A Prospective Study on Muscle Strength Assessment Using Phase Angle from Bioelectrical Impedance Analysis After ACL Reconstruction

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Conflict of Interest Disclosure (COI)

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Introduction

Body composition analyzer

Bioelectrical Impedance Analysis (BIA): Estimating Body Composition

✓Principle:

- Fat tissue resists electrical current.
- Fat-free tissue (high in water & electrolytes) conducts electricity easily.

✓Method:

1. A weak electrical current is applied.
2. Impedance (resistance) is measured.
3. Body composition is calculated using regression equations (algorithms) with weight & height.

MC-980A-N plus, Tanita Corp.

https://www.tanita.co.jp/product/business/bodycompositionanalyzer/4094/

Phase angle

✓Represents *the ratio of resistance to reactance* as an angle.*

✓Typically measured using a 50 kHz electrical current.

*Impedance of the Human Body

• Resistance: Opposition to electrical current caused by extracellular and intracellular fluids.

• Reactance: Opposition caused by cell membrane capacitance.
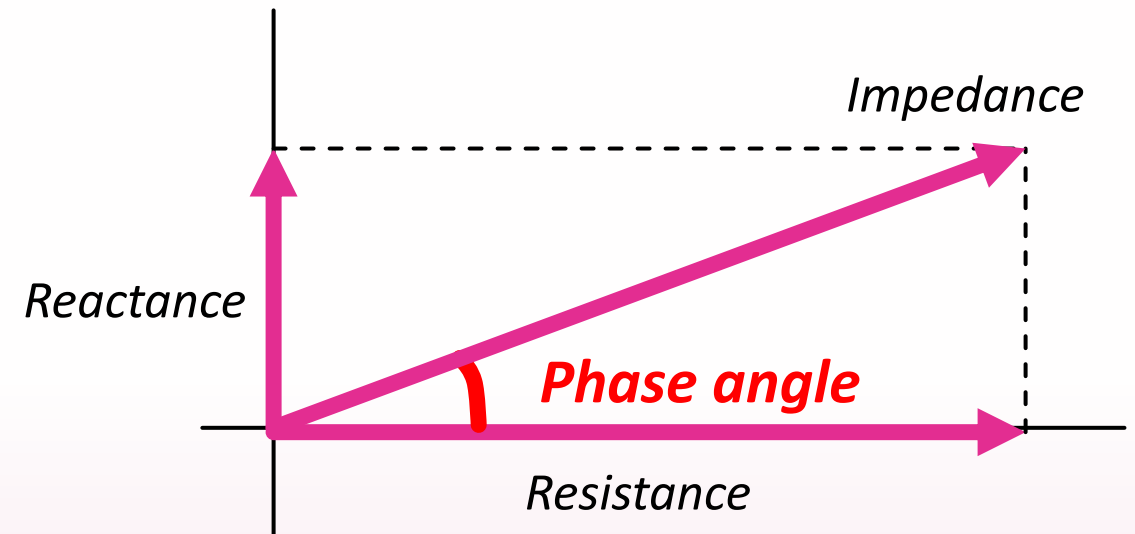
High Phase Angle: Indicator of Muscle Health

✓Higher Phase Angle reflects better muscle condition:

- Greater number of muscle cells.
- Thicker muscle fibers.

✓Mechanism:

- Healthy cells have a higher capacity to store electrical charge in their membranes (capacitance).
- This increases reactance, resulting in a higher Phase Angle.

■ *Muscle fibers*
■ *Fat and connective tissue*

Impedance

Reactance
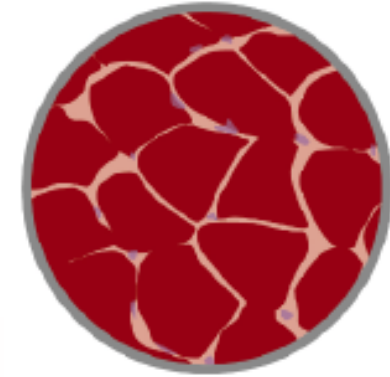
Phase angle

Resistance
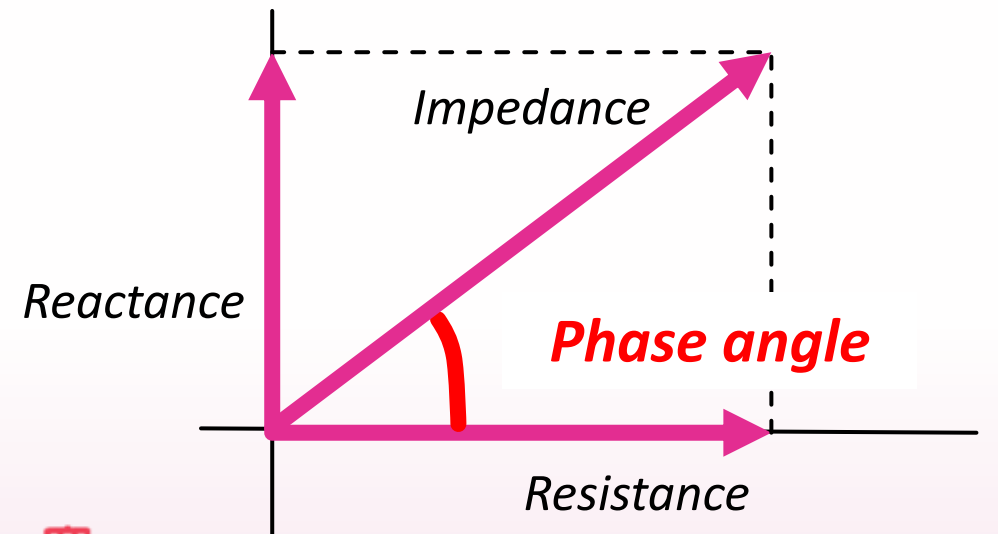
Low Phase Angle: Indicator of Reduced Muscle Quality

✓Characteristics of Low Phase Angle:

- Reduced muscle fiber density due to smaller or fewer muscle cells.

- Decreased intracellular fluid and smaller cell membrane surface area.

✓Mechanism:

- Lower capacitance (ability to store electrical charge) reduces reactance, resulting in a lower Phase Angle.

✓Implication:

- Reflects thinner muscle fibers, smaller muscle cells, and fewer muscle cells.

■ *Muscle fibers*
■ *Fat and connective tissue*

Impedance

Reactance
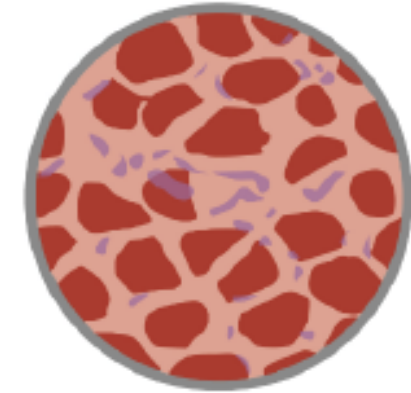
Phase angle

Resistance
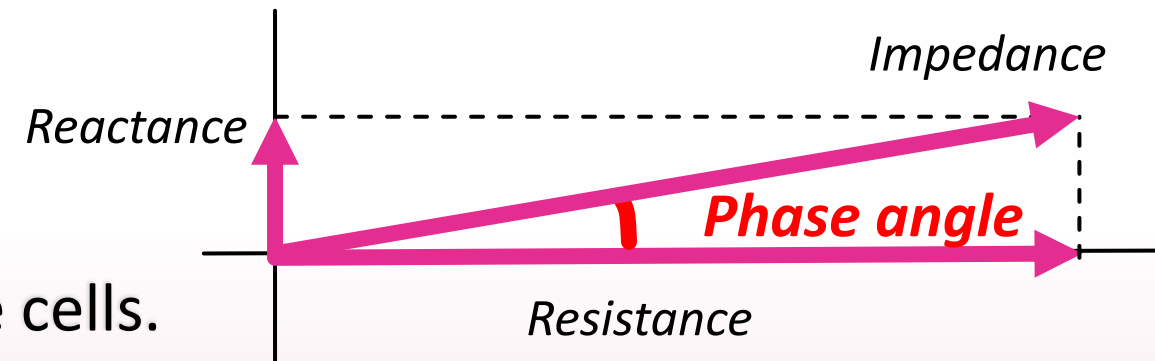
Purpose

✓Purpose

To determine whether the evaluation of Phase Angle using a body composition analyzer is useful for assessing muscle strength after ACL reconstruction.

✓Hypothesis
 The phase angle results correlate with muscle strength assessment using BIODEX.

✓Study Design:
 Prospective observation study

Materials and methods

✓Participants:
We included patients who underwent primary arthroscopic ACL reconstruction at our institution between September 2020 and April 2023.
27 patients (**21** males, **6** females; mean age: 33.5 years).

✓Excluded:
Re-injuries and multiple ligament injuries.
Patients with missing data

✓Evaluation Timeline:
Postoperative assessments at **3**, **6**, **9**, and **12** months.

✓Measurements:
Muscle strength: Knee extension strength at 60° /sec using **BIODEX**.
Phase angle: Measured with BIA (**MC-980A-N plus, Tanita**).
Limb Symmetry Index (LSI): Calculated for both BIODEX and phase angle.

Results

|	Knee extension strength at 60° /sec			Phase angle		
	affected	unaffected	*LSI*	affected	Unaffected	*LSI*
pre op	161.8	238.9	*0.666*	-6.488	-6.725	*0.964*
3M postop	143.4	238.5	*0.597*	-6.036	-6.584	*0.916*
6M postop	173.6	248.1	*0.700*	-6.293	-6.596	*0.953*
9M postop	193.7	249.0	*0.772*	-6.513	-6.744	*0.965*
12M postop	202.8	255.6	*0.796*	-6.435	-6.610	*0.974*

Mean data and Limb Symmetry Index (LSI) for affected and unaffected sides.
*M: month

Correlation between BIODEX and Phase Angle
(Pearson's correlation coefficient)

LSI (BIODEX)

LSI(Phase angle)

timing
- 0
- 3
- 6
- 9
- 12
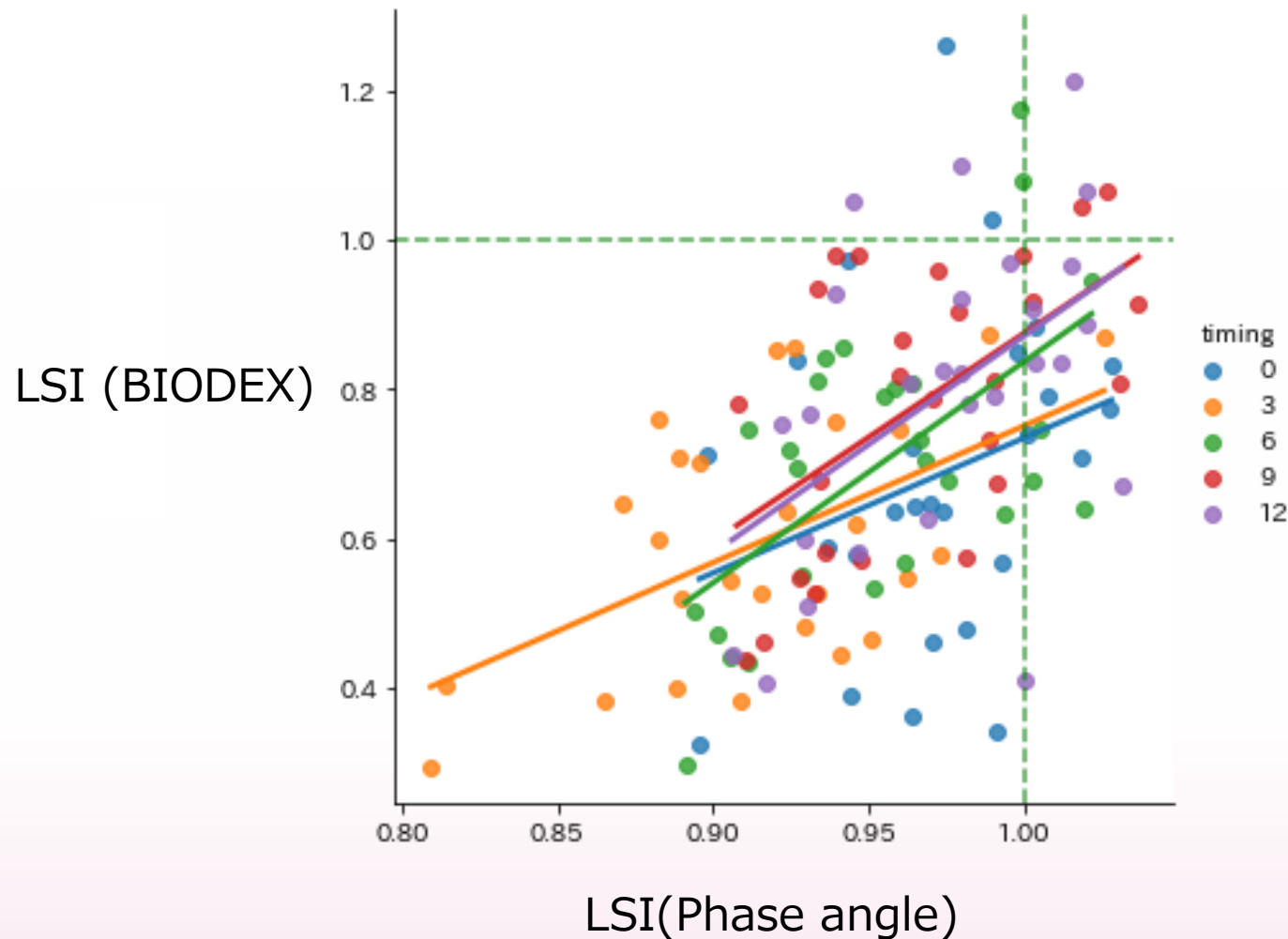
Correlation coefficient results
- Preop : no correlation
- 3M postop : R=0.528
- 6M postop : R=0.596
- 9M postop : R=0.591
- 12M postop : R=0.502
- Entire period : R=0.541   P<0.05

*Correlation metrics
0.00–0.19: Very weak
0.20–0.39: Weak
0.40–0.59: Moderate
0.60–0.79: Strong
0.80–1.00: Very strong

Discussion

✓The most important finding of this study is that there was a moderate correlation between muscle strength measurement using BIODEX and Phase angle in the LSI.

✓Based on my review of the literature, this appears to be the first study to compare BIODEX measurements and phase angle.

✓Previous studies have demonstrated that phase angle correlates with muscle quality and overall health status, and has been reported as a potential indicator of sarcopenia.[1-4]

✓Based on our findings, bioelectrical impedance analysis may offer a non-invasive and straightforward method for assessing postoperative muscle strength.

Limitation

✓Small sample size

✓Homogeneity of the study population (exclusively Japanese subjects)

✓High number of cases excluded due to missing data

✓BIODEX measurements potentially yielding extremely low values in the presence of pain

✓Possible influence of postoperative edema on the results

Conclusion and Reference

✓Conclusion
In patients following ACL reconstruction, a moderate correlation was observed between muscle strength measurements using BIODEX and phase angle ratios between affected and unaffected limbs. Phase angle may serve as a potentially useful, non-invasive, and convenient method for postoperative muscle strength assessment.

✓Reference

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