The role of ultrasound in the early assessment of sarcopenia

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Disclosure

I have nothing to disclose.

There are no relevant financial relations interfering with this presentation.

Objective of today

In a glance

Overview of current sarcopenia screening

In two glances

Overview of where and why ultrasound can be of help herein

Keep it simple and logical

Content

- Introduction
- Screening
- Muscle mass
- Ultrasound
- Future
- Take home messages

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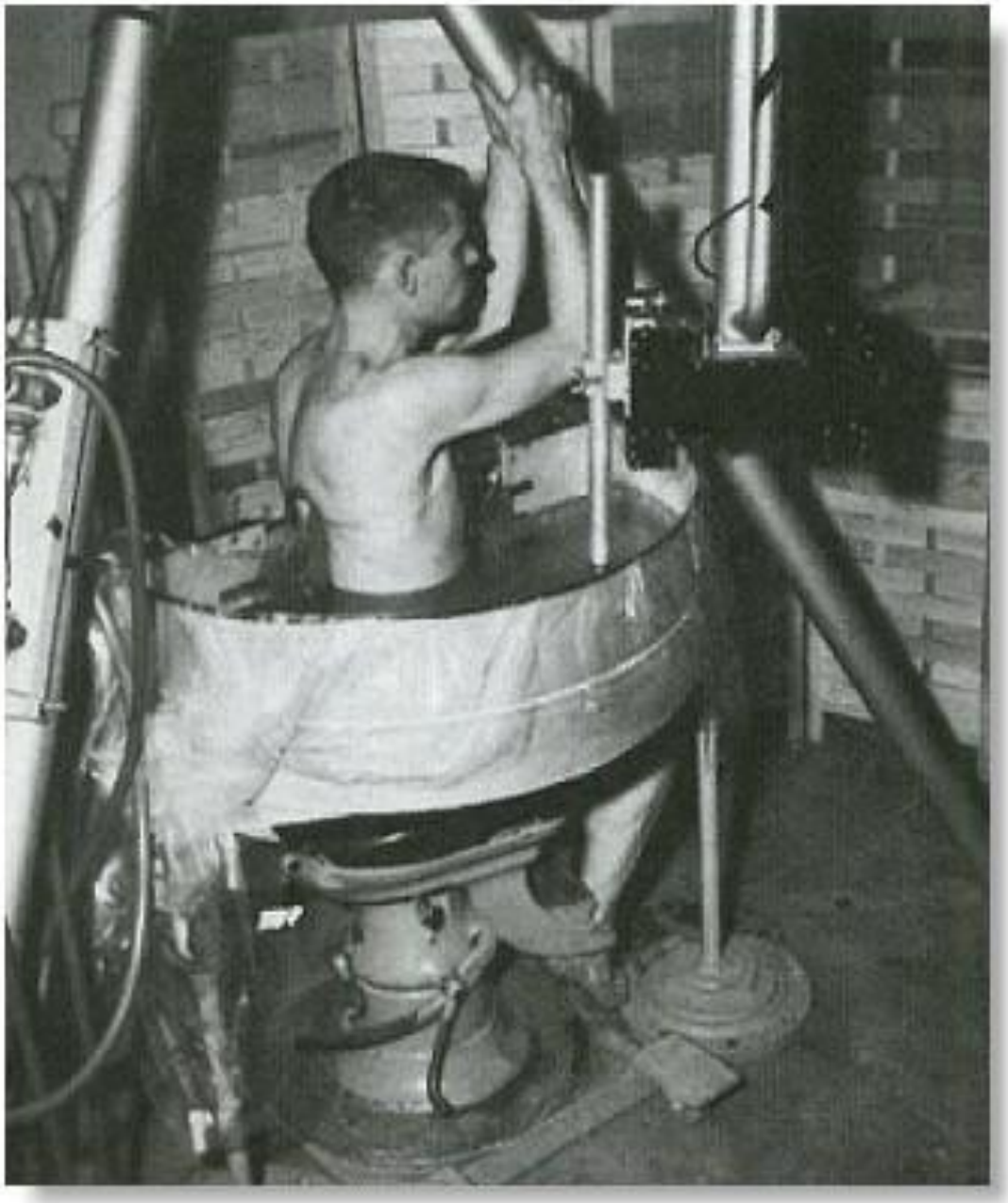
Ultrasc



Ultrasound - history

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Screening for sarcopenia

Why would we want to screen?

What would we want to screen?

How will we do the screening?

Why screening?

Sarcopenia is related to

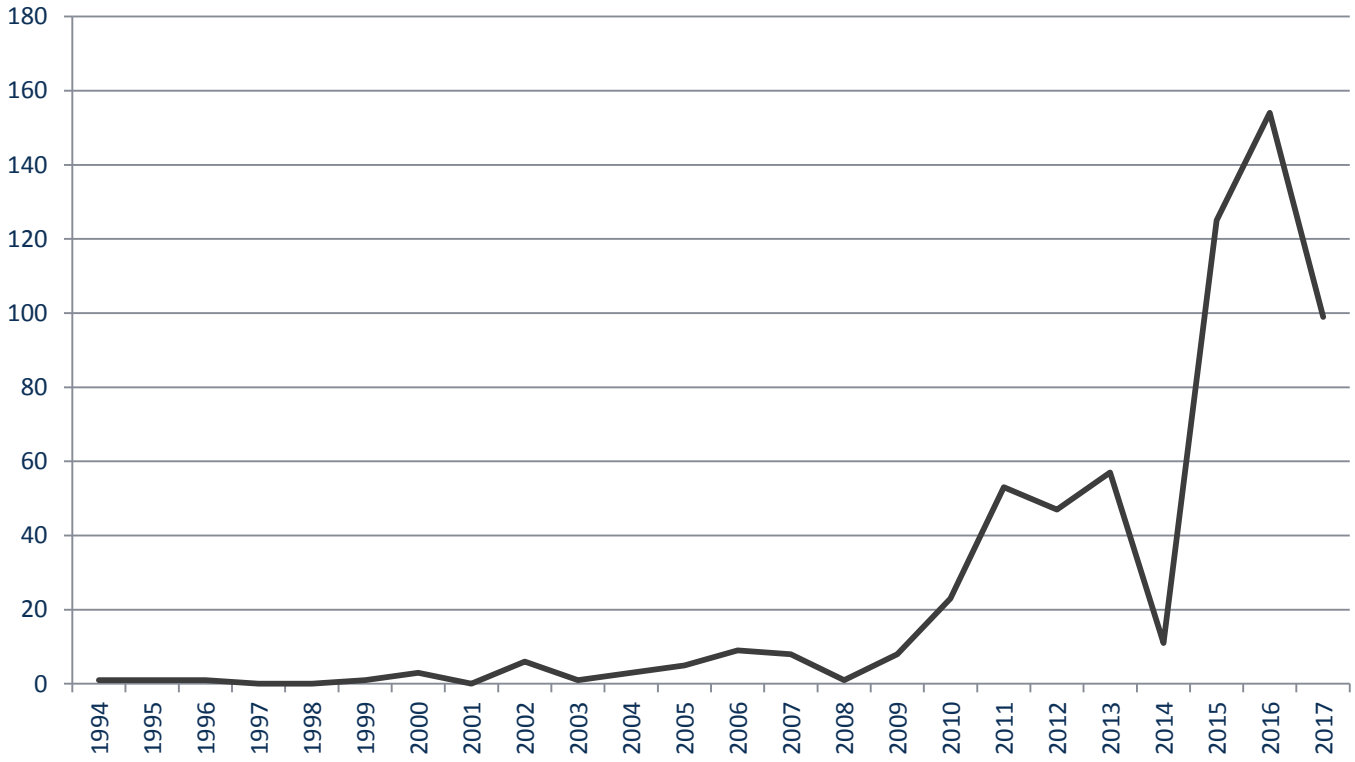
Frailty, decreased muscle strength, problems with mobility, falls, decreased activity levels, loss of physical function, loss of independence

Osteoporosis, fractures, middle-age weight gain, diabetes (increased insulin resistance), worse outcomes after surgery and oncologic treatment, more postoperative complications, increased readmission, prolonged hospital stay

Quality of life, mortality

Why screening?

Pubmed search ‘sarcopenia’ and ‘mortality’

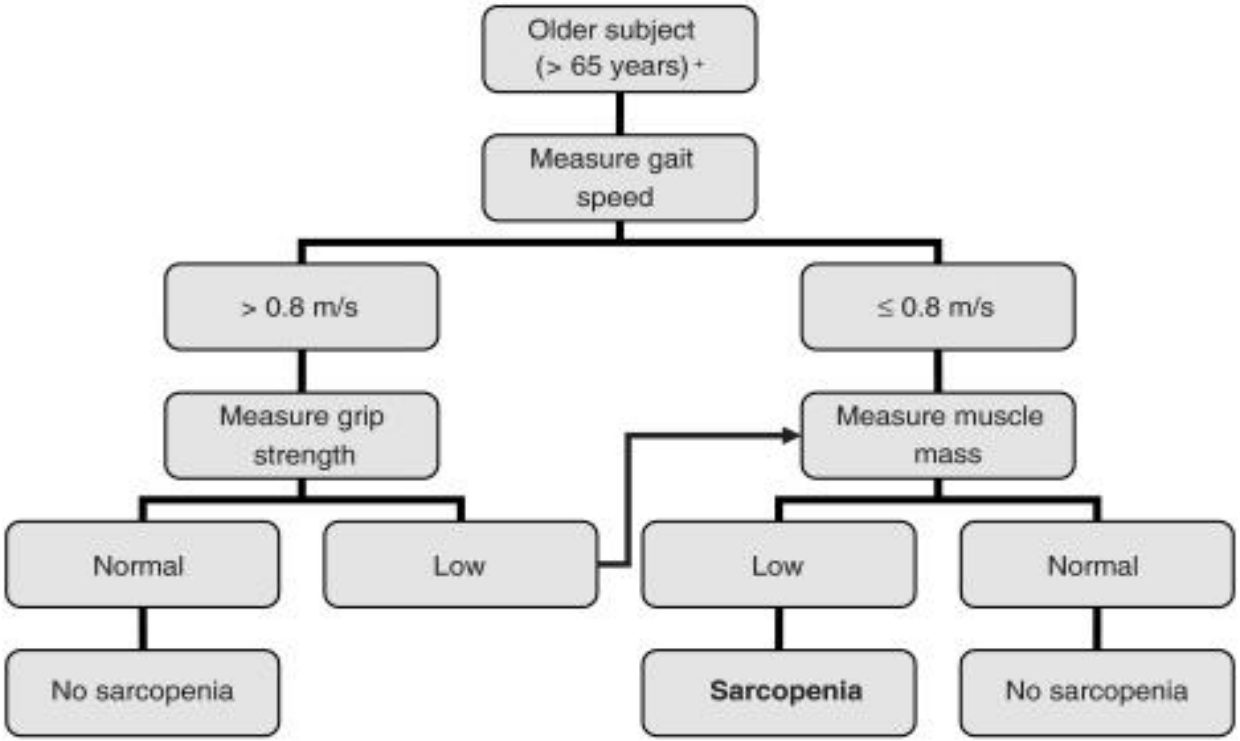


What to screen?

EWGSOP Working Definition of Sarcopenia

Stage	Muscle mass	Muscle strength	Performance
Presarcopenia	↓		
Sarcopenia	↓	↓	Or ↓
Severe sarcopenia	↓	↓	↓

What to screen?



Cruz-Jentoft AJ et al. Sarcopenia: European consensus on definition and diagnosis. Report of the European Working Group on Sarcopenia in Older People. Age Ageing 2010

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Muscle

Largest organ of the body - 40% bodyweight

Largest protein reservoir

Muscle mass and quality

- regarded as biomarkers
- patient's physiologic reserves

Measuring muscle mass

Many different methods

24-hour urinary creatinine method

Total body potassium

Bio-electrical impedance analysis (BIA) – practice/research

Dual energy X-ray absorptiometry (DEXA) – practice/research

Computed tomography (CT) - research

Magnetic resonance imaging (MRI) - research

Questions for the audience

For routine muscle mass screening, who has access to

- BIA?
- DEXA?
- CT?
- MRI?

Who has incorporated muscle mass screening in his daily clinical routine?

So who would like to have access to an easy way of assessing/screening muscle mass?

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- Ultrasound
  - Advantages / disadvantages
  - What is there to measure

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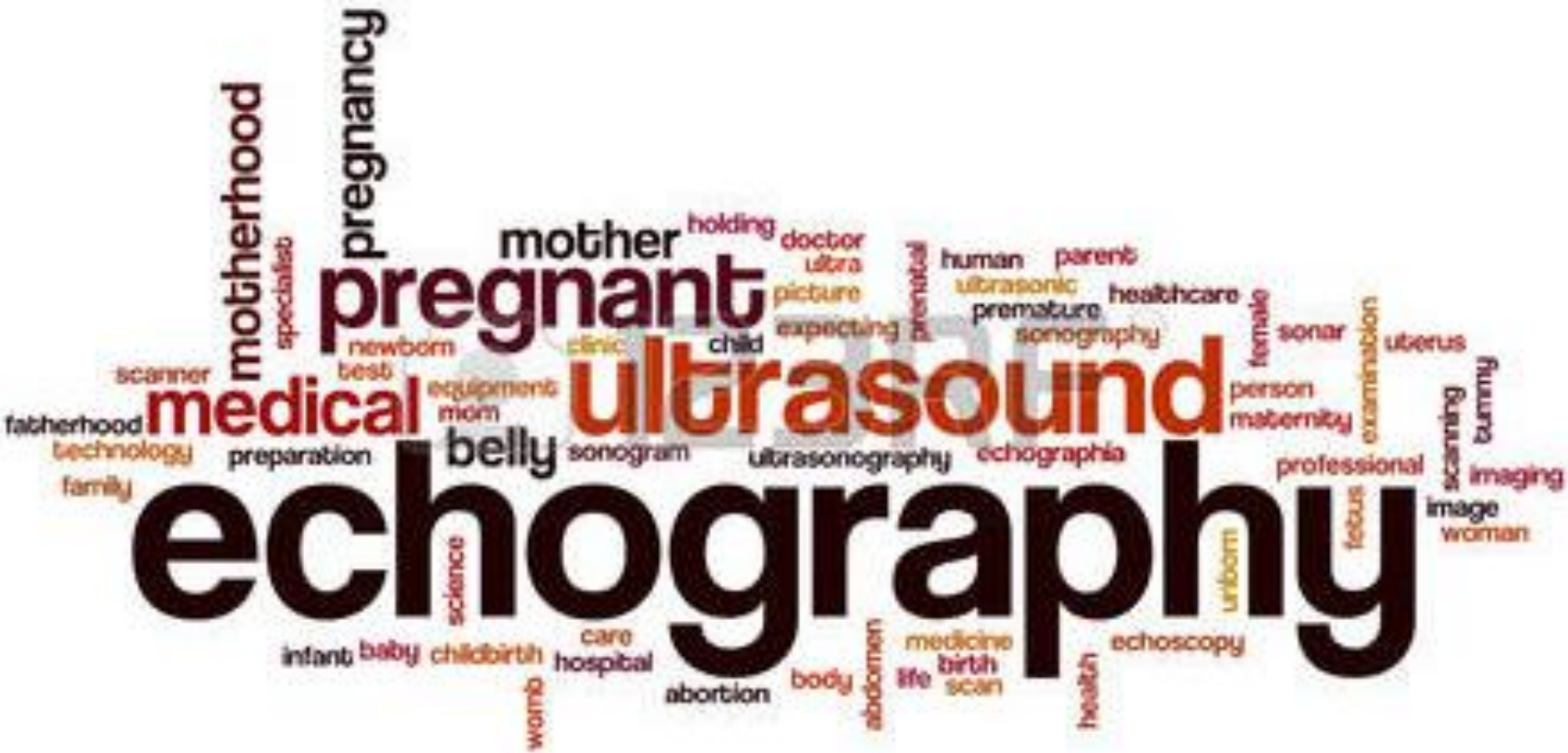
Measuring muscle mass: where is the ultrasound?



Ultrasound: first thing you need to know

≠

Ultrasound: advantages

Cheap

fast

easy

- Low cost/maintenance
- Quickness of execution, no preparation time
- Easy to use, availability at bedside

Expected problems / difficulties

Technique related: reproducibility (probe, settings, …)

Patient related: body type

Muscle related: rest versus contraction

⇒ No standardization or strict protocol = no reliable or reproducible results

⇒ Protocol different in every study

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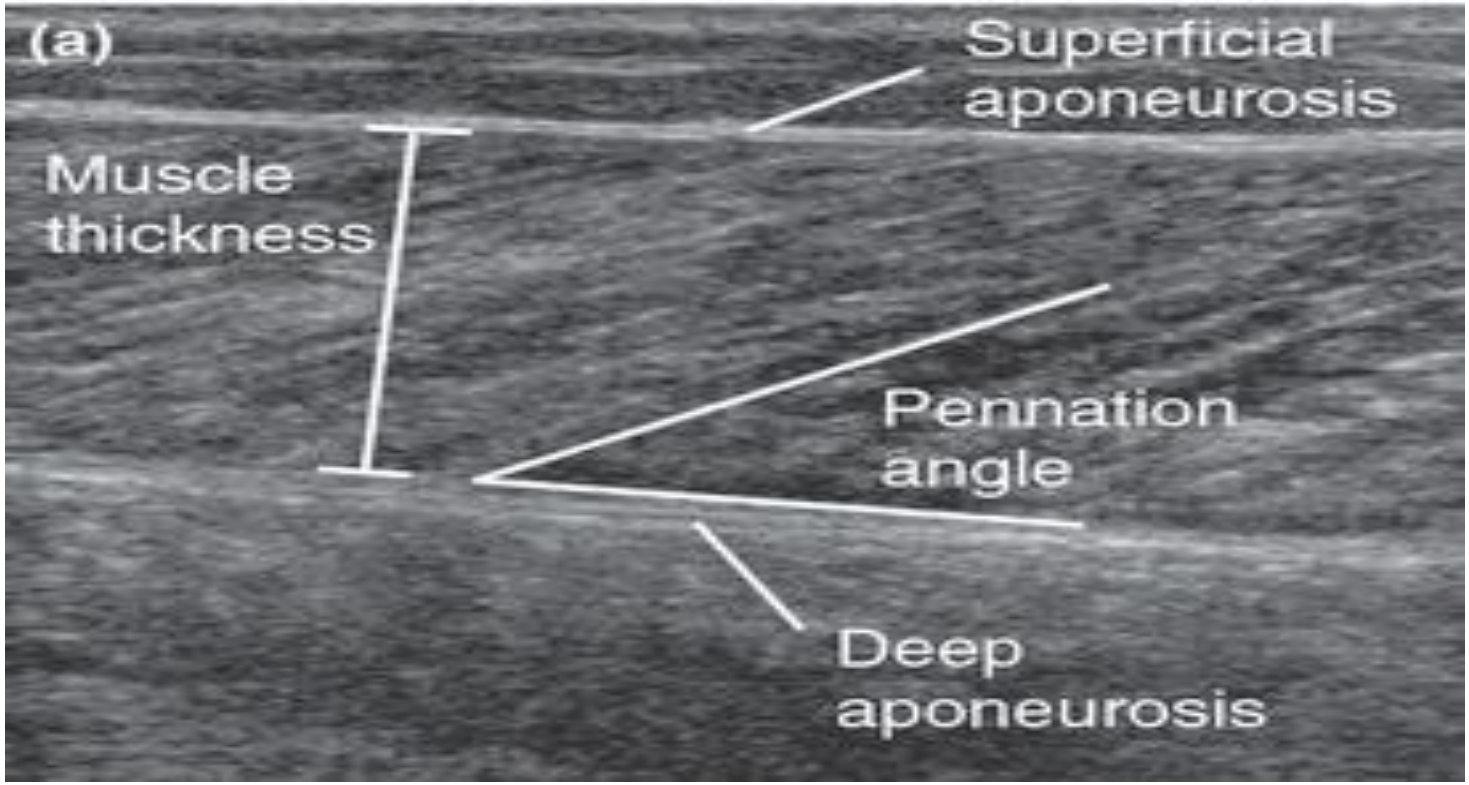
Ultrasound: what can we measure?

- Regional assessment of muscle quantity (size/mass) and quality (echo intensity)

- Five main parameters
  - Muscle thickness
  - Muscle cross-sectional area
  - Fascicle length
  - Pennation angle
  - Echo-intensity

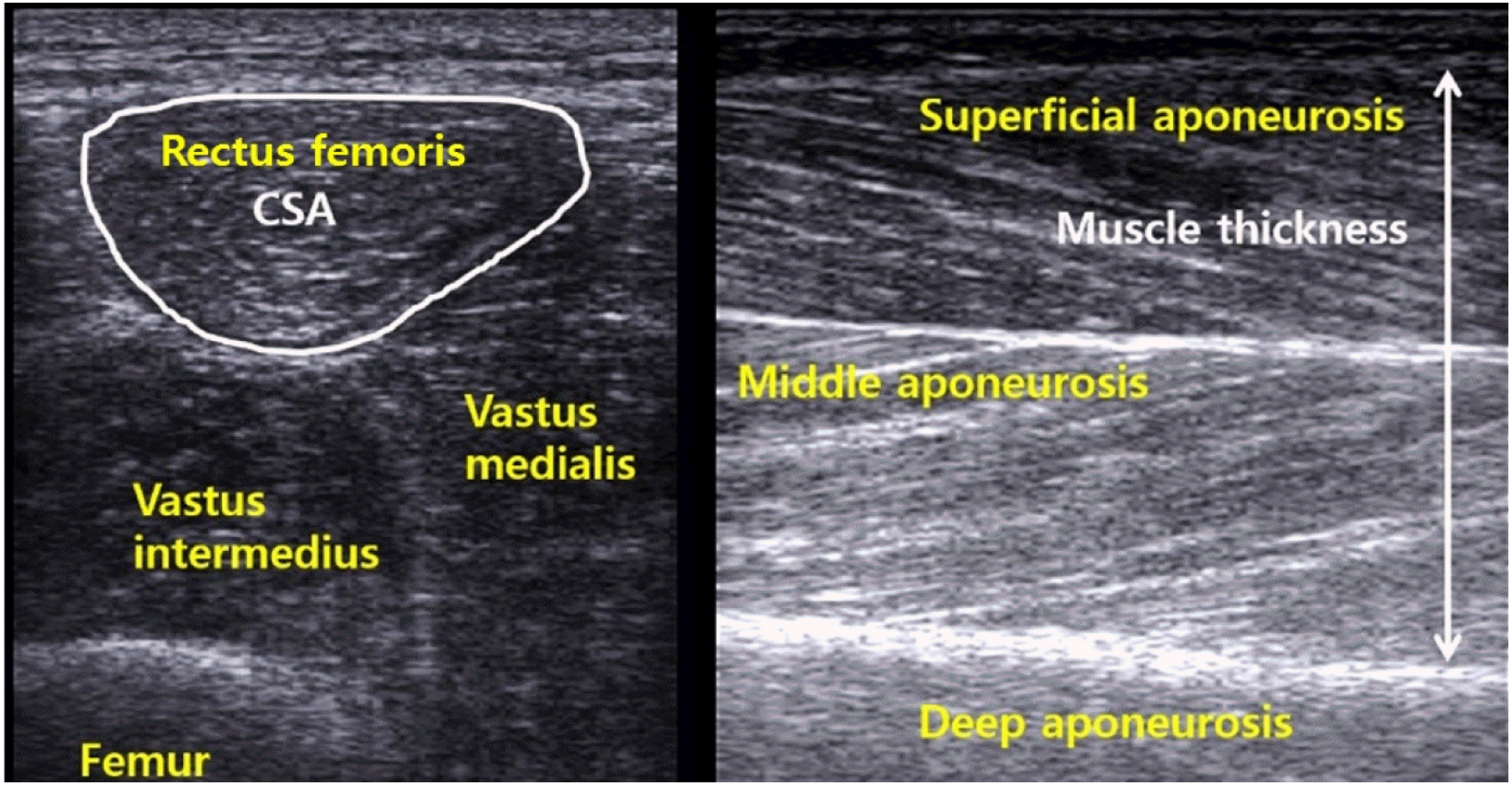
Muscle thickness



Muscle thickness

- Muscle thickness is highly correlated with maximum voluntary contraction force
- Total skeletal muscle may be estimated using muscle thickness, with a strong correlation with both MRI and DEXA.
- Changes can be measured after 6 weeks of training
- Caveat: rest versus contraction

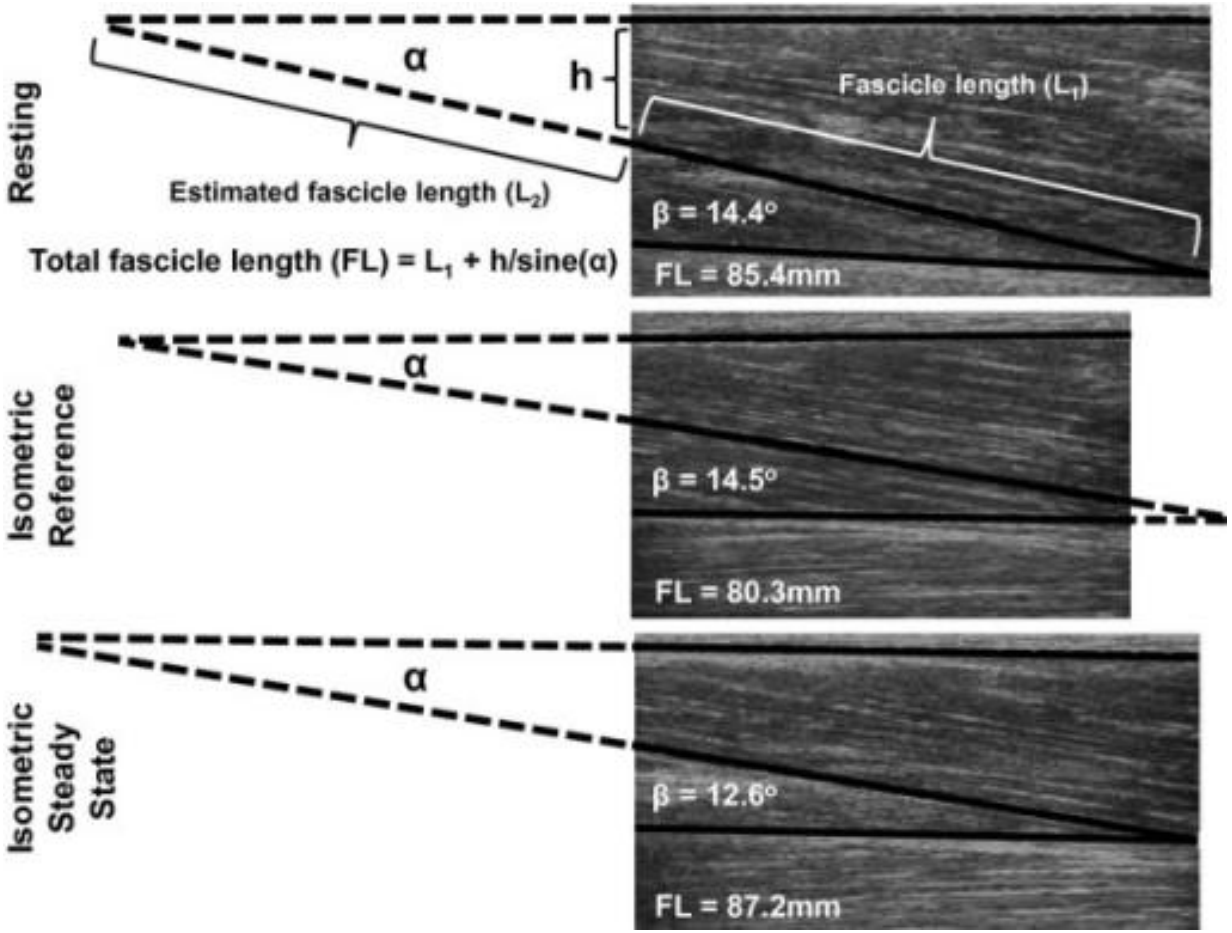
Muscle cross-sectional area



Muscle cross-sectional area

- Area is measured perpendicular to fiber length
- CSA: inter- and intrareader reliability similar to those for MRI
- Correlated with postoperative complications
- Changes can be measured after 6 weeks of training
- Anatomical CSA (ACSA) ≠ physiological CSA (PCSA)

Fascicle length

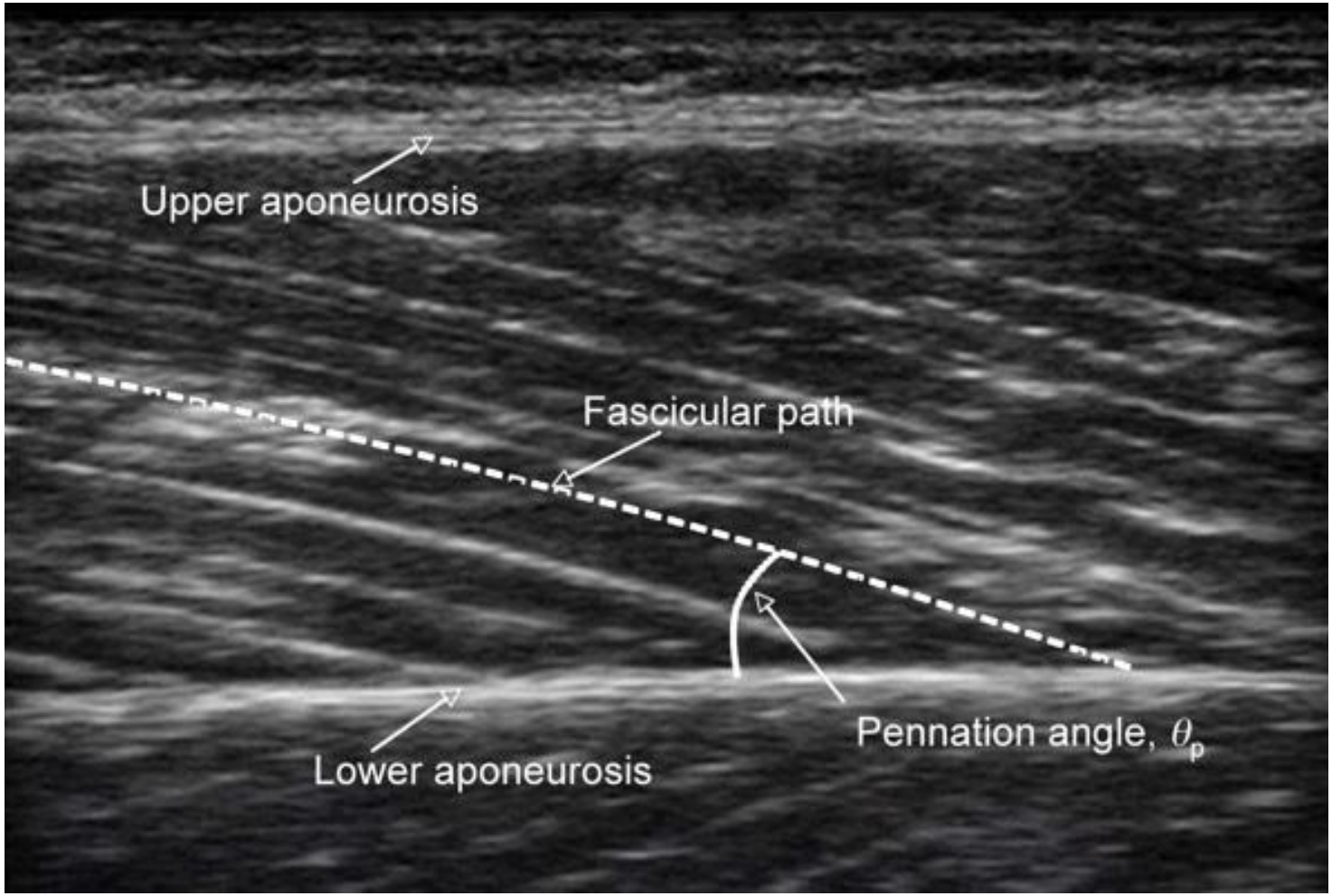


Fascicle length

- Increases with training (sprint versus endurance)
- Contractions can be measured
- Difficult to measure strength of contraction
- Fascicle length affects
  - Motor-unit recruitment
  - Discharge rate
  - Central command: contractions at different lengths give different central output

Change in Muscle Fascicle Length Influences the Recruitment and Discharge Rate of Motor Units During Isometric Contractions. Pasquet et al.

Pennation angle



Pennation angle

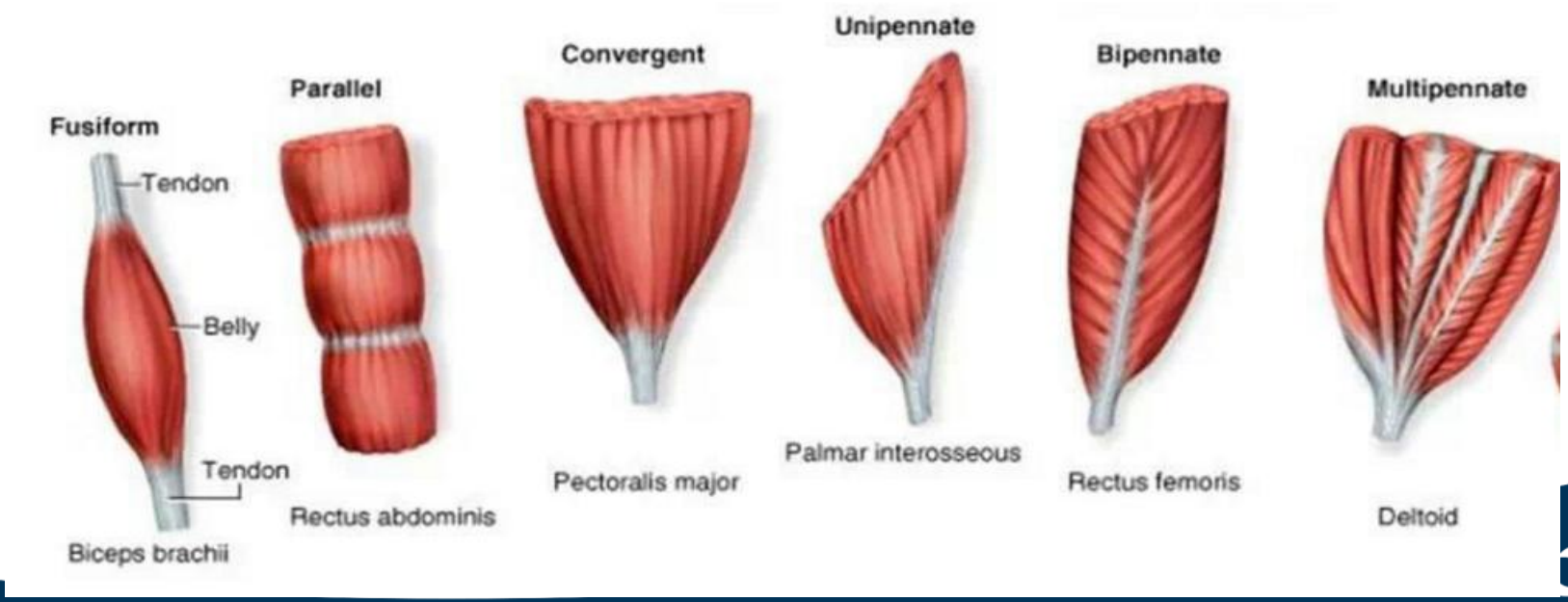
- Symbol commonly used is Θ
- Line of pull of a muscle fiber towards the tendon
- Pennation angle is linked to the force generating potential of a muscle
- Influenced by tendon properties, fat infiltration of the muscle
- Is seen in pennate muscles
- In these muscles, physiological CSA is better used

Intermezzo: parallel versus pennate muscles

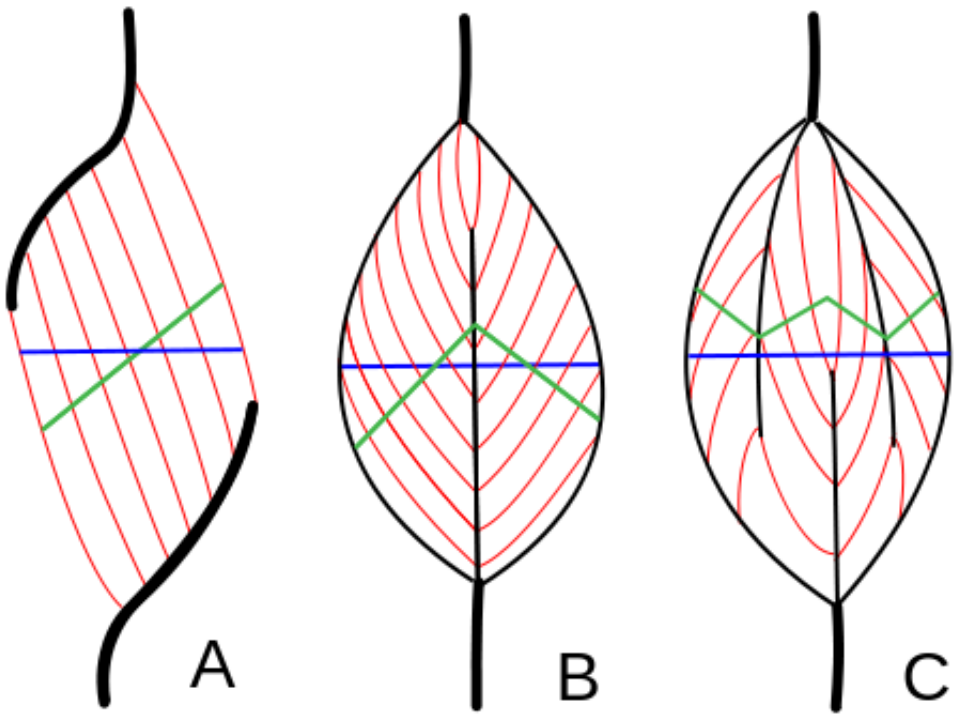
Parrallel: fibers are parallel to the force-generating axis

Pennate: Fibers are at an angle to the force-generating axis (pennation angle)

PCSA = mass x cos Θ / fiber length x muscle density



Intermezzo: parallel vs pennate

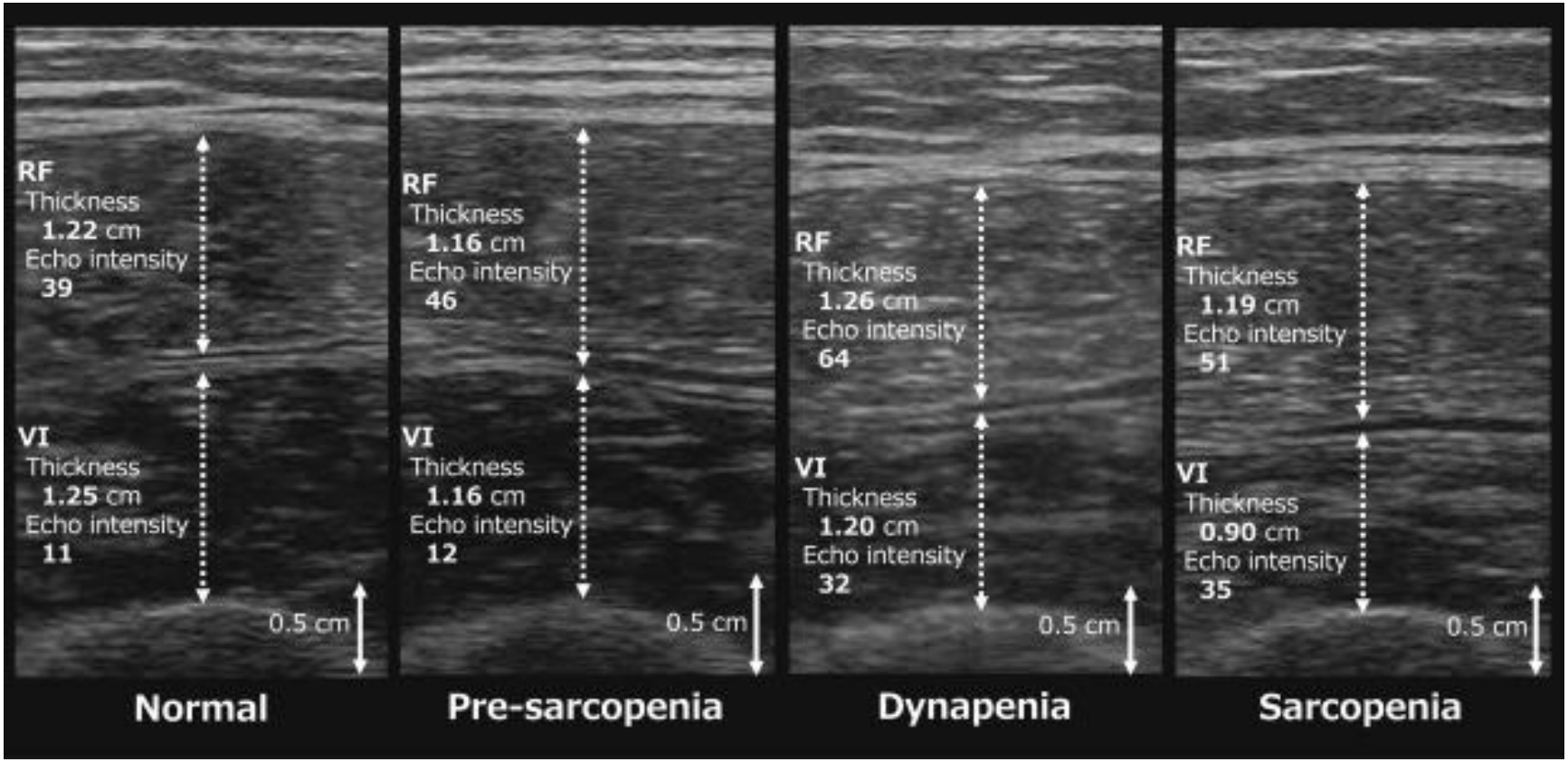


Green lines: PCSA; blue lines: ACSA (U. Gille)

Pennate muscle: PCSA > ACSA

Non-pennate muscle: PCSA = ACSA

Echo-intensity



Differential Characteristics of Skeletal Muscle in Community-Dwelling Older Adults. Minoru Y et al. JAMDA September 2017.

Echo-intensity

Quantative gray scale analysis, marker of muscle quality (fat, fibrous)

Negatively correlated with

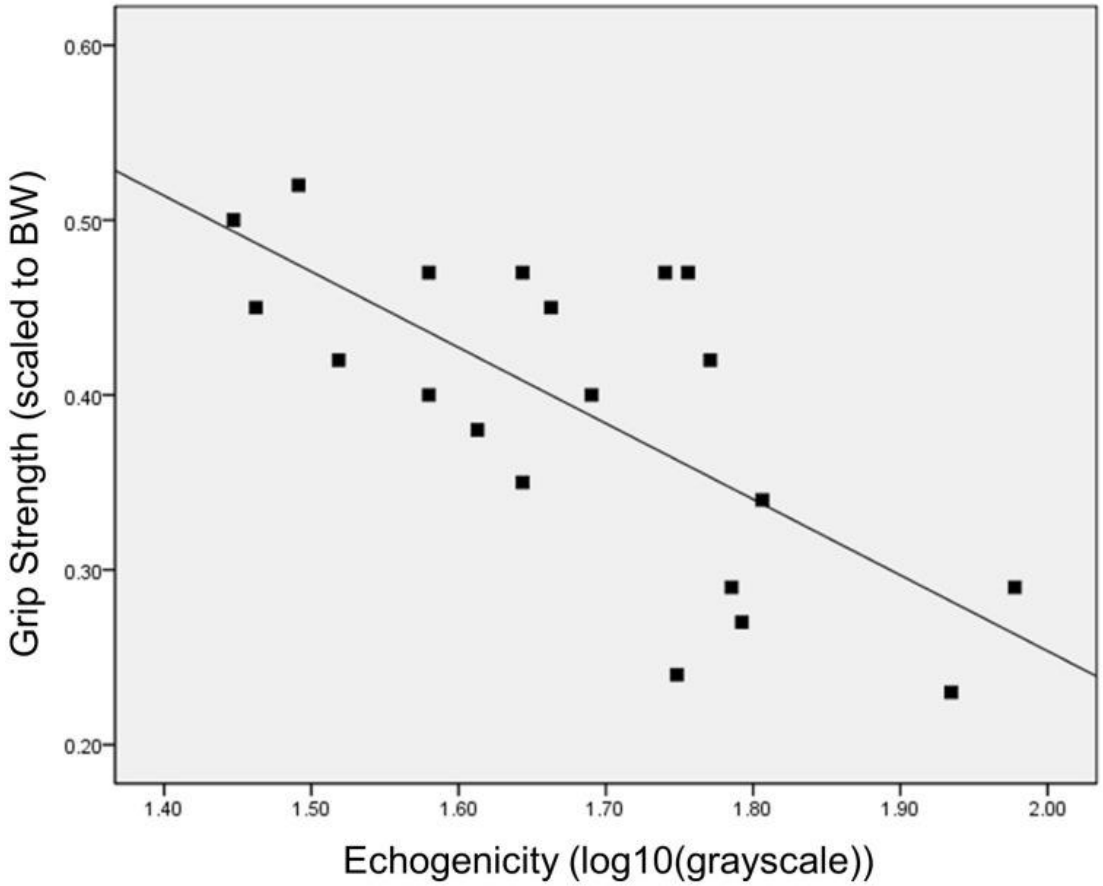
- Muscle thickness
- Muscle strength (independent of age or muscle thickness)

Caveat:

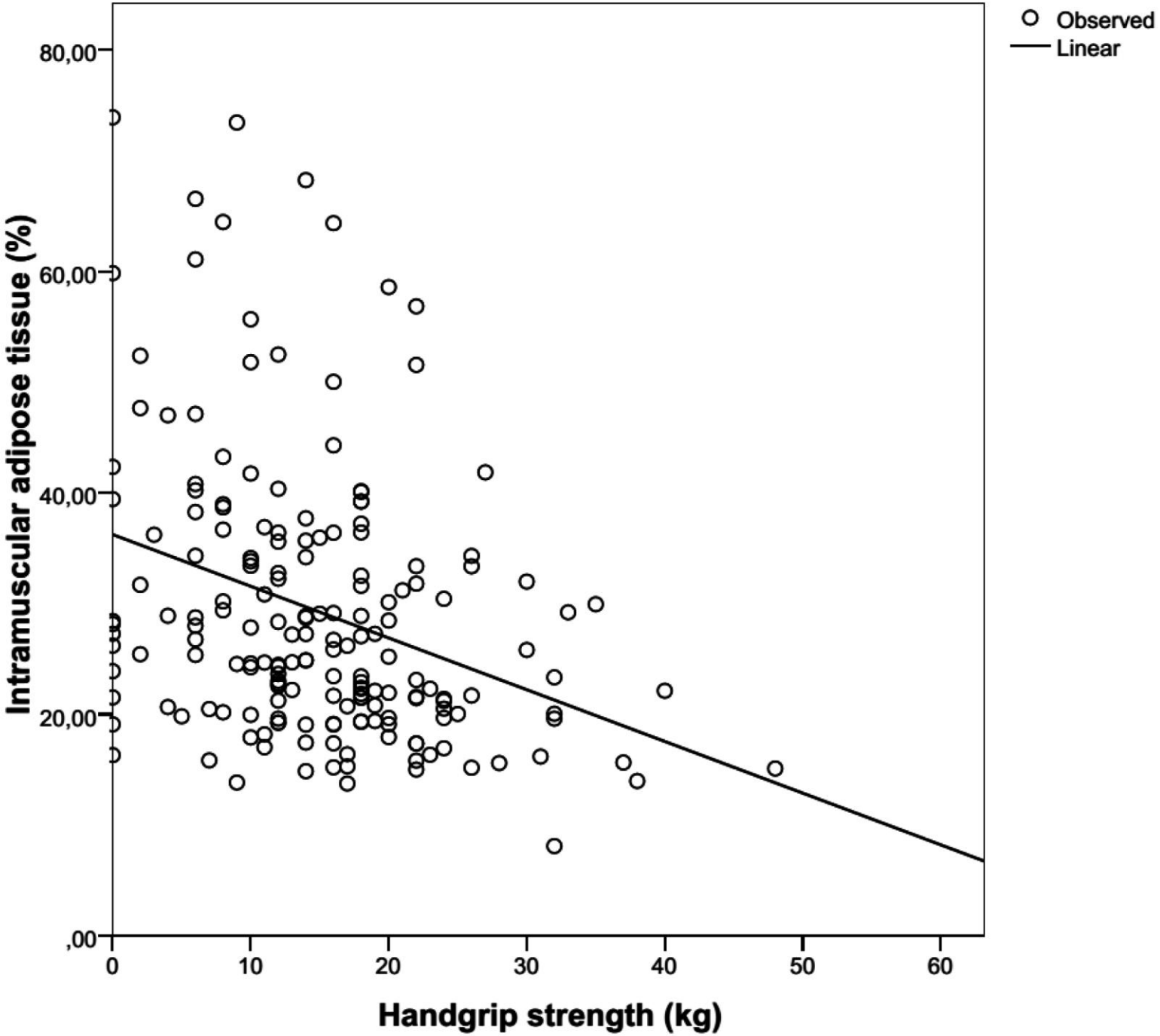
- Low inter- and intra-operator reproducibility
  - Compression
  - Focus

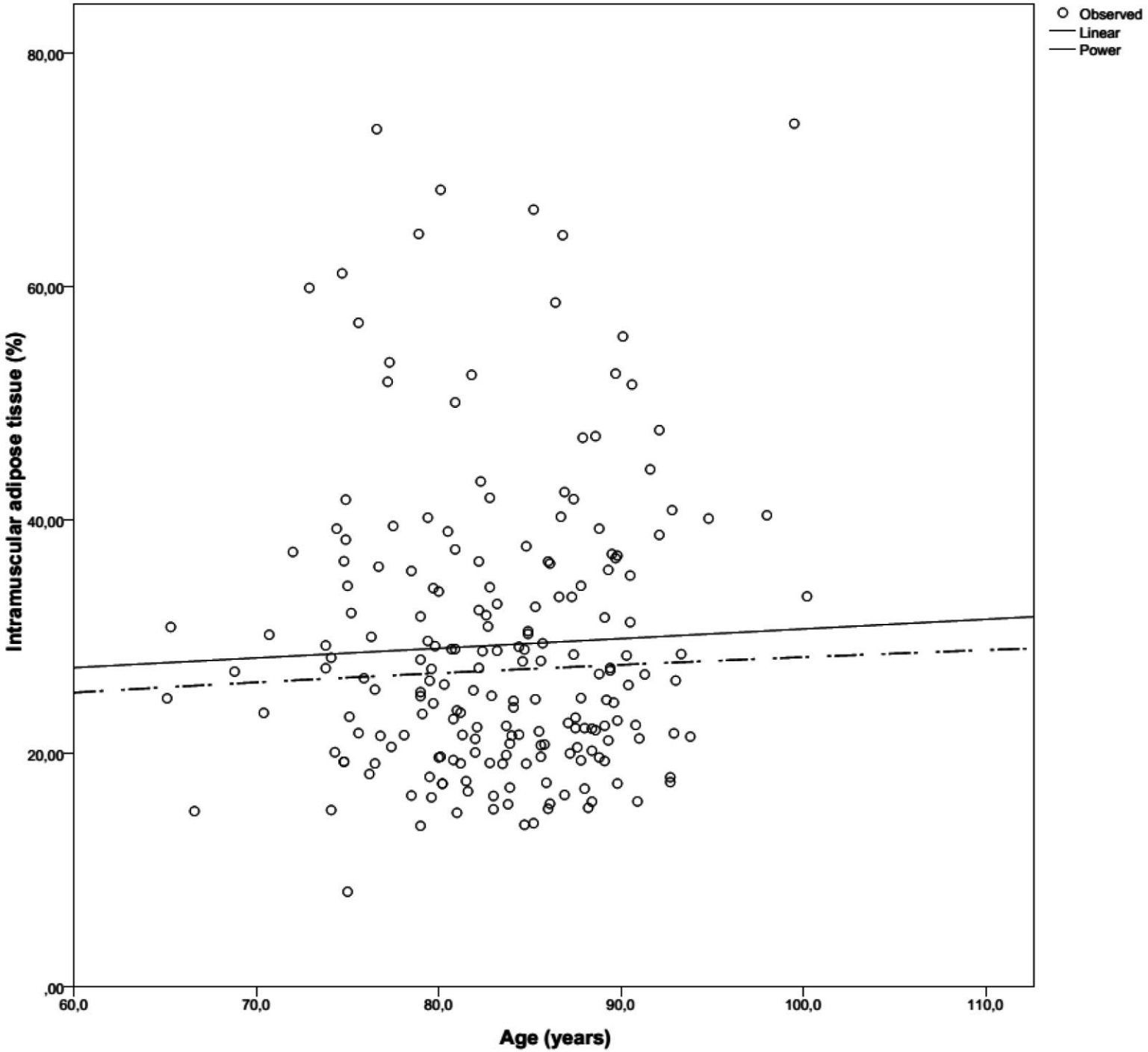
- System settings will strongly influence values
  - Gain (more gain = more white ≠ less muscle mass)
  - Time gain compensation (TGC)

Echo-intensity



Diagnostic ultrasound estimates of muscle mass and muscle quality discriminate between women with and without sarcopenia. Catheeja et al. Front Physiol. 2015; 6: 302.


Observed
Linear
80,00
60,00
40,00
20,00
,00
Intramuscular adipose tissue (%)
0
10
20
30
40
50
60
Handgrip strength (kg)


Observed
Linear
Power
80,00
60,00
40,00
20,00
,00
Intramuscular adipose tissue (%)
60,0
70,0
80,0
90,0
100,0
110,0
Age (years)

But Wait...

THERE'S MORE!

Ultrasound: can we measure even more?

Additional parameters, not yet “fully operational” in sarcopenia setting:

- Mechanical properties - muscle stiffness
- Vascular flow/microvasculature
- Muscle mobility (fasciculations)
- Belly gearing evaluation

Also, just a glance…

Muscle stiffness / hardness

Muscle stiffness = resistance of a muscle tissue against perpendicular pressure

Muscle stiffness is correlated with pennation angle & muscle thickness

Elastography: different techniques, strain seems to be the most useful

No clear role so far in sarcopenia, but promising!

Vascular flow/microvasculature

Older muscle: diminished vascularization

Use of contrast-enhanced ultrasound (CEUS)

Untargeted CEUS

- Intravenous injection of gas-filled microbubbles
- High degree of echogenicity

Targeted CEUS

- Intravenous injection of specific targeting ligands
- Accumulation in area of interest
- Preclinical development, not FDA approved

No clear role so far in sarcopenia, but promising!

Even less clear role in sarcopenia

Muscle mobility (fasciculations): mainly used in diagnosis of neuromuscular diseases

Belly gearing evaluation: incorporation of tendon properties

- Muscle-tendon gearing is the ratio of the muscle-tendon unit velocity to the fascicle velocity
- Expressed as the product of the gearing within the muscle belly and the gearing due to tendon stretch.

Not to be discussed at this time

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Not the future but the present
Where are we now?

Ultrasound

High concordance with DXA, CT and MRI

High sensitivity and negative predictive value in detecting sarcopenia

Best measurements in proximal leg muscles

Where do we need to be in 5 years?

Standardization, because of many factors available

- Type of probe (linear 4-10 cm, curved, extended field-of-view)
- Position of probe (perpendicular to the skin, inclination, pressure)
- Ultrasound frequency (5-7.5 MHz)
- Type of parameters measured
- Fixed anatomical sites / landmarks for measurements
- Posture of patient (bed, chair), state of muscle (rest vs. contraction)

Where do we need to be in 5 years?

Further assessment and validation of ultrasound as a standard imaging algorithm for sarcopenia

Use of ultrasound in **screening** and **prevention**

International collaboration versus mushroom working

Perhaps even a sarcopenia SIG project…

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Take home messages

- Strong need for routine muscle mass screening
- Ultrasound: think ‘cheap – fast – easy’
- Correlated with DEXA, CT and MRI = reliable and valid tool
- Need for standardized protocol

  and international collaboration

Thank you for your attention! Questions?

Remember: 30 min. walk to the beach = perfect sarcopenia prevention!