Stay in Your Lane!

Do compensatory strategies rehabilitation potential?
<table>
<thead>
<tr>
<th>Compensatory Strategies</th>
<th>Rehabilitative Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short term</strong></td>
<td><strong>Long term</strong></td>
</tr>
<tr>
<td>Reduce impairment</td>
<td>Restore function</td>
</tr>
<tr>
<td>Effects only when in use</td>
<td>Effects after use</td>
</tr>
<tr>
<td>i.e. “Crutch”</td>
<td>Improved strength or skill</td>
</tr>
</tbody>
</table>
Occupational Therapy

Constraint induced movement therapy

Constrain the good arm

Challenge bad arm to work

Form of rehabilitation
Challenge

Arduous  Strenuous  Difficulty  Effort  Trial  Demand
Typical Table of Compensatory Strategies

<table>
<thead>
<tr>
<th>Disorder Observed on Fluoroscopy</th>
<th>Posture Applied</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inefficient oral transit</td>
<td>Head back</td>
<td>Utilizes gravity to clear oral cavity</td>
</tr>
<tr>
<td>Delay in triggering the pharyngeal swallow (Bolus past rama of mandible, but pharyngeal swallow not triggered)</td>
<td>Chin down</td>
<td>Widens valleculae to prevent bolus entering airway, narrows airway entrance, pushes epiglottis posteriorly</td>
</tr>
<tr>
<td>Reduced posterior motion of tongue base (Residue in valleculae)</td>
<td>Chin down</td>
<td>Pushes tongue base backward toward pharyngeal wall</td>
</tr>
<tr>
<td>Unilateral laryngeal dysfunction (Aspiration during swallow)</td>
<td>Head rotated to damaged side; chin down</td>
<td>Places extrinsic pressure on thyroid cartilage, increasing adduction</td>
</tr>
<tr>
<td>Reduced laryngeal closure (Aspiration during swallow)</td>
<td>Chin down; head rotated to damaged side</td>
<td>Puts epiglottis in more protective position; narrows laryngeal entrance; increases vocal fold closure by applying extrinsic pressure</td>
</tr>
<tr>
<td>Reduced pharyngeal contraction (Residue spread throughout pharynx)</td>
<td>Lying down on one side</td>
<td>Eliminates gravitational effect on pharyngeal residue</td>
</tr>
<tr>
<td>Unilateral pharyngeal paresis (Residue on one side of pharynx)</td>
<td>Head rotated to damaged side</td>
<td>Eliminates damaged side from bolus path</td>
</tr>
<tr>
<td>Unilateral oral and pharyngeal weakness on the same side (Residue in mouth and pharynx on same side)</td>
<td>Head tilt to stronger side</td>
<td>Directs bolus down stronger side</td>
</tr>
<tr>
<td>Cricopharyngeal dysfunction (Residue in pyriform sinuses)</td>
<td>Head rotated</td>
<td>Pulls cricoid cartilage back from posterior pharyngeal wall, reducing intra pharyngeal pressure</td>
</tr>
</tbody>
</table>

### Common postural techniques & some indications for use

<table>
<thead>
<tr>
<th>Compensatory technique</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chin tuck</td>
<td>Reduced oral bolus control with aspiration before or during the swallow</td>
</tr>
<tr>
<td>Neck extension</td>
<td>Impaired oral bolus propulsion</td>
</tr>
<tr>
<td>Head turn to weak side</td>
<td>Unilat. Pharyngeal weakness with retention after swallowing</td>
</tr>
<tr>
<td>Head tilt to weak side</td>
<td>Unilat. Oral &amp; pharyngeal weakness</td>
</tr>
<tr>
<td>Reclining position</td>
<td>Pharyngeal weakness with retention &amp; overflow after swallowing</td>
</tr>
<tr>
<td>Supraglottic swallow</td>
<td>In adequate or delayed closure of laryngeal aditus (entrance)</td>
</tr>
<tr>
<td>Effortful swallow</td>
<td>Poor tongue based retraction</td>
</tr>
<tr>
<td>Mendofelsohn maneuver</td>
<td>Inadequate upper esophageal sphincter opening</td>
</tr>
<tr>
<td>Syringe feeding</td>
<td>Impaired oral bolus propulsion</td>
</tr>
<tr>
<td>Altering solids &amp; liquids</td>
<td>Retention in the pharynx after swallowing</td>
</tr>
</tbody>
</table>
Comes from dysphagia “bible”

Jeri Logemann, Ph.D., CCC-SLP
Our studies

chinch up and chin down
(principles of motor adaptation)

bolus modification
(principles of sensitivity shifting)

might challenge your views on the potential of compensatory strategies
chin up and chin down
Chin-Down

Reduced oral bolus control → Widens valleculae, prevents aspiration

Chin-Up

Reduced posterior propulsion of bolus by tongue → Utilizes gravity to clear oral cavity

Logemann, 1998
Motor Adaptation

Can a swallow be challenged?

How?
Motor adaptation (aka error-based learning)

Movement errors are prevented when the nervous system (primary cerebellum) predicts the outcome of a movement before the movement is made.
Task: quickly lift bag to shoulder level

overshoot shows adaptation After-effects (planning for 15lb)

pre-perturbation

perturbation unexpected weight increase

post-perturbation unexpected weight decrease
Chin-Down

16 healthy adults
(Macrae et al. 2014)

Chin-Up

12 healthy adults
(Sunday et al. submitted)
1. Are there **immediate** changes in swallowing kinematics during postural swallows?

2. Do swallowing kinematics change over several trials of the posture?

3. Are aftereffects present in neutral swallows after performing several postural swallows?

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**Chin-Down**

- 16 healthy adults
  - (Macrae et al. 2014)

**Chin-Up**

- 12 healthy adults
  - (Sunday et al. *submitted*)
Study Design

Healthy adults

45 swallows
(5ml thin liquid barium)

videofluoroscopy
Study Design

Chin Down Group: Baseline head-neutral swallows

Chin-down swallows

Chin-up swallows

Chin-Up Group: Head-neutral swallows
Three Research Questions

1. What are the **immediate** effects of the chin up and chin down postures?
Three Research Questions

2. Do swallowing kinematics change over several trials of the posture?
Three Research Questions

3. Are aftereffects present in neutral swallows after performing several postural swallows?
### Outcome Measures

<table>
<thead>
<tr>
<th>Airway Protection</th>
<th>Chin-Down</th>
<th>Chin-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Laryngeal vestibule closure <strong>duration</strong></td>
<td>Time to max hyoid elevation</td>
</tr>
<tr>
<td></td>
<td>Laryngeal vestibule closure <strong>reaction time</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Molfenter, S.M., Steele, C.M. (2012)*
Chin Down Results
laryngeal vestibule closure duration

Baseline head-neutral swallows

94ms

$ p = 0.018 $
laryngeal vestibule closure reaction time

Chin Down Group

Baseline head-neutral swallows

Chin-down swallows

Head-neutral swallows

no change
pharyngeal transit time

Chin Down Group

Baseline head-neutral swallows

Chin-down swallows

Head-neutral swallows

40ms

$p = 0.046$
Does the chin-down swallowing strategy challenge swallowing?

The increase in laryngeal vestibule closure likely only occurred because the chin down position places the hyoid and larynx closer together (Bulow 1999, 2001), not because participants volitionally maintained longer closure.
Chin Up Results
Chin-up swallows

Baseline head-neutral swallows

67ms

p = 0.027

time to max hyoid elevation

Chin Up Group

Head-neutral swallows
Chin-up swallows

Baseline head-neutral swallows

Chin-up swallows

Head-neutral swallows

UES opening reaction time

50ms

$p=0.03$
Chin-up swallows
Baseline head-neutral swallows
Chin-up swallows
Head-neutral swallows
Pharyngeal transit time

Chin Up Group

$p=0.026$

52ms
Does the chin-up swallowing strategy challenge swallowing?

The chin-up strategy had a similar effect on limiting the time to max hyoid elevation (+67ms) as found with electrical stimulation (+73ms)

Anderson & colleagues (2015)
Summary
How can the impairment determine if a compensatory strategy can challenge the impairment, rather than just reduce the impairment?
Strategy

Proposed Theory

Reduce Impairment

Swallow onset delay

Challenge Impairment?

Posterior oral bolus movement

Posterior oral bolus movement

Swallow onset delay
Proposed Theory

Strategy

Reduce Impairment

weak left, close left

Challenge Impairment?

close right, open left

Proposed Theory

Strategy

weak right, close right

Proposed Theory

Strategy

left

close right, open left

Proposed Theory

Strategy

right

close left, open right
bolus modification
Anesthesia

Multiple saliva swallows

decreased sensory input

= Mansonn 1975a, 1975b; Teismann 2007

Absent, late, reduced swallow response
Large bolus sensory input = robust swallow response

(Dantas 1990; Kahrilas 1998; Lazarus 1993)
Oral sensation modulates the swallow response to accommodate the properties of the bolus
Molfenter et al, 2012
But are these relationships fixed?
bolus volume: 30 mL, 30 mL, 30 mL
UES opening duration: 500 ms, 500 ms, 500 ms
Sensitivity Shifting

Allows us to determine whether or not the same stimulus induces various sensory-motor responses.

These modifications are based on prior sensory experiences.
Sensitivity Shifting

50° outdoors warm

70° indoors cool

90° outdoors
Sensitivity Shifting

70°

indoors

same: indoor condition
different: sensory experience
Sensitivity Shifting

Is the response to one bolus modified based on the sensory experiences that immediately preceded it?

Humbert et al, 2012
swallowing example

small bolus block
large bolus block

small vs large bolus block

catch trial
Our Study Design
Humbert et al, 2012

Results - no difference

10 swallows too few? Perhaps a large catch trial?
Therefore, we had to challenge the system
Figure 1. Swallow Reaction Time (Healthy N=3)
The MBSImP Protocol

**Thin Liquid**
- 5ml teaspoon
- 5ml teaspoon with strategy (chin tuck, head turn, effortful swallow, etc…)
- Single cup sip
- Sequential Swallow

**Nectar Thick Liquid**
- 5ml teaspoon
- Single cup sip
- Sequential swallow

**Honey Thick Liquid**
- 5ml teaspoon

**Pudding Thick**
- 5ml teaspoon

**Solid**
- ½ shortbread cookie (1”x1” x .25”) coated with 3ml pudding consistency
The MBSImP Protocol

<table>
<thead>
<tr>
<th>Type</th>
<th>Volume</th>
<th>Strategy</th>
<th>Single cup sip</th>
<th>Sequential swallow</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thin Liquid</strong></td>
<td>5ml</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Single cup sip</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nectar Thick Liquid</strong></td>
<td>5ml</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Honey Thick Liquid</strong></td>
<td>5ml</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pudding Thick</strong></td>
<td>5ml</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Solid</strong></td>
<td>½</td>
<td>✓</td>
<td></td>
<td></td>
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</table>

What are the limits of the system? Are we challenging the swallow?
• **Compensatory strategies**: limiting the system

• **Rehab**: understanding the limits of the system
bolus volume

opening duration

(Steele & Miller, 2010; Molfenter et al, 2012)
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2

Seconds

.21 sec
.23
.45

.67 sec

larger bolus strategy

even larger bolus strategy

Molfenter et al 2012
Derived from 14 studies
1. The system is responding to bolus volume as it should

2. You’ve identified the impairment (reduced UES duration)
Sensitivity Shifting in one patient post-stroke

heap 1/2 heap 1/2 heap 1/2 heap

small - 1/2 tsp pudding; large heaping tsp pudding
Sensitivity Shifting in one patient post-stroke

small - 1/2 tsp pudding; large heaping tsp pudding
Bolus Modification

I’d be willing to bet…

Now:
Think of it as a way to tease out the problem with the swallowing system
bolus volume

Brain

UES opening duration
How can you probe the brain in this example?
bolus volume

Brain

UES opening duration

-
How can you target the brain in this example?

Would you have an advantage if I told you that the step circles are farther from one another with each step?
Hallmark of dysphagia: Inability to manage a wide range of boluses

- belief: sensorimotor response fixed
- boluses tested small to large
- restrict bolus volumes and consistencies
  - deprived of practice?
Physical Therapy
Occupational Therapy

Swallowing Therapy

bad arm

good arm

good arm

bad arm
understanding the impairment

understanding the strategy

testing the limits of the system, not limiting the system

sweet spot
Neuroplasticity

The brain's ability to reorganize itself by forming new neural connections:

- normal development
- after injury
- in response to new situations / changes in environment.
Use it or lose it!

If certain brain areas are not biologically active, they may begin to degrade.
Principles of Neuroplasticity

- Use
- Repetition
- Intensity
- Specificity
- Salience
- Difficulty
- Transference

Use it repeatedly!

If certain brain areas are not biologically active frequently, they may begin to degrade.
Principles of Neuroplasticity

Use
- Repetition
- Intensity
- Specificity
- Salience
- Difficulty
- Transference

Use it intensely!
If certain brain areas are not used beyond typical activity, they may remain stagnant.
Principles of Neuroplasticity

Use
- Repetition
- Intensity
- Specificity
- Salience
- Difficulty

.Use it with specificity!

If certain brain areas are not used for a specific task, performance of that specific task might not improve.
Principles of Neuroplasticity

Use
- Repetition
- Intensity
- Specificity
- Salience
- Difficulty
- Transference

Use it with attention!

If certain brain areas are motivated or heightened during a specific task, performance of that specific task might not improve.
Principles of Neuroplasticity

Use it and challenge it!

If certain brain areas are not **challenged** during a specific task, performance of that specific task might not improve.
Principles of Neuroplasticity

Use
- Repetition
- Intensity
- Specificity
- Salience
- Difficulty
- Transference

Use it in different ways!

If certain brain areas become plastic, they may transfer or generalize to other behaviors, tasks, or domains.
Principles of Neuroplasticity

- Use
- Repetition
- Intensity
- Specificity
- Salience
- Difficulty

Can we use “compensatory strategies” to challenge swallowing?
Thanks

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