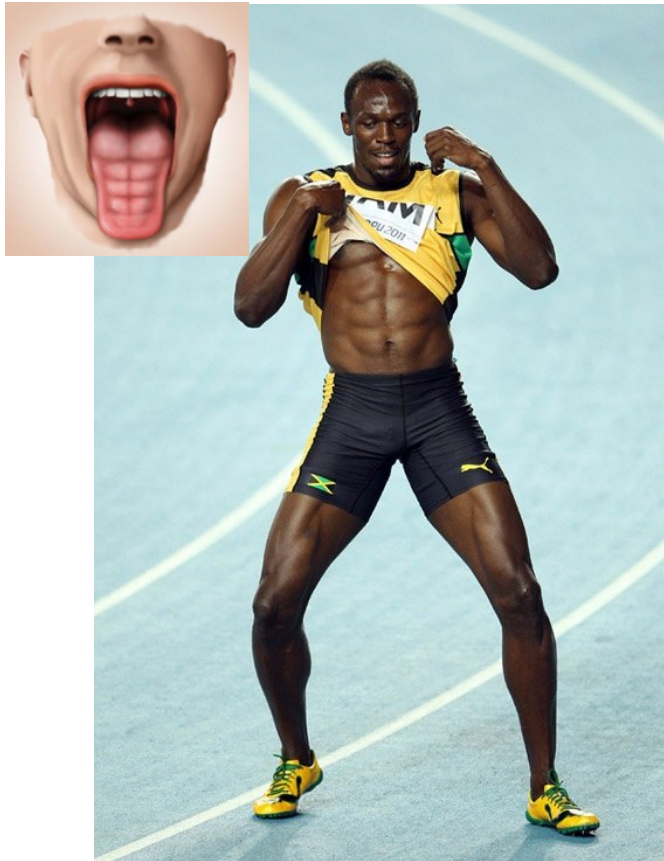
Open Access

Study protocol for a randomized controlled trial: tongue strengthening exercises in head and neck cancer patients, does exercise load matter?  CrossMark

Gwen Van Nuffelen^{1,2*}, Leen Van den Steen¹, Olivier Vanderveken^{1,2}, Pol Specenier³, Carl Van Laer¹, Diane Van Rompaey¹, Cindy Guns¹, Steven Mariën¹, Marc Peeters^{2,3}, Paul Van de Heyning^{1,2}, Jan Vanderwegen^{4,5} and Marc De Bodt^{1,2,6}

- **HNC** study is ongoing
- similar study in patients with **neuromuscular disorders**
- meanwhile in **clinical practice** (UZA):
 - generally: 80 % 1 RM
 - very frail patient or patient with low intrinsic motivation → 60 % 1 RM

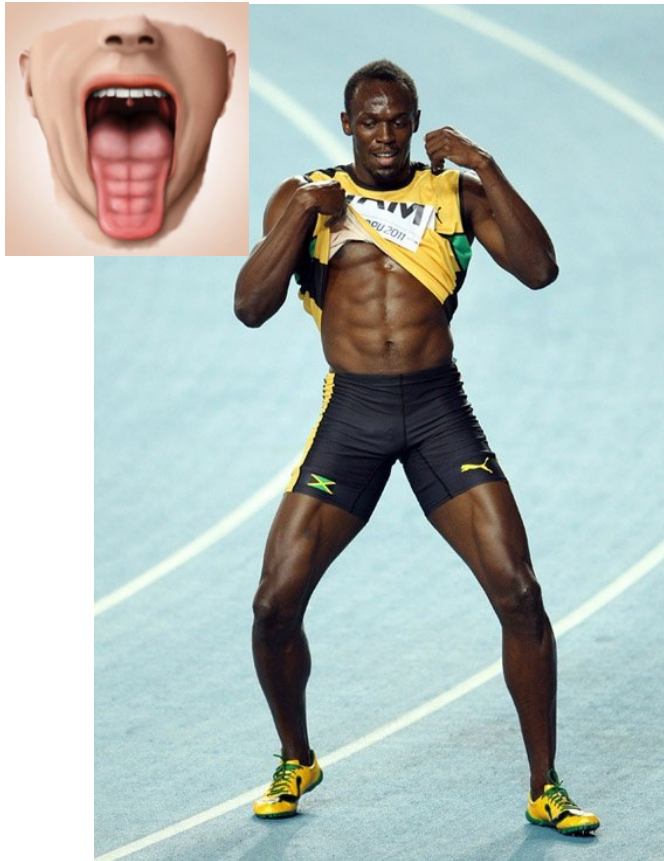
How to make TSE effective and efficient?



Overload

- ✓ resistance
- ✓ # repetitions
- ✓ frequency of practice
- ✓ duration

How to make TSE effective and efficient?



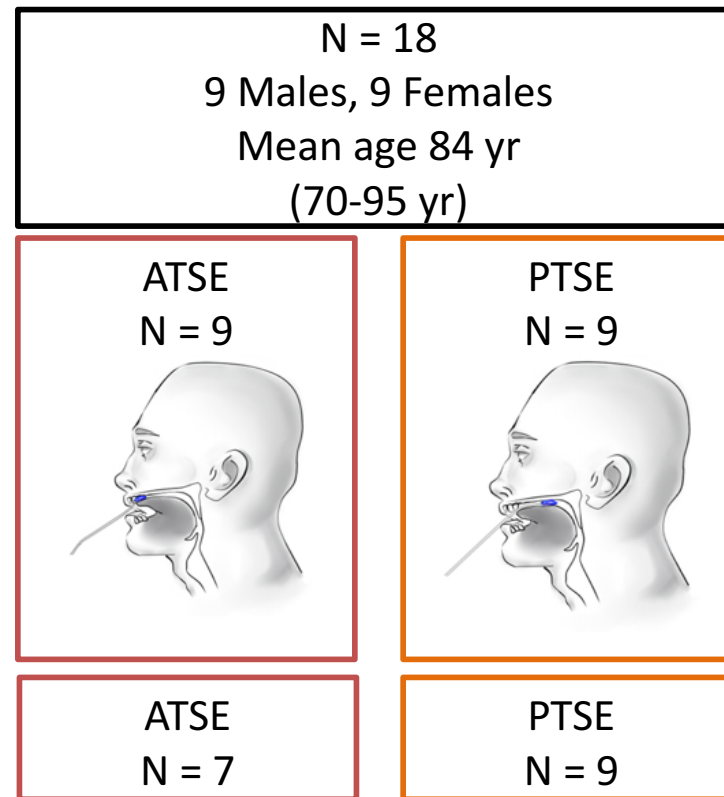
Overload

- ✓ resistance: (60) 80% 1RM
- ✓ # repetitions: 120 reps/session
- ✓ frequency of practice: 3 times/week
- ✓ duration: 8 weeks

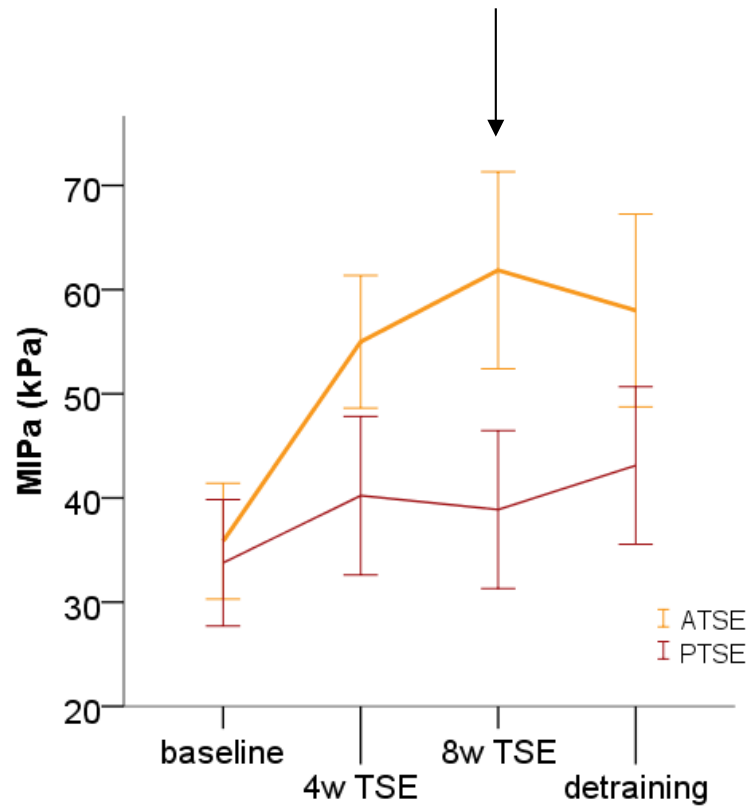
→ push the system, push the patient

Yes, but... my patient has a serious gag reflex

Yes, but... my patient has a serious gag reflex



Results - MIP_A

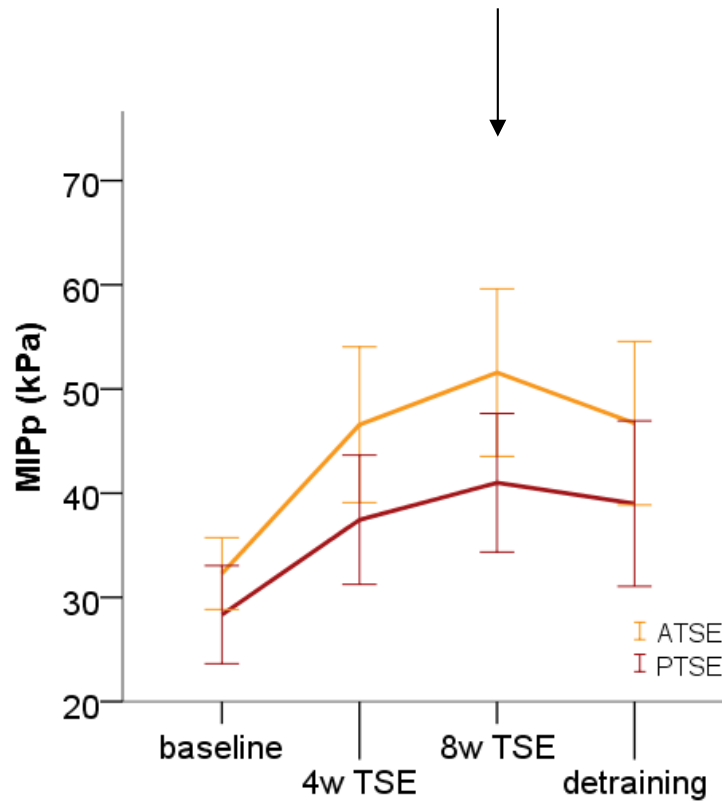


+72% MIP_A @ 8w ATSE

+15% MIP_A @ 8w PTSE

gain in ATSE > PTSE: p = .003

Results - MIP_p



+60% MIP_p after ATSE

+44% MIP_p after PTSE

gain after ATSE = PTSE: $p > .05$

Yes, but... my patient has a serious gag reflex

Solution:

- then practice only anteriorly
- but double the number of anterior reps (eg 120)
- to achieve similar total overload

Yes but... I can't afford an IOPI

- talk with ATOS 😊
- tongue depressor? Yes but ...
 - no visual feedback
 - no feedback on performance
 - motivation?
 - level of resistance?
 - no progressive overload



Lazarus 2003

In conclusion ...

Measuring & improving tongue strength?



In conclusion ...

Measuring & improving tongue strength?



תודה
Dankie Gracias
Спасибо شکرًا
Merci Takk
Köszönjük Terima kasih
Grazie Dziękujemy Děkojame
Ďakujeme Vielen Dank Paldies
Kiitos Täname teid 谢谢
Thank You Tak
感謝您 Obrigado Teşekkür Ederiz
Σας ευχαριστούμε 감사합니다
Bedankt Дěkujeme vám
ありがとうございます
Tack