INSTRUMENTAL TECHNIQUES IN DYSPHAGIA REHABILITATION

Jan Vanderwegen, MD
Thomas More University College, Antwerp, Belgium
Belgian Society Swallowing Disorders
IDDSI-board member

1

MENU

- Introduction
- IOPI
- CTAR
- EMST
- sEMG

4

INTRODUCTION

- Aims:
  - provide sufficient hydration and nutrition
  - in a safe way (avoiding aspiration)
  - while maintaining quality of life

5

INTRODUCTION - THERAPY

- Compensation:
  - no goal to modify swallowing physiology
  - posture modification, bolusmodification, swallowing manoeuvers,...
  - temporary (rehab not yet possible) or permanent (rehab no longer possible)
- Rehabilitation
  - goal is modifying physiology
  - muscle strength and -endurance
  - coordination, range of motion, speed of muscular contraction

6

INTRODUCTION - THERAPY

- Rehabilitation
  - change = plasticity
    - neural
    - muscular
  - improvement
    - neural control = functional patterns of movement
    - strength and skills

7

INTRODUCTION - THERAPY

Published in final edited form as:
J Speech Lang Hear Res. 2008 February ; 51(1): S240–S258.

Translating Principles of Neural Plasticity into Research on Speech Motor Control Recovery and Rehabilitation

Christy L. Ludlow,
National Institute of Neurological Disorders and Stroke, Bethesda, MD
Jeannette Hall,
University of Arizona, Tucson, AZ
Raymond Kent,
University of Wisconsin, Madison, WI
Lorraine O. Ramig,
University of Colorado, Boulder, CO
Rahul Shrivastav,
University of Florida, Gainesville, FL
Edythe Strand,
Mayo Clinic, Rochester, MI
Kathryn Yorkston, and
University of Washington, Seattle, WA
Christine Sapienza
University of Florida, Gainesville, FL

8

INTRODUCTION - THERAPY

Principles of Experience-Dependent Neural Plasticity: Implications for Rehabilitation After Brain Damage

Jeffrey A. Klein
McKnight Brain Institute, University of Florida, Gainesville, and Brain Rehabilitation Research Center, Malcom Randall VA Hospital, Gainesville

Theresa A. Jones
University of Texas at Austin

SUPPLEMENT

Journal of Speech, Language, and Hearing Research • Vol. 51 • S225–S239 • February 2008 • © American Speech-Language-Hearing Association
1092-4388/08/5101-S225

INTRODUCTION - PRINCIPLES

Principle	Description
1. Use It or Lose It	Failure to drive specific brain functions can lead to functional degradation
2. Use It and Improve It	Training that drives a specific brain function can lead to an enhancement of that function
3. Specificity	The nature of the training experience dictates the nature of the plasticity.
4. Repetition Matters	Induction of plasticity requires sufficient repetition.
5. Intensity Matters	Induction of plasticity requires sufficient training intensity.
6. Time Matters	Different forms of plasticity occur at different times during training.
7. Salience Matters	The training experience must be sufficiently salient to induce plasticity.
8. Age Matters	Training induced plasticity occurs more readily in younger brains.
9. Transference	Plasticity in response to one training experience can enhance the acquisition of similar behaviors
10. Interference	Plasticity in response to one experience can interfere with the acquisition of other behaviors.

INTRODUCTION - PRINCIPLES

Strength-Training Exercise in Dysphagia Rehabilitation: Principles, Procedures, and Directions for Future Research

Lori M. Burkhead, PhD,[1,3] Christine M. Sapienza, PhD,[2,3] and John C. Rosenbek, PhD[1,3]
[1]Department of Communicative Disorders, University of Florida, Gainesville, Florida, USA, [2]Department of Communication Sciences and Disorders, University of Florida, Gainesville, Florida, USA, and [3]Brain Rehabilitation Research Center of Excellence, Malcom Randall VA Medical Center, Gainesville, Florida, USA

Dysphagia 22:251–265 (2007)
DOI: 10.1007/s00455-006-9074-z

INTRODUCTION - PRINCIPLES

- Intensity and 'overload'
- Specificity
- Transference
- 'Use it and improve it'
- 'Use it or lose it'

INTRODUCTION - INTENSITY AND OVERLOAD

- force the neuromuscular system *beyond* usual activity to elicit adaptation
- progressive resistance: increased muscle strength needs increased resistance

INTRODUCTION - INTENSITY AND OVERLOAD

- resistance used is a fraction (%) of maximal muscular power
- maximal muscular power = '1-repetition maximum' = 1RM
- progressive resistance in swallowing rehabilitation
  - need to be able to measure 1RM
  - need to be able to adjust % of resistance

INTRODUCTION - INTENSITY AND OVERLOAD

- ideal training volume? ('volume of practice')
- repetitions/set
- sets/session and rest between sets
- sessions/day
- days/week
- number of weeks
- unclear: need for dose-response studies

15

INTRODUCTION - SPECIFICITY

- to be a better swallower, you must swallow!
- task-salience
- but what about 'oral cripples'...

16

INTRODUCTION - TRANSFERENCE

- isolated strength training with progressive resistance can result in functional improvement
- strength as a precursor to function!
- solution for severe dysphagic patients

17

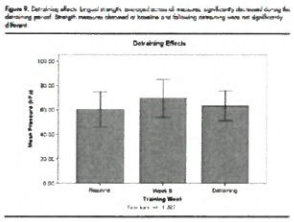
INTRODUCTION - USE IT AND IMPROVE IT

- building muscles takes time!
- muscle learning: increased number of motor units recruited at activity (2-4 weeks)
- muscle hypertrophy: bigger muscle fibers (8 weeks)

18

INTRODUCTION - USE IT OR LOSE IT

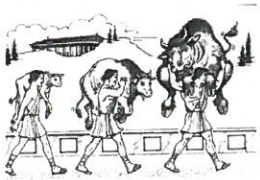
- disuse muscle atrophy
- skeletal muscles
- also in swallowing muscles?



19

INTRODUCTION - HISTORY

- ancient insights! Milo of Croton, 6th century BC



20

INTRODUCTION - POSSIBILITIES

- physical therapy!

Het is hun drijfveer om elke dag en elke behandeling nóg beter te doen dan de vorige, om zo een **maximaal resultaat** na te streven. Hij leidt, begeleidt, stuurt aan en begeestert zijn medewerkers die allen dezelfde filosofie voor ogen houden. De revalidatie van topsporters werd zijn handelsmerk. Zo passeerden onder meer Andriy Shevchenko, Filippo Inzaghi, Marouane Fellaini, Mounsa Dembele, Johan Museeuw, Michele Bartoli, Frank Vandenbroucke, Yanina Wickmayer, Justine Henin, Xavier Malisse, Joël Smets.... door zijn handen op hun terugweg naar de top.

INTRODUCTION - PRINCIPLES

IOPI

Iowa Oral Performance Instrument

oralingual muscle assessment and training

IOPI

Measuring tongue strength

Is tongue strength training effective?

Indications and contra-indications for tongue strength training

IOPI - MEASURING TONGUE STRENGTH

- screening
- pathophysiologic diagnosis
- follow-up

IOPI - SCREENING

- sarcopenia: "generalized muscle weakness"

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

must 1. low *skeletal muscle mass* index (kg/m²) by *bioelectrical impedance analysis*

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

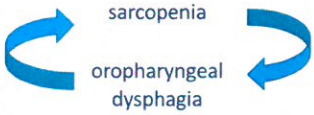
IOPI - SCREENING

- 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

27

IOPI - SCREENING

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



28

IOPI - SCREENING

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

29

IOPI - SCREENING

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

30

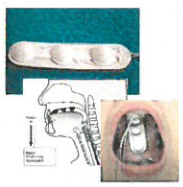
TONGUE STRENGTH - MEASUREMENT

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

31

TONGUE STRENGTH - MEASUREMENT

- KayPentax Signals Lab
  - expensive
  - discontinued



32

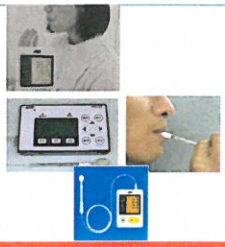
TONGUE STRENGTH - MEASUREMENT

- SwallowSTRONG (JoAnn Robbins)
  - bankruptcy

33

TONGUE STRENGTH - MEASUREMENT

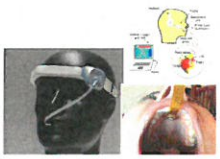
- JMS/Handy probe
  - anterior tongue only
  - non-available in Europe (no CE-mark)



34

TONGUE STRENGTH - MEASUREMENT

- Oropress
  - anterior tongue only
  - status?



35

TONGUE STRENGTH - MEASUREMENT

- Tongueometer
  - Android-based system
  - cheap
  - new player - commercially viable?

36

IOPI - SCREENING

- the 'de facto' golden standard
  - pro: clinician
  - trainer: patient
  - software available/in development

37

IOPI - SCREENING

- 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?

38

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

39

CLARK HM ET AL. RELATIONSHIPS AMONG SUBJECTIVE AND OBJECTIVE MEASURES OF TONGUE STRENGTH AND ORAL PHASE SWALLOWING IMPAIRMENTS. AM J SPEECH LANG PATHOL. 2003

- relation subjective - objective tongue strength

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

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

40

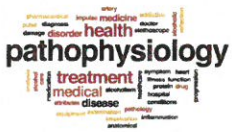
IOPI - SCREENING

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

41

IOPI - MEASURING TONGUE STRENGTH

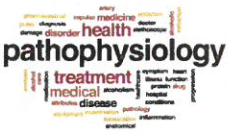
- screening
- **pathophysiologic diagnosis**
- follow-up



42

IOPI - PATHOPHYSIOLOGY

- tongue function?
- stages of deglutition
  - oral phase
    - oral preparation
    - oral transport ←
  - pharyngeal phase
  - esophageal phase



43

IOPI - PATHOPHYSIOLOGY

Oral Transport Phase - Kahrilas '93

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

44

IOPI - PATHOPHYSIOLOGY

transition from respiratory oropharynx to deglutative oropharynx

Concept Model of Dysphagia
-
Kahrilas & Logemann '93

bolus transport mechanisms
↓
tongue propulsion
pharyngeal clearance

reconfiguration oro- and hypopharynx from respiration to deglutition
↓
velopharyngeal closure
laryngeal closure
UES opening

45

IOPI - PATHOPHYSIOLOGY

Concept Model of Dysphagia
-
Kahrilas & Logemann '93

		Reconfiguration	
		OK	not OK
Transport	OK	OK	Misdirected
	not OK	Weak /Inefficient	Delayed /Mistimed

↓
residue

46

IOPI - PATHOPHYSIOLOGY

Weak / Insufficient Swallow

- make an educated guess using the location of the residue

47

IOPI - PATHOPHYSIOLOGY

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

48

IOPI - PATHOPHYSIOLOGY

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

49

IOPI - PATHOPHYSIOLOGY

"Patho-"

- what defines "patho-'?
- normative data!

50

IOPI - PATHOPHYSIOLOGY

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

51

IOPI - PATHOPHYSIOLOGY

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 and children

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

52

IOPI - PATHOPHYSIOLOGY

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 and children and teenagers

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

53

IOPI - PATHOPHYSIOLOGY

normative data

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	72	85
31-40	38	46	46	57	63	71	77
41-50	27	38	47	57	67	73	76
51-60	20	28	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	26	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

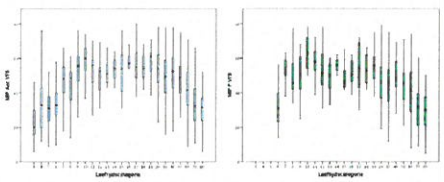
54

IOPI - PATHOPHYSIOLOGY

tongue strength across all ages...

MIP anterior

MIP posterior



55

IOPI - MEASURING TONGUE STRENGTH

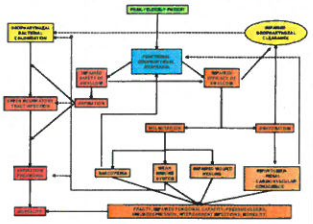
- screening
- pathophysiologic diagnosis
- follow-up

56

IOPI - FOLLOW-UP

Decline of tongue strength

- progressive decrease of tongue strength
- reduction of oral feeding capabilities
- malnutrition - dehydratation
- mortality



57

IOPI - FOLLOW-UP

Multiple diseases are associated with changes in tongue strength

58

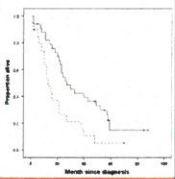
IOPI - FOLLOW-UP: ALS

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. Welkamp · H. J. Schelhaas · J. C. M. Hendriks · B. J. M. de Swart · A. C. H. Geurts



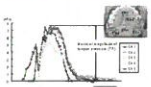
59

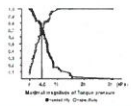
IOPI - FOLLOW-UP: STROKE

Hirota N., Stroke. 2010 Dec.

Reduced tongue pressure against the hard palate on the paralyzed side during swallowing predicts Dysphagia in patients with acute stroke.

- stroke +/- dysphagia
- tongue strength dysphagia- > dysphagia+





60

IOPI - FOLLOW-UP: HEAD-NECK CANCER

Husaini, Dysphagia 2014. A survey of variables used by speech-language pathologists to assess function and predict functional recovery in oral cancer patients.

- 95% SLPs routinely evaluates tongue strength in HNC
- only 13% use an objective measurement device

Lazarus, Ann Otol Rhinol Laryngol. 2013. Tongue strength as a predictor of functional outcomes and quality of life after tongue cancer surgery.

- Patients with tongue strength ≥ 30 kPa: better performance status scales and multiple QOL measurements

Lazarus, Dysphagia. 2014. Functional outcomes and quality of life after chemoradiotherapy: baseline and 3 and 6 months post-treatment.

- Tongue strength, cheek range of motion (ROM), and saliva production significantly lower 3 and 6 months after baseline

61

IOPI - FOLLOW-UP: INTENSIVE CARE

Su et al. Dysphagia 2015. Tongue weakness and somatosensory disturbance following oral endotracheal extubation.

- 30 adults with urgent intubation during ≥ 48 hours (+ control group)
- tongue strength after extubation - 7 days - 14 days (no intervention oral condition/intake)

Outcome	Intubated group Mean ± SD	Comparison group Mean ± SD	Adjusted group difference[2] Beta (95% CI)	Adjusted p^2
Maximum tongue strength (kPa)				
T0	30.9 ± 14.7	47.4 ± 9.6	16.9 (10.4, 25.4)	<0.001
T1	33.5 ± 14.9		19.2 (7.5, 23.1)	<0.001
T2	36.7 ± 11.4		8.7 (0.6, 16.3)	0.03

- clear reduction tongue strength with slow recuperation!
  - no follow-up beyond 14 days

62

IOPI - FOLLOW-UP

Increase of 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..."

63

IOPI

Measuring tongue strength

Is tongue strength training effective?

Indications and contra-indications for tongue strength training

64

IOPI - TONGUE STRENGTHENING

- traditional dysphagia therapy
  - *compensation* to prevent aspiration
    - postural
    - bolus-modification (viscosity, volume, consistency)
  - *exercise*
    - range of motion
    - increasing effort
    - stimulating the sensory system
  - *biofeedback*

66

IOPI - TONGUE STRENGTHENING

- recent insights: adaptation of 'exercise training practices'
- physical therapy insights
  - neural plasticity, muscular adaptation
  - 'force the neuromuscular system beyond the level of usual activity'
  - based on 'skeletal muscles'

67

IOPI - TONGUE STRENGTHENING

- aims of tongue strengthening?

increase maximum tongue strength?

↓

increase swallowing strength?

↓

improved swallowing?

68

IOPI - TONGUE STRENGTHENING: HOW?

- repetitive tongue-palate resistance training
- anterior and/or posterior tongue

69