Respiratory Muscle Strength Training (RMST): Practical Strategies for Immediate Clinical Translation

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Laboratory for the Study of Upper Airway Dysfunction
TEACHERS COLLEGE, COLUMBIA UNIVERSITY

Aerodigestive Innovations Research (AIR)

Weill Cornell Medicine
Medical College

Disclosures

James Curtis:

- Salaried employee of Weill Cornell Medical College and Weill Cornell Medicine/NewYork-Presbyterian
- No other relevant financial or non-financial disclosures or conflicts of interest
- I have no financial relationships or conflicts of interested associated with any of the devices or pieces of equipment shared in this presentation

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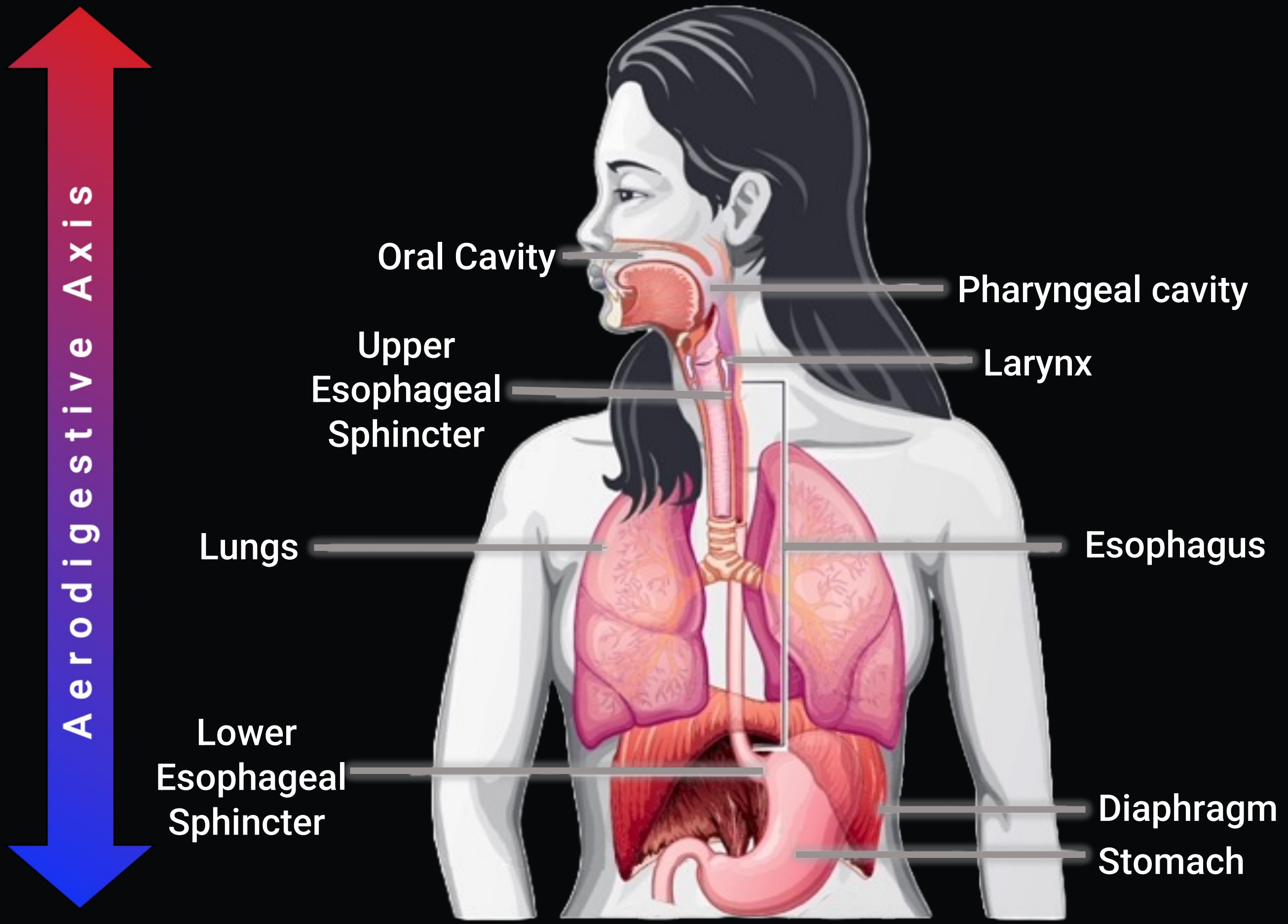
- No relevant financial or non-financial disclosures or conflicts of interest

Outline

1. Background
2. Assessment
3. Practical Strategies
4. Case Study
5. Question & Answer Session

Multiple Systems Impact Airway Protection



Anatomic Images Adapted from Hixon et al. 2018

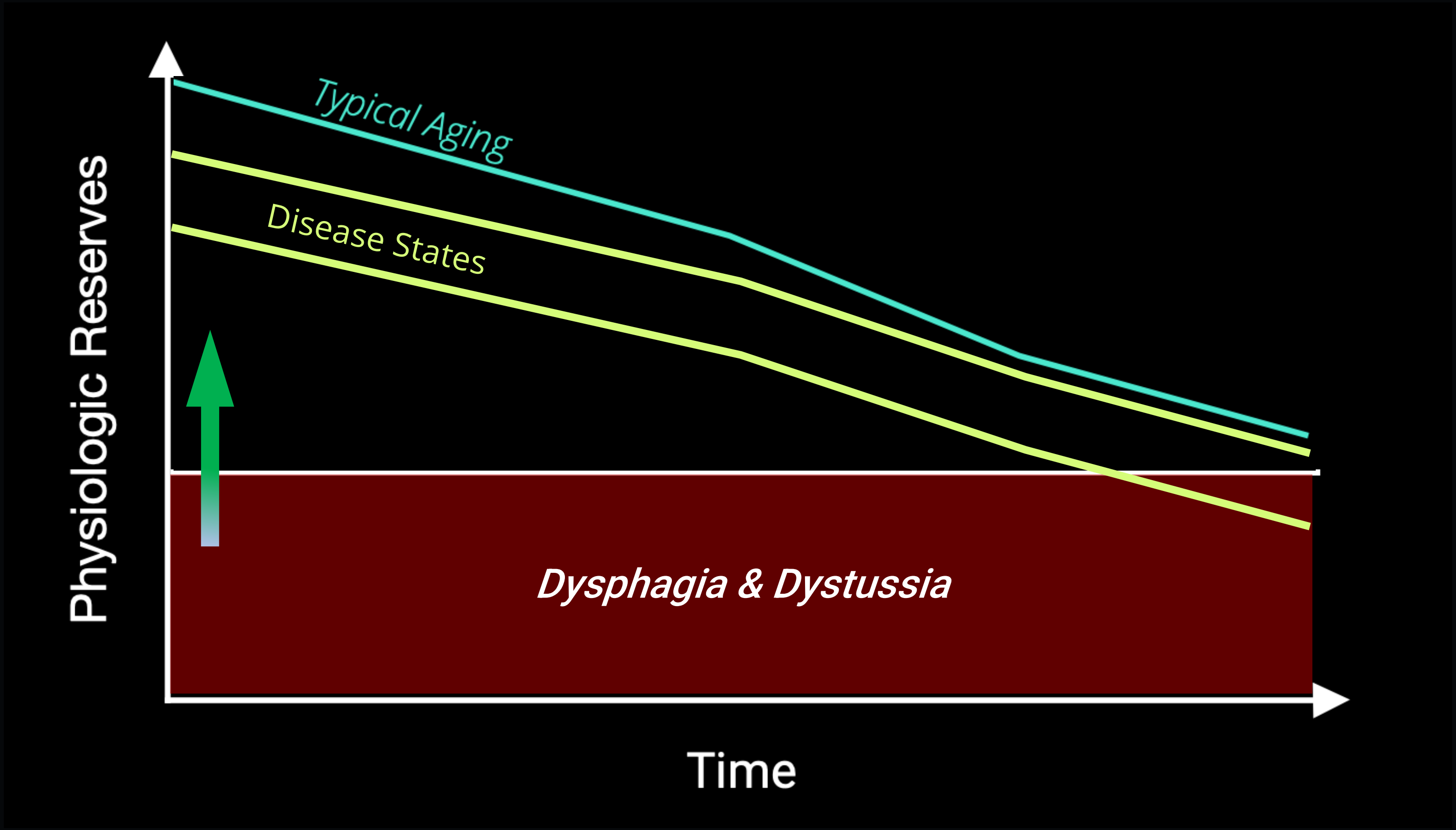
Airway Protection: Continuum of Behaviors

Shared Neural Substrates: Swallow, Cough & Breathing

Mechanisms of Disruption: Swallow, Cough & Breathing

Individuals with Dysphagia Present with Both Swallow & Cough Impairments

Importance of Physiologic Reserves



How do we increase functional physiologic reserves to maintain breathing, swallowing and cough?

Intervention: Respiratory Muscle Strength Training

EMST

Patient ***expires*** forcefully into a one-way spring loaded & calibrated trainer.

IMST

Patient ***inspires*** rapidly into a one-way spring loaded & calibrated trainer.

Intervention: Respiratory Muscle Strength Training

Resistance training against set pressure threshold to ***overload*** expiratory and inspiratory muscles.

Intensity, uses ***increased resistance over time*** and principles of sports medicine to promote adaptation in muscle strength (% relative to maximum).

Adequate ***repetition***, typically 5 / 5 / 5 rule.

Sufficient ***duration*** or total time spent exercising.

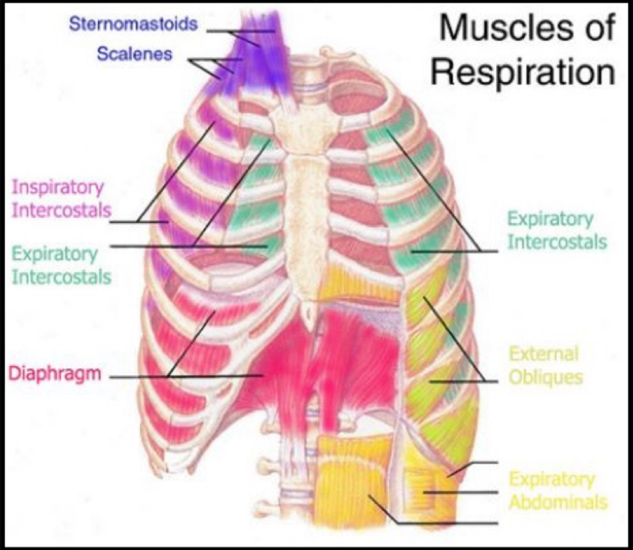
Sufficient ***frequency*** of exercise.

Adequate breaks, ***time between repetitions***.

Intervention: Respiratory Muscle Strength Training

EMST

- Internal intercostals
- External & internal abdominal oblique
- Transversus abdominis
- Rectus abdominis



IMST

- External intercostals
- Parasternal intercostals
- Diaphragm
- Scalenes
- Sternocleidomastoid

Airway Protection: Continuum of Behaviors

Prevention → **Ejection**

Swallowing

- Velopharyngeal port closure
- Submental activation
- Hyoid elevation
- UES opening
- Laryngeal framework lift
- Aytenoid-epiglottic approximation
- Pharyngeal shortening

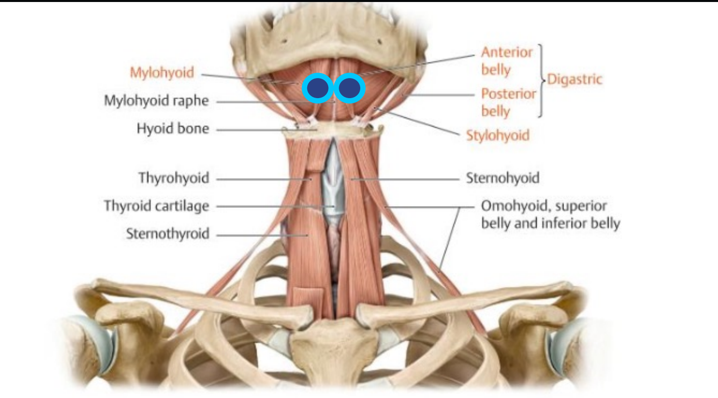
Huthcheson, 2017; Wheeler, 2007 & 2008; Tabor, 2017; Plowman, 2016; Pitts, 2008 & 2010

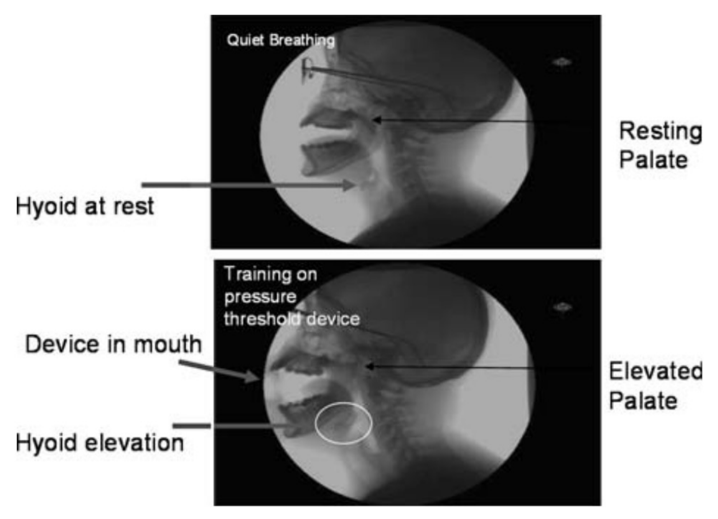
Cough

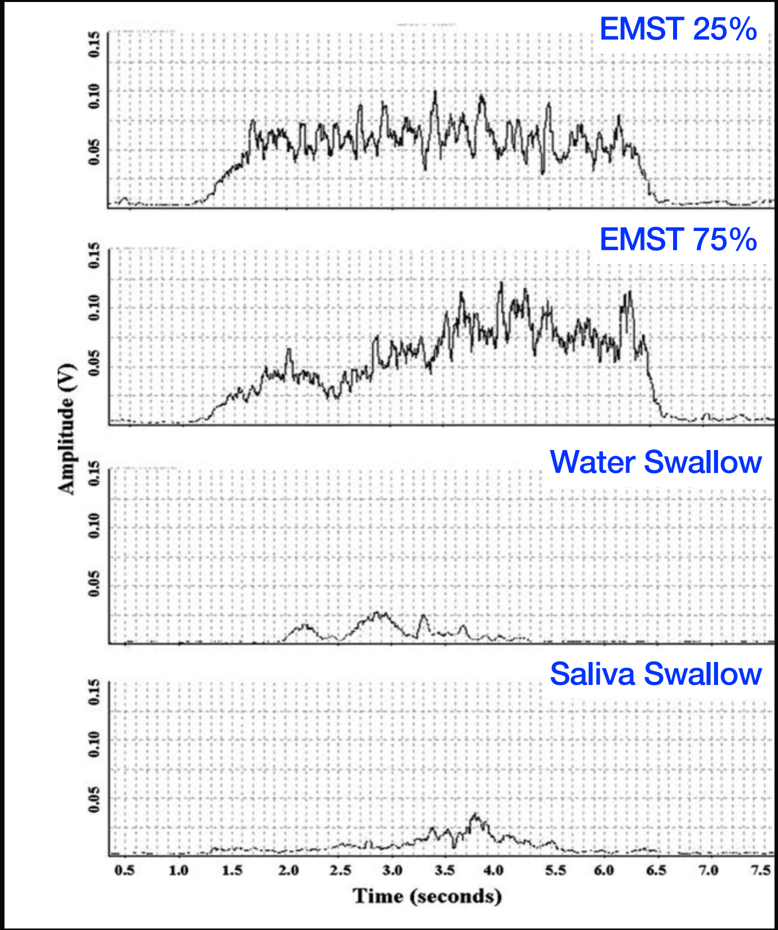
- Increased sub-glottic air pressure generation
- Increased Peak Cough Flow
- Increased Cough Volume Acceleration
- Decreased Compression Phase Duration

Baker, 2005; Chiari, 2006; Sapienza, 2002; Weiner, 2003; Pitts, 2010, Troche 2010

Mechanisms Underpinning RST in Healthy Adults

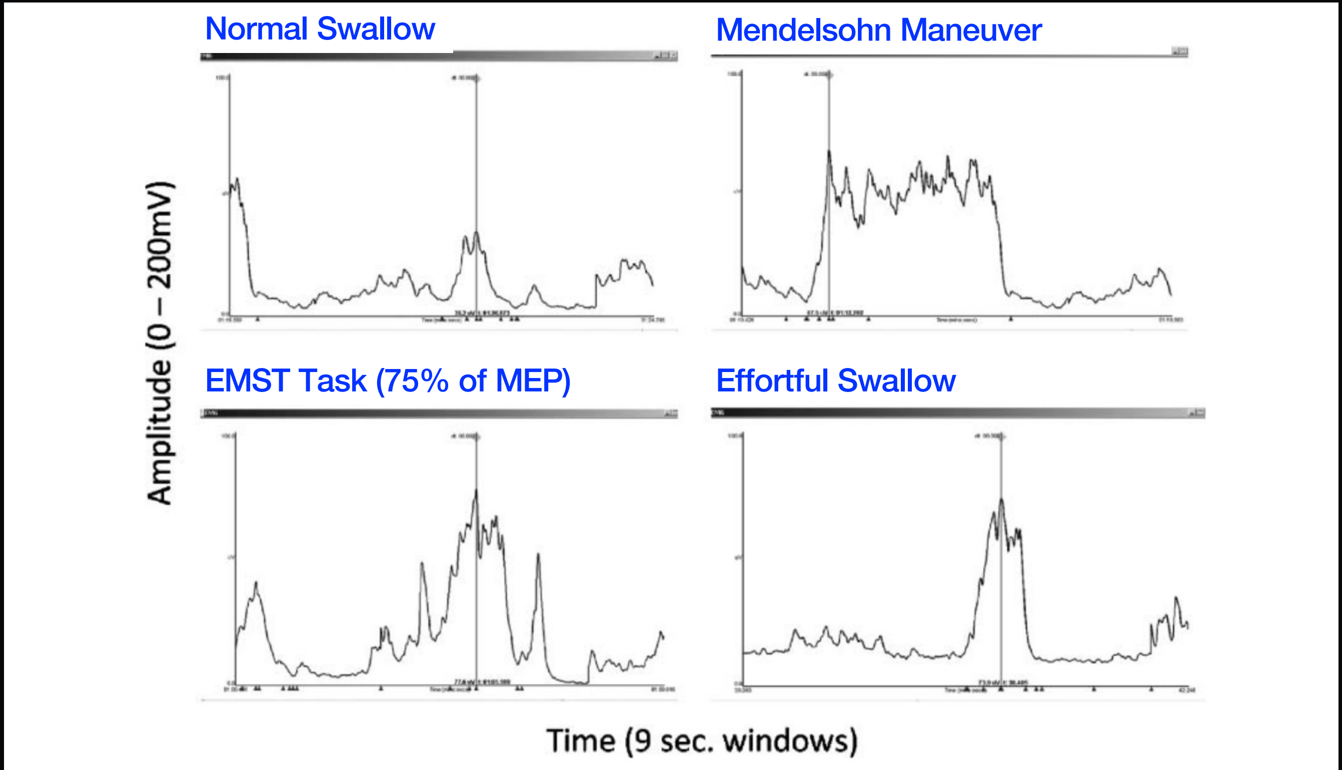






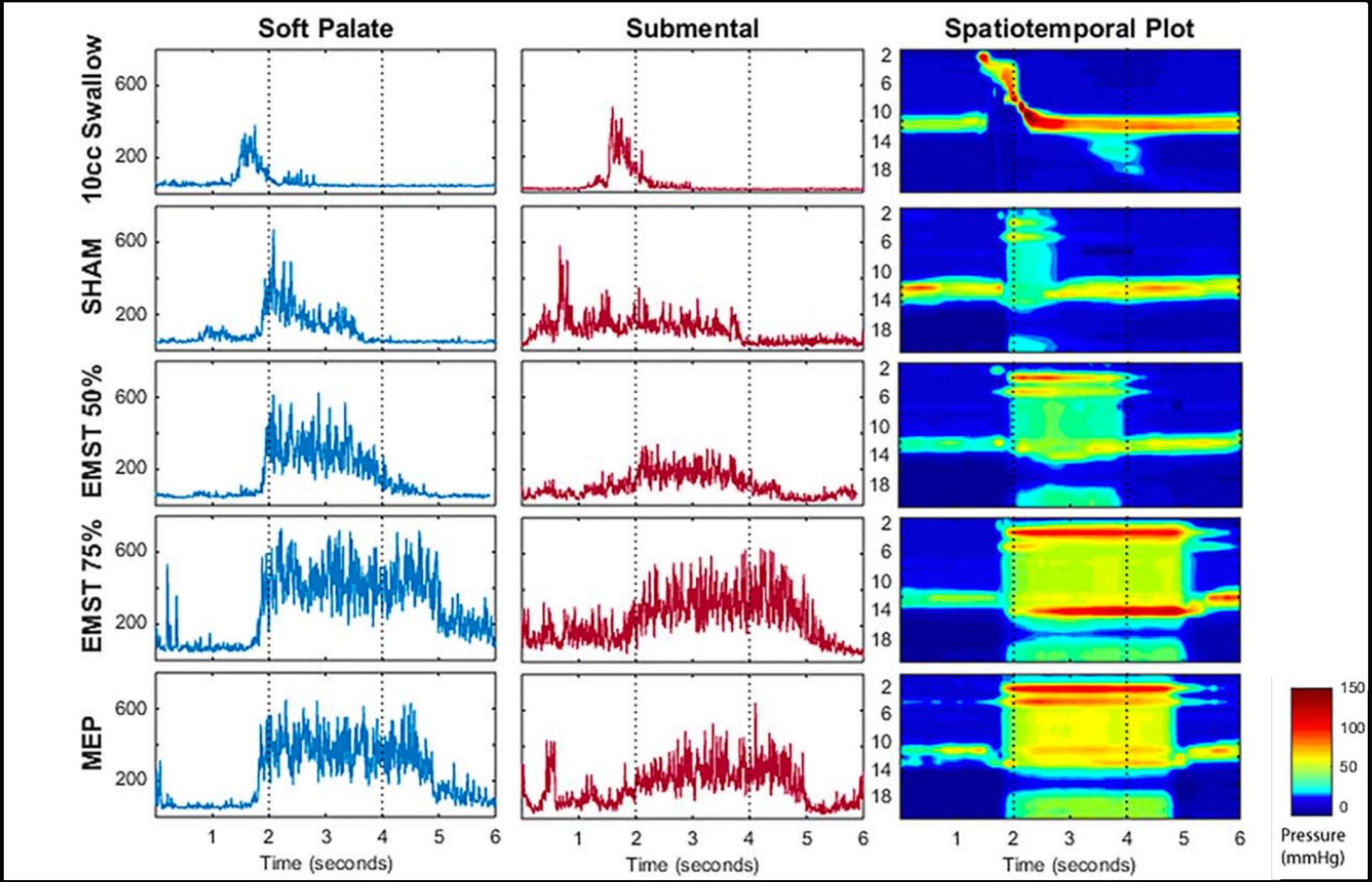
Wheeler et al. 2007; *Kendall 2014; Plowman et. al. 2021*

Mechanisms Underpinning RST in Healthy Adults



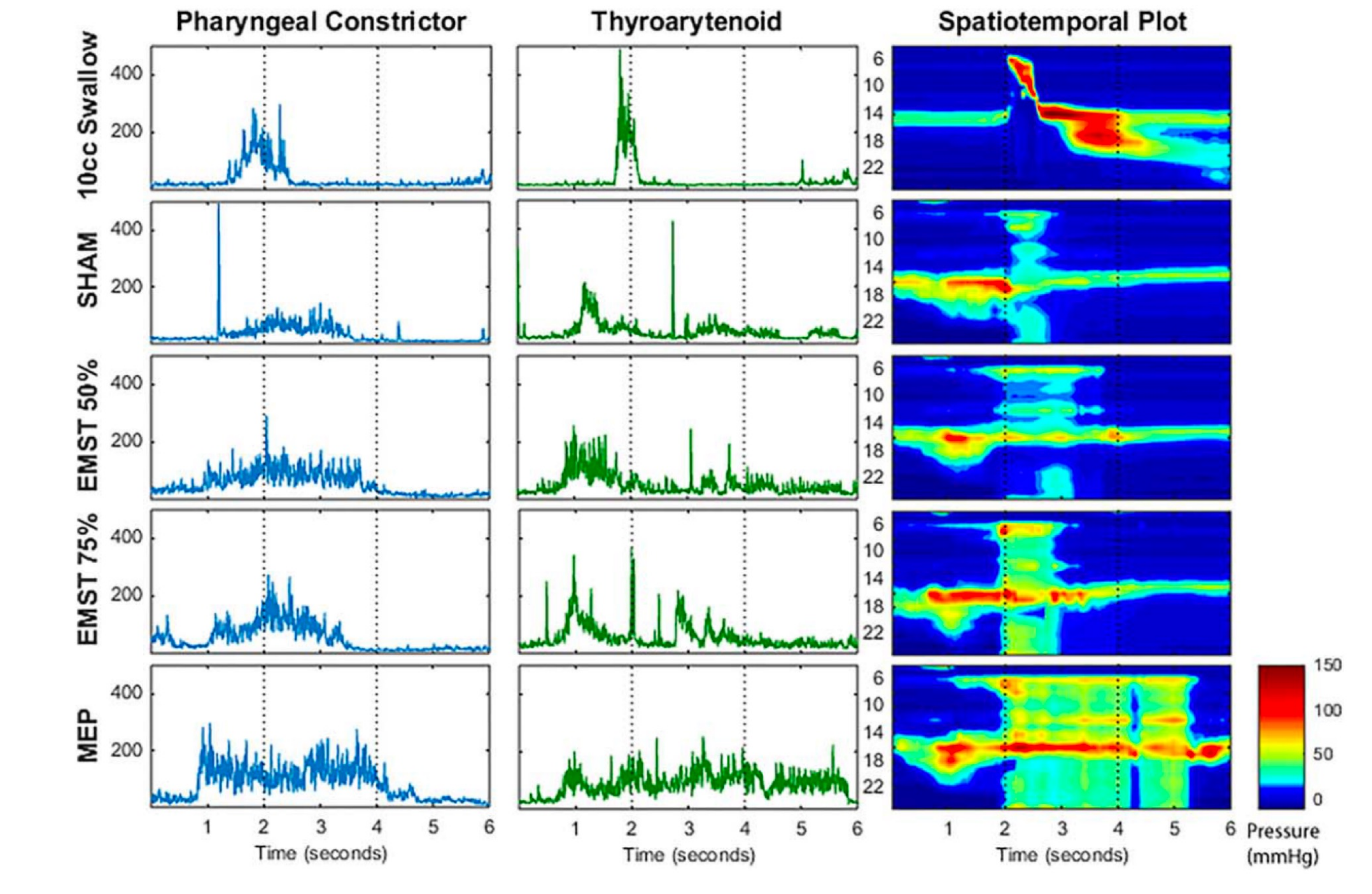
Wheeler-Hegland et al. 2008

Mechanisms Underpinning RST in Healthy Adults



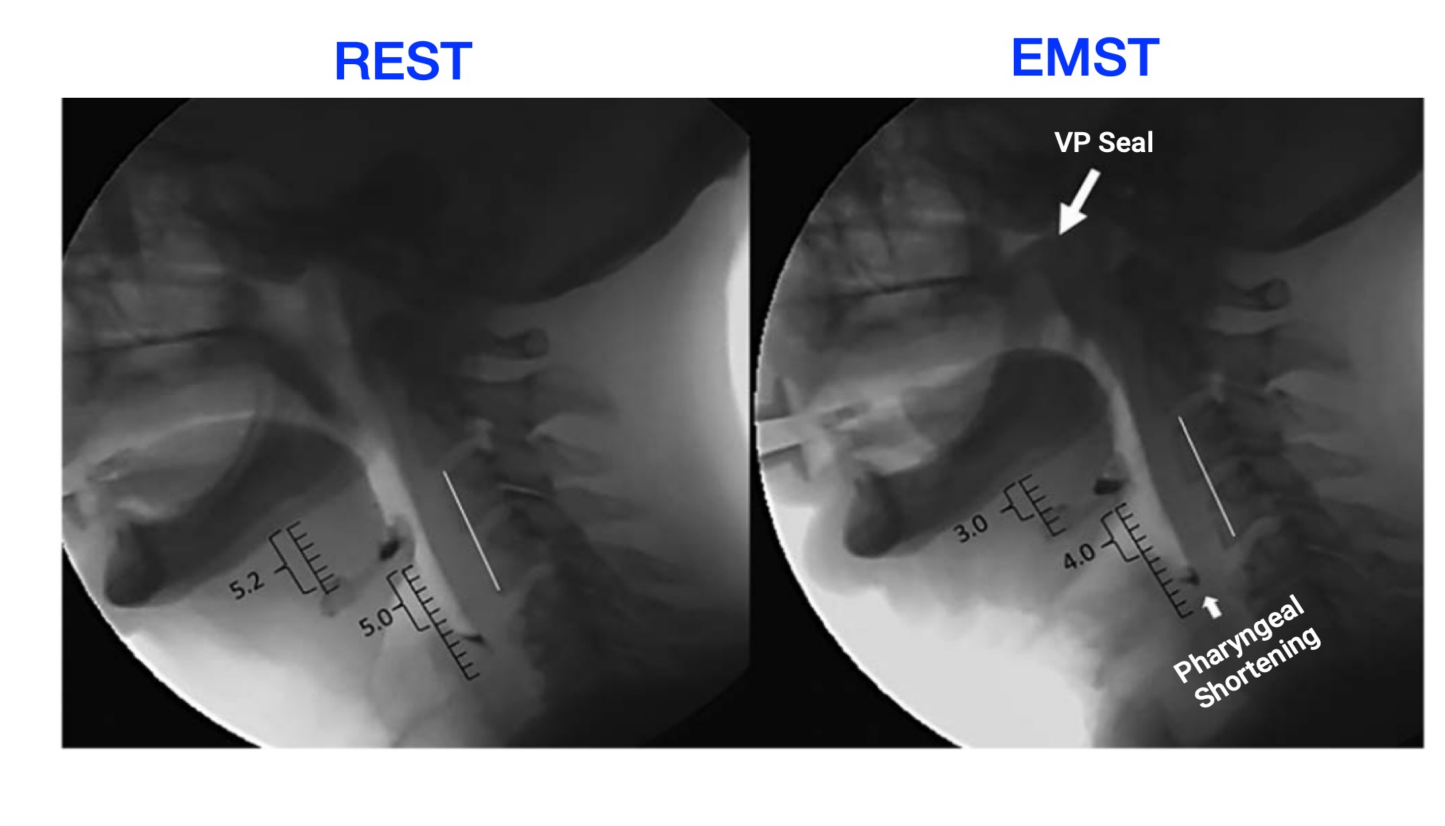
Hutcheson et al. 2017

Mechanisms Underpinning RST in Healthy Adults



Hutcheson et al. 2017

Mechanisms Underpinning RST in Healthy Adults



Hutcheson et al. 2017

Evidence & Outcomes for RST in Patient Populations

Reference	Patient Population	Resp load (% MIP/MEP)	Repetitions (# / time session)	Frequency (days / week)	Duration (weeks)
Weiner et al., 2003; 2006	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Chiara et al., 2006	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Pitts et al., 2009	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Troche et al., 2009; 2014; 2022		[redacted]	[redacted]	[redacted]	[redacted]
Martin et al., 2011	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Reyes et al., 2015	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Plowman et al., 2019; 2023	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Hegland et al., 2016	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Hutcheson et al., 2018	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Donohue et al. 2023	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Assessing Respiratory Muscle Strength

Why assess respiratory muscle strength?

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To develop an educated hypothesis on if respiratory muscle strength is reduced and contributing to cough and swallowing impairments

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To develop rationale for recommending RMST

Why assess respiratory muscle strength?

To develop an educated hypothesis on if respiratory muscle strength is reduced and contributing to cough and swallowing impairments

To develop rationale for recommending RMST

To personalize the delivery of an RMST protocol

How do I assess respiratory muscle strength?

RMS Testing Instructions

American Thoracic Society/European Respiratory Society

ATS/ERS Statement on Respiratory Muscle Testing

This Joint Statement of the American Thoracic Society (ATS), and the European Respiratory Society (ERS) was adopted by the ATS Board of Directors, March 2001 and by the ERS Executive Committee, June 2001

RMS Testing Instructions

In clinical practice, respiratory muscle strength (RMS) is primarily assessed by measuring:

- Maximal expiratory pressure (MEP; PE_{max})
- Maximal inspiratory pressure (MIP; PI_{max})

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MEP involves inhaling to the top of vital capacity, then exhaling with maximal effort for at least 1.5 seconds

RMS Testing Instructions

In clinical practice, respiratory muscle strength (RMS) is primarily assessed by measuring:

- Maximal expiratory pressure (MEP; PE_{max})
- Maximal inspiratory pressure (MIP; PI_{max})

MEP involves inhaling to the top of vital capacity, then exhaling with maximal effort for at least 1.5 seconds

MIP involves exhaling to the bottom of vital capacity, then inhaling with maximal effort for at least 1.5 seconds

RMS Testing Instructions

- Prevent air leakage around the lips and through the nose (use nose clips for the nose, and have an extra pair of hands to squeeze the lips around the mouthpiece)

RMS Testing Instructions

Prevent air leakage around the lips and through the nose (use nose clips for the nose, and have an extra pair of hands to squeeze the lips around the mouthpiece)

The maximum of 3 trials that vary by ≤ 20% is then recorded

Equipment for RMS Testing

Equipment for RMS Testing

Manometer, capable of measuring positive & negative pressures

Equipment for RMS Testing

Manometer, capable of measuring positive & negative pressures

± Disposable respiratory bacterial filter

Equipment for RMS Testing

MicroRPM

Low-cost generic manometer

Pressure Threshold Devices (e.g., EMST150)

MicroRPM

MicroRPM Respiratory Pressure Manometer (MD Spiro)
'Industry Standard'

MicroRPM

MicroRPM Respiratory Pressure Manometer (MD Spiro)
‘Industry Standard’

$1500 MicroRPM

$4.30 per Flanged Expiratory Filter

$4.30 per Flanged Inspiratory Filter

$1.82 per filter
(A-M Systems; 15 x 22 mm)

Low-Cost Generic Manometer

Leaton Digital Manometer (LDM)
‘Low-Cost Alternative’

The Laryngoscope

Concurrent Validity of a Low-Cost Manometer for Objective Assessments of Respiratory Muscle Strength

James A. Curtis, PhD, CCC-SLP, BCS-S; Valentina Mocchetti, MS, CCC-SLP; Anaïs Rameau, MD

Low-Cost Generic Manometer

Leaton Digital Manometer (LDM)
‘Low-Cost Alternative’

$40.00 LDM

$1.82 per filter
(A-M Systems; 15 x 22 mm)

$0.41 per adaptor
(Qosina; 6 x 22 mm)

$2.13 per foot, silicone tubing
(Quickrun; 6 mm ID)

Pressure Threshold Training Products

Pressure Threshold Training Products

RMS training can be facilitated using two types of devices

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Continuous flow devices – greater pressure is required to blow through open tubes with smaller diameters, assuming flow and volume of air are held constant

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Continuous flow devices – greater pressure is required to blow through open tubes with smaller diameters, assuming flow and volume of air are held constant

Pressure threshold devices – one-way valve that only opens once an (adjustable) specified pressure level is achieved

Can be used to estimate MEP and MIP

Pressure Threshold Training Products

EMST150, EMST75 Lite, IA150 Inspiratory Adapter
'Industry Standard' for RMST (not necessarily RMS testing)

Pressure Threshold Training Products

EMST150, EMST75 Lite, IA150 Inspiratory Adapter
'Industry Standard' for RMST (not necessarily RMS testing)

$54.99 EMST150

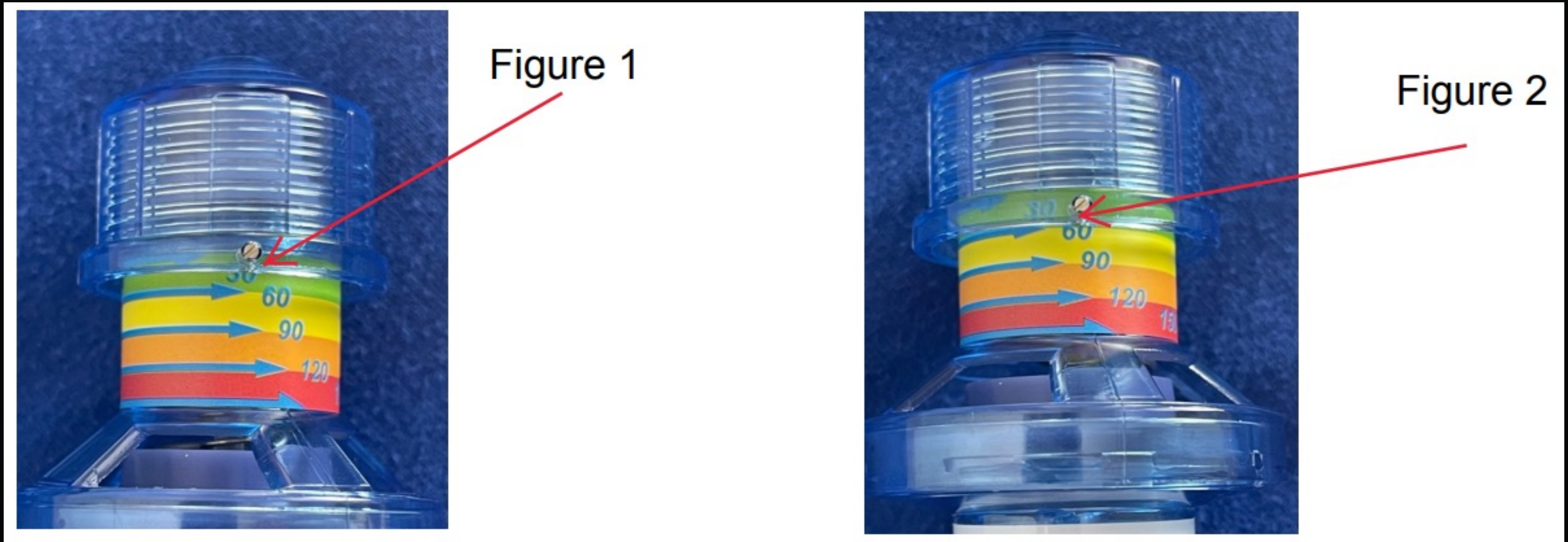
$54.99 EMST75 Lite

$29.99 IA 150 Inspiratory Adaptor

$1.82 per filter

(A-M Systems; 15 x 22 mm)

Calculating MEP/MIP From the EMST Devices



Calculating MEP/MIP From the EMST Devices

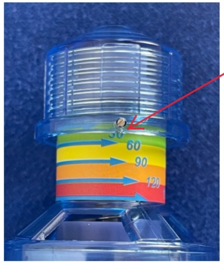
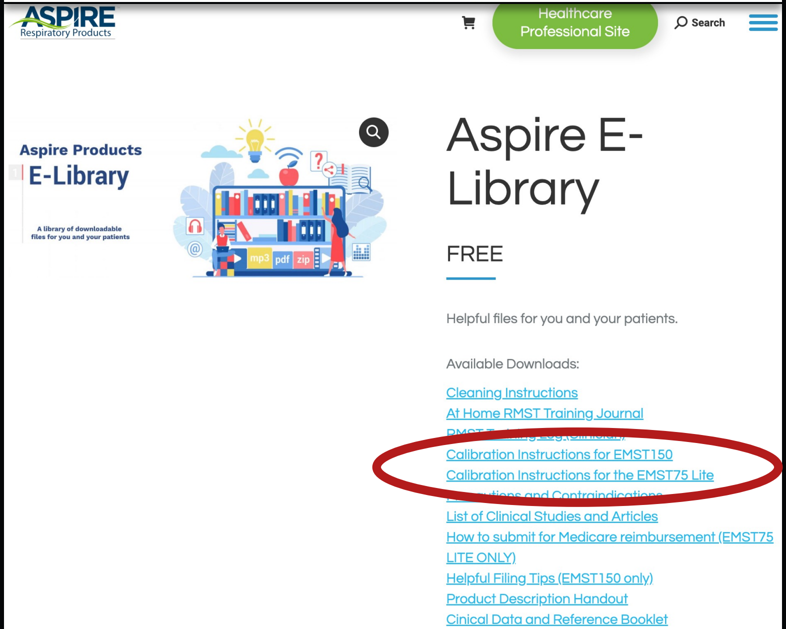


Figure 1

Figure 2



EMST 150 Pressure	Whole Turn	Quarter Turn
30	0	0 (* Home base)
37.5	0	1
45	0	2
52.5	0	3
60	1	0 (* Home base)
63.75	1	1
67.5	1	2
71.25	1	3
75	2	0 (* Home base)
78.75	2	1
82.5	2	2
86.25	2	3
90	3	0 (* Home base)
93.75	3	1
97.5	3	2
101.25	3	3
105	4	0 (* Home base)
108.75	4	1
112.5	4	2
116.25	4	3
120	5	0 (* Home base)
127.5	5	1
135	5	2
142.5	5	3
150	6	0 (* Home base)

RMS testing requires an element of coordination – so even though 'strength assessment' skill is still involved and can impact the strength measures!

RMS testing requires an element of coordination – so even though 'strength assessment' skill is still involved and can impact the strength measures!

Consider asking the examinee to rate their Rating of Perceived Exertion (RPE) to better identify if maximal effort was accurately achieved!

(learn more about RPE in the next section)

Compare to Normative Data

Comparing to normative data assists in estimating if the person has MEPs and MIPs that are lower than expected

Sociedad Española de Neumología y Cirugía Torácica SEPAR

ARCHIVOS DE Bronconeumología

www.archbronconeumol.org

Original Article

Maximal Respiratory Pressure Reference Equations in Healthy Adults and Cut-off Points for Defining Respiratory Muscle Weakness

Ana Lista-Paz[a,*], Daniel Langer[b,c], Margarita Barral-Fernández[a], Alejandro Quintela-del-Río[d,1], Elena Gimeno-Santos[e,f,g], Ane Arbillaga-Etxarri[h], Rodrigo Torres-Castro[i,j], Jordi Vilaró Casamitjana[k], Ana B. Varas de la Fuente[l], Cristina Serrano Veguillas[l], Pilar Bravo Cortés[m], Concepción Martín Cortijo[n,o], Esther García Delgado[n,o], Beatriz Herrero-Cortina[p,q], José Luis Valera[r], Guilherme A.F. Fregonezi[s], Carolina González Montañez[t,u], Rocío Martín-Valero[v], Marina Francín-Gallego[q], Yolanda Sanesteban Hermida[a,w], Esther Giménez Moolhuyzen[a,w], Jorge Álvarez Rivas[x], Antonio T. Ríos-Cortes[y,z], Sonia Souto-Camba[a,2], Luz González-Doniz[a,2]

Table 2
Maximal Respiratory Pressures in Females and Males by Age Groups.

Sex/Age Groups, Years	*n*	Maximal Respiratory Pressures	
		PImax, cmH_2O	PEmax, cmH_2O
Females	314	98.74 (24.1)	141.7 (30.9)
18–29	58	103.9 (23.3)	139.5 (29.3)
30–39	50	106.9 (20.1)	152.1 (30.3)
40–49	57	102.4 (26.1)	142.7 (28.2)
50–59	52	101.3 (18)	150.3 (27.3)
60–69	55	90.6 (27.8)	136.3 (34.5)
70–80	42	84.4 (19.8)	127.4 (31)
Males	296	126.7 (27.8)	194.6 (45.6)
18–29	52	136.2 (25.1)	184 (39.5)
30–39	54	129.9 (32.2)	200.7 (48.9)
40–49	55	133.3 (21.8)	202.8 (40.9)
50–59	48	130.9 (28.1)	205.3 (53)
60–69	48	122 (20.8)	199.2 (37.2)
70–80	39	100.6 (22.6)	170 (45.5)

Data are reported as mean (standard deviation) unless otherwise stated.
cmH_2O: centimetres of water; PEmax: maximal expiratory pressure; PImax: maximal inspiratory pressure.

Compare to Normative Data

Comparing to normative data assists in estimating if the person has MEPs and MIPs that are lower than expected

If MEP and MIP are reduced, and if you think this reduction in RMS is contributing to cough and/or swallowing decline, then consider the potential role for RMST www.jamescurtisphd.me

(Tutorials > Cough > Respiratory Muscle Strength Testing)

Practical EMST Strategies

Exercise principles for rehabilitation
EMST in-person
EMST via telehealth

Exercise principles for rehabilitation

Resources for exercise/rehabilitation prescription:

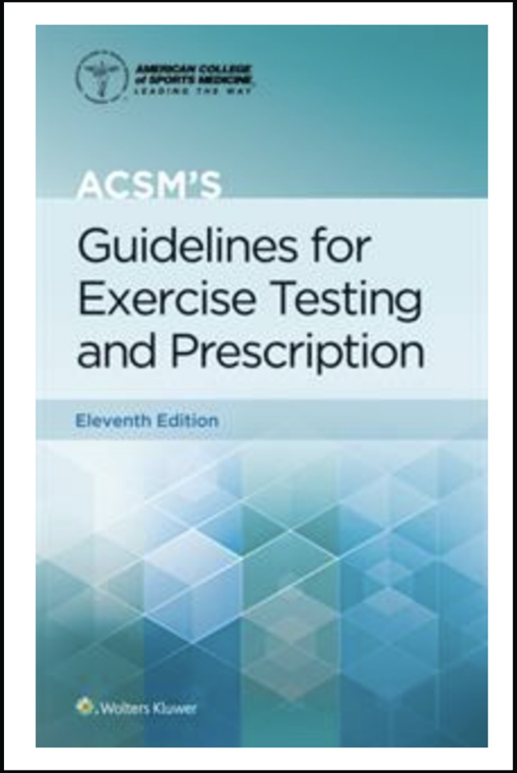
SPECIAL COMMUNICATIONS

AMERICAN COLLEGE of SPORTS MEDICINE

POSITION STAND

Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise

This pronouncement was written for the American College of Sports Medicine by Carol Ewing Garber, Ph.D., FACSM, (Chair); Bryan Blissmer, Ph.D.; Michael R. Deschenes, Ph.D., FACSM; Barry A. Franklin, Ph.D., FACSM; Michael J. Lamonte, Ph.D., FACSM; I-Min Lee, M.D., Sc.D., FACSM; David C. Nieman, Ph.D., FACSM; and David P. Swain, Ph.D., FACSM.



Garber, 2011; ACSM 2021

Resources for exercise/rehabilitation prescription:

Resistance exercise		
Frequency	Each major muscle group should be trained on 2–3 $d \cdot wk^{-1}$.	A
Intensity	60%–70% of the 1RM (moderate to hard intensity) for novice to intermediate exercisers to improve strength.	A
	≥80% of the 1RM (hard to very hard intensity) for experienced strength trainers to improve strength.	A
	40%–50% of the 1RM (very light to light intensity) for older persons beginning exercise to improve strength.	A
	40%–50% of the 1RM (very light to light intensity) may be beneficial for improving strength in sedentary persons beginning a resistance training program.	D
	<50% of the 1RM (light to moderate intensity) to improve muscular endurance.	A
	20%–50% of the 1RM in older adults to improve power.	B
Time	No specific duration of training has been identified for effectiveness.	
Type	Resistance exercises involving each major muscle group are recommended.	A
	A variety of exercise equipment and/or body weight can be used to perform these exercises.	A
Repetitions	8–12 repetitions is recommended to improve strength and power in most adults.	A
	10–15 repetitions is effective in improving strength in middle aged and older persons starting exercise	A
	15–20 repetitions are recommended to improve muscular endurance	A
Sets	Two to four sets are the recommended for most adults to improve strength and power.	A
	A single set of resistance exercise can be effective especially among older and novice exercisers.	A
	≤2 sets are effective in improving muscular endurance.	A
Pattern	Rest intervals of 2–3 min between each set of repetitions are effective.	B
	A rest of ≥48 h between sessions for any single muscle group is recommended.	A
Progression	A gradual progression of greater resistance, and/or more repetitions per set, and/or increasing frequency is recommended.	A
Flexibility exercise		

*1RM = 1 repetition maximum = MEP

Garber, 2011

Additional Considerations…

- Weeks 1-8 → NEURAL adaptation to training[6]
    - Improvements in coordination
    - May see rapid strength gains

- Weeks 8+ → changes in muscle structure and size
    - May see slower strength gains

- If you aren't seeing improvements continue EMST for at least 12 weeks

Gabriel, 2006

Application to EMST

- In sedentary patients → start with lower resistive load
- In active patients → consistency and performance
- In neurodegenerative patients → PATHOPHYSIOLOGY!
    - Parkinson's → moderate – high resistive loads*
    - ALS → low – moderate resistive loads*

*patient-specific! Consider current health status and previous physical activity

Exercise/rehabilitation prescription:

International Journal of Sport Nutrition and Exercise Metabolism, (Ahead of Print)
https://doi.org/10.1123/ijsnem.2023-0087
First Published Online: Oct. 24, 2023

Human Kinetics
ORIGINAL RESEARCH

Muscle Mass and Strength Gains Following Resistance Exercise Training in Older Adults 65–75 Years and Older Adults Above 85 Years

Gabriel Nasri Marzuca-Nassr,[1] Andrea Alegría-Molina,[1] Yuri SanMartín-Calísto,[1] Macarena Artigas-Arias,[1] Nolberto Huard,[2] Jorge Sapunar,[3] Luis A. Salazar,[2] Lex B. Verdijk,[4] and Luc J.C. van Loon[4]

[1]Departamento de Ciencias de la Rehabilitación, Facultad de Medicina, Universidad de La Frontera, Temuco, Chile; [2]Centro de Biología Molecular y Farmacogenética, Departamento de Ciencias Básicas, Facultad de Medicina, Universidad de La Frontera, Temuco, Chile; [3]Departamento de Medicina Interna, Facultad de Medicina, Universidad de La Frontera, Temuco, Chile; [4]Department of Human Biology, NUTRIM School of Nutrition and Translational Research in Metabolism, Maastricht University Medical Centre+, Maastricht, The Netherlands

You can download older versions online (for free)

Rating of perceived exertion/effort (RPE) scale[1]

- Used by coaches, trainers, physical therapists, etc. to measure exercise effort
- Monitor (and adjust) exercise intensity
- Engages your client!
- Data tracking

[1]Borg, 1982

EMST Prescription- What's the evidence?

- 5x5x5 at 75% of MEP
- Few studies have focused on how modifying EMST exercise parameters impact outcomes
  - Resistive load, number of repetitions, training frequency, duration, etc.
  - RPE?

How do individuals rate their effort in a high intensity EMST session?

[3]Dakin & Troche, *in preparation*

Effort and Physiologic Response to EMST

- 20 healthy adult participants
  - Performed 10 sets of 10 repetitions (100 repetitions)
  - 75% of MEP
  - Reported their RPE after each repetition
  - Monitored heart rate and oxygen saturation
  - Repetition pacing to avoid lightheadedness/dizziness

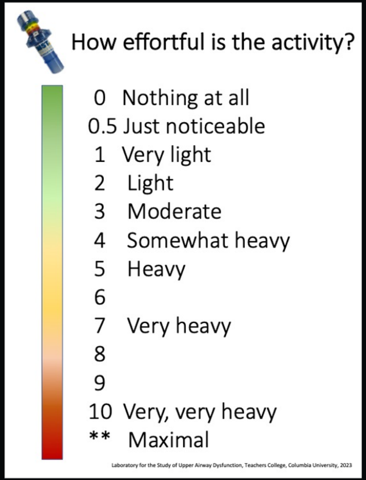
- Research questions:
  - Did RPE change in the session?
  - Did physiologic measures change in the session?

Effort and Physiologic Response to EMST

- Results: RPE increased by .04 with each set
  - A tiny change!
  - Median rating remained at a 7

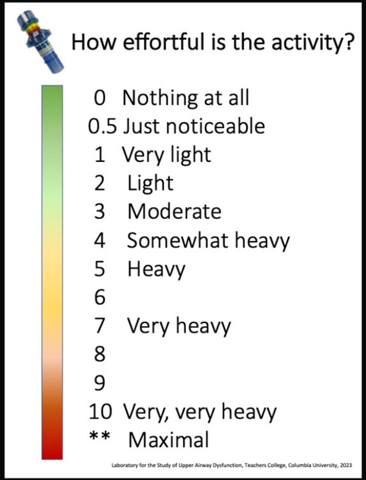
- Heart rate at the end of each set increased by .08
  - Tiny change again!

- Oxygen saturation did not change



Effort and Physiologic Response to EMST

- Results continued...
- 3/20 participants reported cheek soreness 24 hours post-session
- 2 participants did not complete protocol due to lightheadedness/dizziness



Effort and Physiologic Response to EMST

- Clinical implications?
  - The respiratory system is designed to be efficient and is not easily fatigable!

- Caveat:
  - Single visit!
  - Participants were healthy adults–more research is needed in clinical populations

EMST in-person

Practical Strategies for EMST - In Person

- STEP 1. Assess MEP

- Introduce the RPE scale
  - Give them high and low anchors

- We want your BEST PERFORMANCE!

Practical Strategies for EMST - In Person

- STEP 2. Provide your rationale
- Cough strength vs swallowing safety

Practical Strategies for RMST - In Person

- STEP 3. Device overview
- *"The EMST device has a one-way pressure valve. You will blow into the device and when you reach the target pressure the valve will open and you will hear a hiss of air flowing through the device. The goal is to produce a strong and crisp hiss."*
- Provide a model if you have an EMST device

Practical Strategies for RMST - In Person

- STEP 4. Familiarization
- At least 3 opportunities at a low setting
- Hand in cheeks***
- Minimize instructions!
  - *“Breathe in, device in, blow hard”*

Practical Strategies for RMST - In Person

- STEP 5. Set the device to the training target
  - e.g, 75% of MEP
- Perform repetitions
  - e.g., 25 repetitions
  - Modify the protocol as needed/preferred
- Ask for RPE

EMST via Telehealth

Practical Strategies for RMST - Telehealth

ASHA American Speech-Language-Hearing Association

AJSLP

Research Article

Rehabilitation of Airway Protection in Individuals With Movement Disorders: A Telehealth Feasibility Study

Jordanna S. Sevitz,[a] James C. Borders,[a] Avery E. Dakin,[a] Brianna R. Kiefer,[b] Roy N. Alcalay,[c,d] Sheng-Han Kuo,[c] and Michelle S. Troche[a,c]

[a] Laboratory for the Study of Upper Airway Dysfunction, Department of Biobehavioral Sciences, Teachers College, Columbia University, New York, NY [b] Department of Speech, Language, and Hearing Sciences, Purdue University, West Lafayette, IN [c] Department of Neurology, Columbia University Irving Medical Center, New York, NY [d] Department of Neurology, Tel Aviv Sourasky Medical Center, Israel

Practical Strategies for RMST - Telehealth

- Aims: Determine the practical feasibility and preliminary treatment effect of EMST and cough skill training (CST) via telehealth

- Methods:
  - 20 participants with movement disorders
  - 4 weeks of EMST and 2 weeks of CST via telehealth
    - 2x per week with a clinician
    - 3x independent practice (+ caregiver as needed)

Practical Strategies for RMST - Telehealth

- Results
  - Practical feasibility
    - 18 min to get pMEP and perform EMST; 18 min for CST
    - Caregivers:
      - Increased device resistance, read peak flow values, helped with data tracking, provided verbal cues/encouragement, adjusted participant posture, helped with lip seal
  - Mean pMEP increased (66 → 87 cmH_20)
  - Mean PEFR increased (293 → 350 L/min)

Practical Strategies for RMST - Telehealth

- Conclusions: The delivery of EMST and CST is feasible via telehealth and yielded improvements in pMEP and PEFR

- Caveat: pMEP was lower than what we have seen in similar groups with in-person assessment
  - In-person baseline and post-assessment is preferred

Takeaways

- There is no one-size-fits-all approach to rehabilitation
- Adapt your protocol based on therapy modality, your client’s health status, rehabilitation goals, and preferences
- Include RPE in your sessions!

Clinical Case:

68 year-old male with Spinal Onset ALS.

~6 months from time of diagnosis.

8 lb. weight loss over past 3 months.

Referred to clinical SLP for swallow and motor-speech evaluation.

Eating Assessment Tool-10

EAT-10 Item:	Score:
1. My swallowing problem has caused me to lose weight.	3
2. My swallowing problem interferes with my ability to go out for meals.	2
3. Swallowing liquids takes extra effort.	2
4. Swallowing solids takes extra effort.	2
5. Swallowing pills takes extra effort.	2
6. Swallowing is painful.	0
7. The pleasure of eating is affected by my swallowing.	2
8. The pleasure of eating is affected by my swallowing.	1
9. I cough when I eat.	2
10. Swallowing is stressful	2

Total Score: *18 indicating moderate self-perceived swallowing impairments.*

Belafsky et al. 2008

Motor-Speech Assessment

Speech Subsystem:	Metric:
Respiratory :	Maximum Phonation Duration: 23 seconds (normal >15 seconds)
	Maximum Loudness: Impaired
	Loudness in Conversation: Reduced
Laryngeal:	Vocal Quality: Breathy
	Pitch Range: reduced
Velopharyngeal:	Resonance: Hypernasal
	Nasal Emission: Not observed
Articulatory:	Precision in Conversation: Imprecise
	Precision in Reading: Imprecise
	During DDK: Increased articulatory breakdown
Prosody:	Prosody: Restricted
Intelligibility:	Informal Clinician Rating during Conversation: ~70% with maximal effort

Bamboo Passage:

Speaking Rate 82.4 WPM or severely reduced compared to norms (160-180 WPM)

Pulmonary Function Tests

Respiratory Testing:	Obtained Value:	Expected Value:	% Predicted:
Forced Vital Capacity	3.84 L	4.86 L	79%
Maximal Expiratory Pressure	136 cmH_20	111.2 cmH_20	122%
Maximal Inspiratory Pressure	105 cmH_20	100 cmH_20	105%

Cough Testing

Cough Testing:	Obtained Value:	Expected Value:	% Predicted:
Peak Cough Flow Meter	5.23 L/s	5.88 L/s	89%

<u>What if it was 2 L/s?</u>

<3.97 L/s is associated with increased risk for airway invasion in ALS populations.

≥3.23 L/s represents a clinically meaningful cutoff for effective airway clearance.

≥ 2.70 L/s is recommended threshold to initiate non-invasive ventilation in ALS according to American Academy of Neurology standards.

Treatment Plan

Pre-Treatment Metric:	Obtained Value:	Expected Value:	% Predicted:
Maximal Expiratory Pressure	136 cmH$_2$0	111.2 cmH$_2$0	122%

8-week RST program at 50% load.

Pre-Treatment Metric:	Obtained Value:	Expected Value:	% Predicted:
Maximal Expiratory Pressure	176 cmH$_2$0	111.2 cmH$_2$0	158%

Plowman et al. 2019; Plowman et al. 2023; Robison et al. 2018

Circling Back!

Prevention → **Ejection**

Swallowing

- Velopharyngeal port closure
- Submental activation
- Hyoid elevation
- UES opening
- Laryngeal framework lift
- Aytenoid-epiglottic approximation
- Pharyngeal shortening

Huthcheson, 2017; Wheeler, 2007 & 2008; Tabor, 2017; Plowman, 2016; Pitts, 2008 & 2010

Cough

- Increased sub-glottic air pressure generation
- Increased Peak Cough Flow
- Increased Cough Volume Acceleration
- Decreased Compression Phase Duration

Baker, 2005; Chiari, 2006; Sapienza, 2002; Weiner, 2003; Pitts, 2010, Troche 2010

Conclusions

RMST is an evidence-based intervention for swallow and cough dysfunction.

RMST is a viable and affordable treatment option for multiple patient populations with dysphagia and dystussia.

Next Steps? Improve accessibility and uptake of approaches (NIH NINDS R01) to Dr. Michelle Troche. Stay tuned!

Questions?

References Available Upon Request