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Ultrasound in Spinal Stabilization

From Imaging to Motor Control Assessment – Expert Workshop

Autor opracowania: Arkadiusz Żurawski

The Core Clinical Problem: Unverified Activation

- Palpation cannot assess deep muscle activation accurately.
- Visible movement does not always equal correct muscle recruitment.
- Patients can perform tasks without activating target stabilizing muscles.

Why Ultrasound for Verification

- Provides real-time visualization of muscle activity and mechanics.
- Enables direct comparison of muscle at rest versus during contraction.
- Offers objective assessment of motor control patterns.
- Facilitates immediate biofeedback for patient learning and correction.

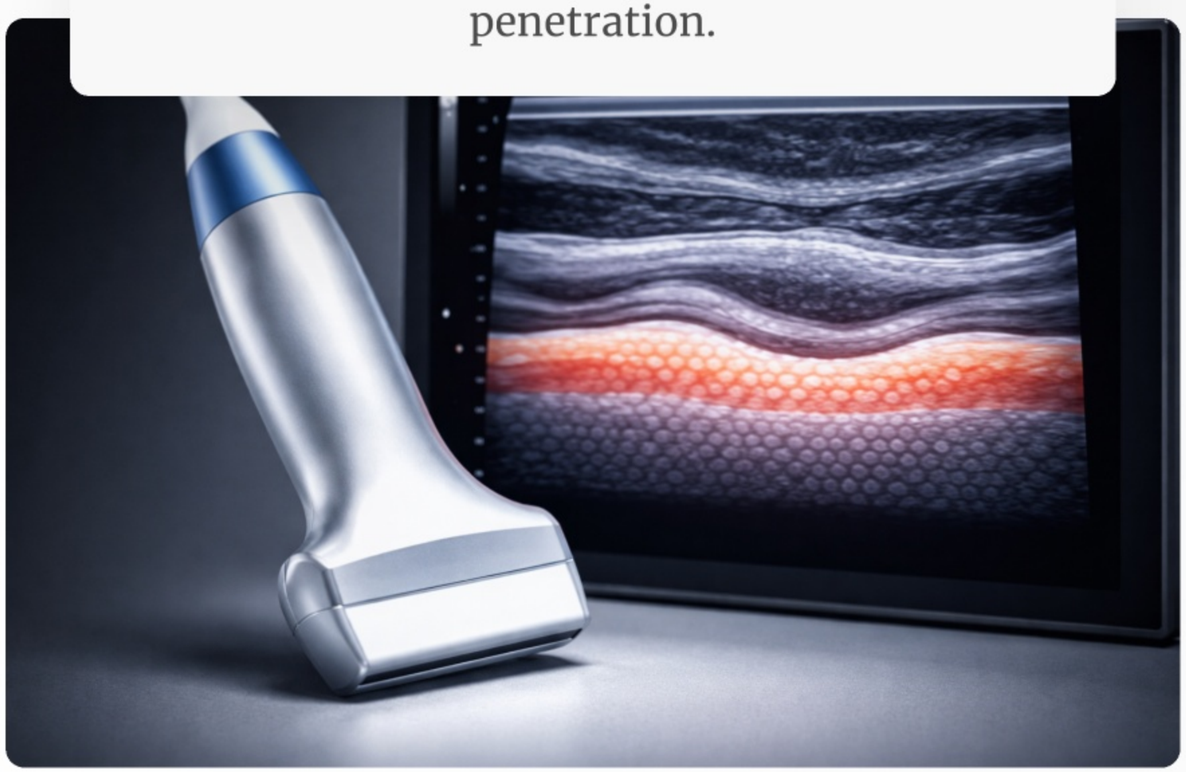
Limitations of Ultrasound Assessment

- Highly operator dependent, requiring specific skill and training.
- Provides an indirect measurement of muscle function, not direct force.
- Susceptible to technical errors in setup or execution.
- Incorrect settings invalidate image interpretation and conclusions.

Fundamentals: Frequency vs. Penetration

High Frequency

Offers high resolution for detailed images of superficial structures, but with limited depth of penetration.



Low Frequency

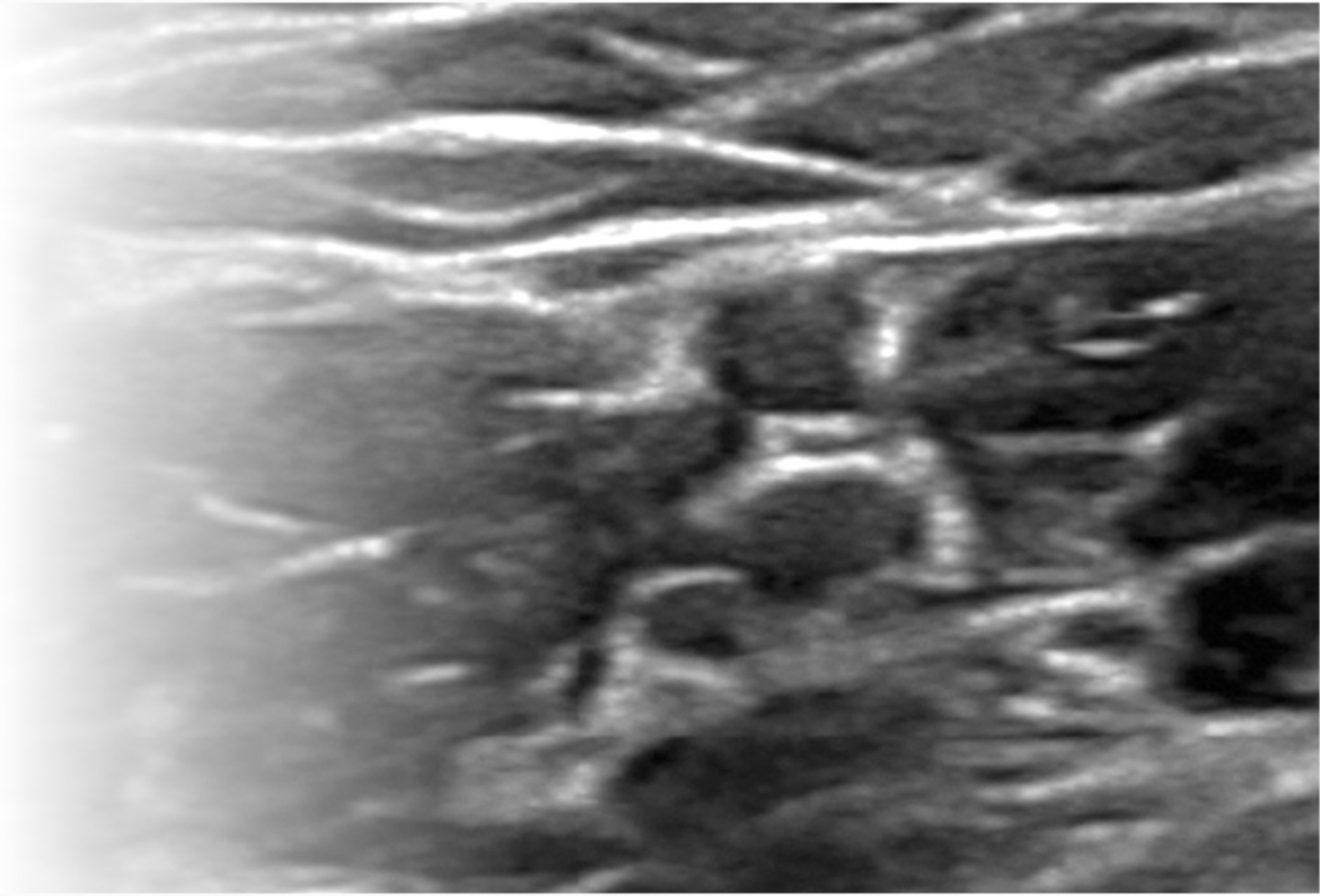
Provides deeper penetration for visualizing deep structures, but at the cost of lower image detail and resolution.

Principles of Reliable Image Interpretation

- Gain settings directly affect image contrast and brightness.
- Depth selection influences spatial interpretation of structures.
- Probe angle critically impacts structure visibility and clarity.
- Incorrect settings invalidate diagnostic interpretation.

Identifying Muscle Tissue on Ultrasound

Muscle tissue typically appears as a hypoechoic (darker) background with hyperechoic (brighter) septa. Its architectural pattern varies based on the probe's orientation relative to the muscle fibers.

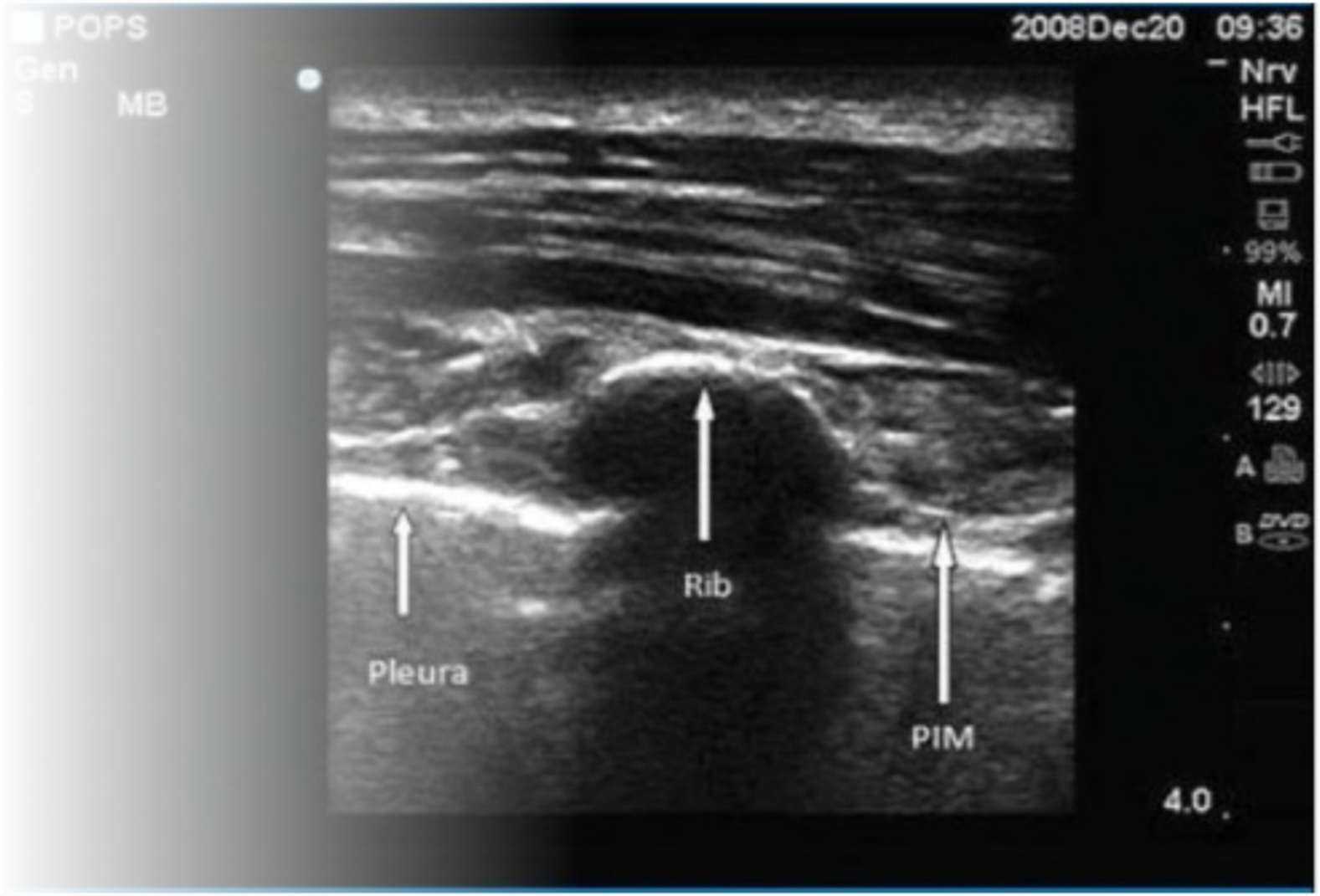


Identifying Tendon Tissue on Ultrasound

Tendons exhibit a distinct fibrillar, organized structure. They are highly anisotropic, meaning their appearance changes significantly with the angle of the ultrasound beam.

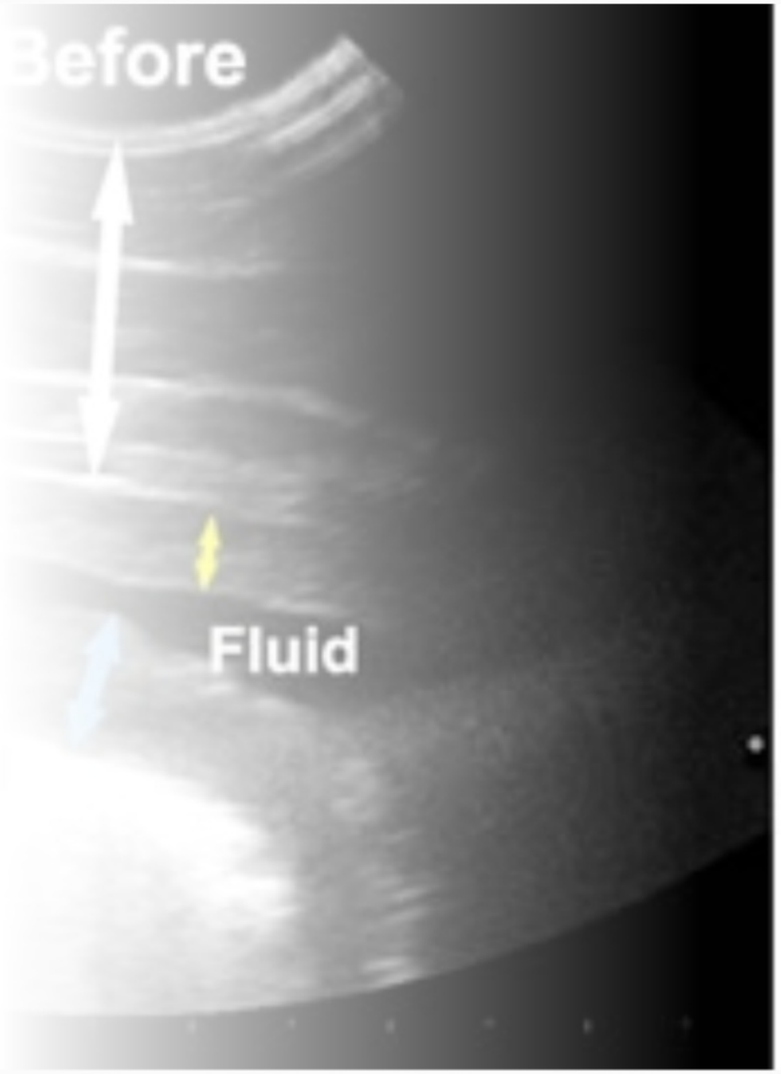
Identifying Bone Structures on Ultrasound

Bone appears as a bright, hyperechoic cortical line at the surface. Critically, it produces a clear posterior acoustic shadow, as ultrasound waves cannot penetrate bone.



Critical Artefact: Anisotropy

Anisotropy is an angle-dependent signal loss specific to highly organized structures like tendons. It can mimic pathology if not correctly identified, leading to misdiagnosis.



Essential Probe Handling Techniques

Stabilize your hand firmly on the patient to ensure steady imaging.

Apply minimal pressure to avoid tissue distortion and patient discomfort.

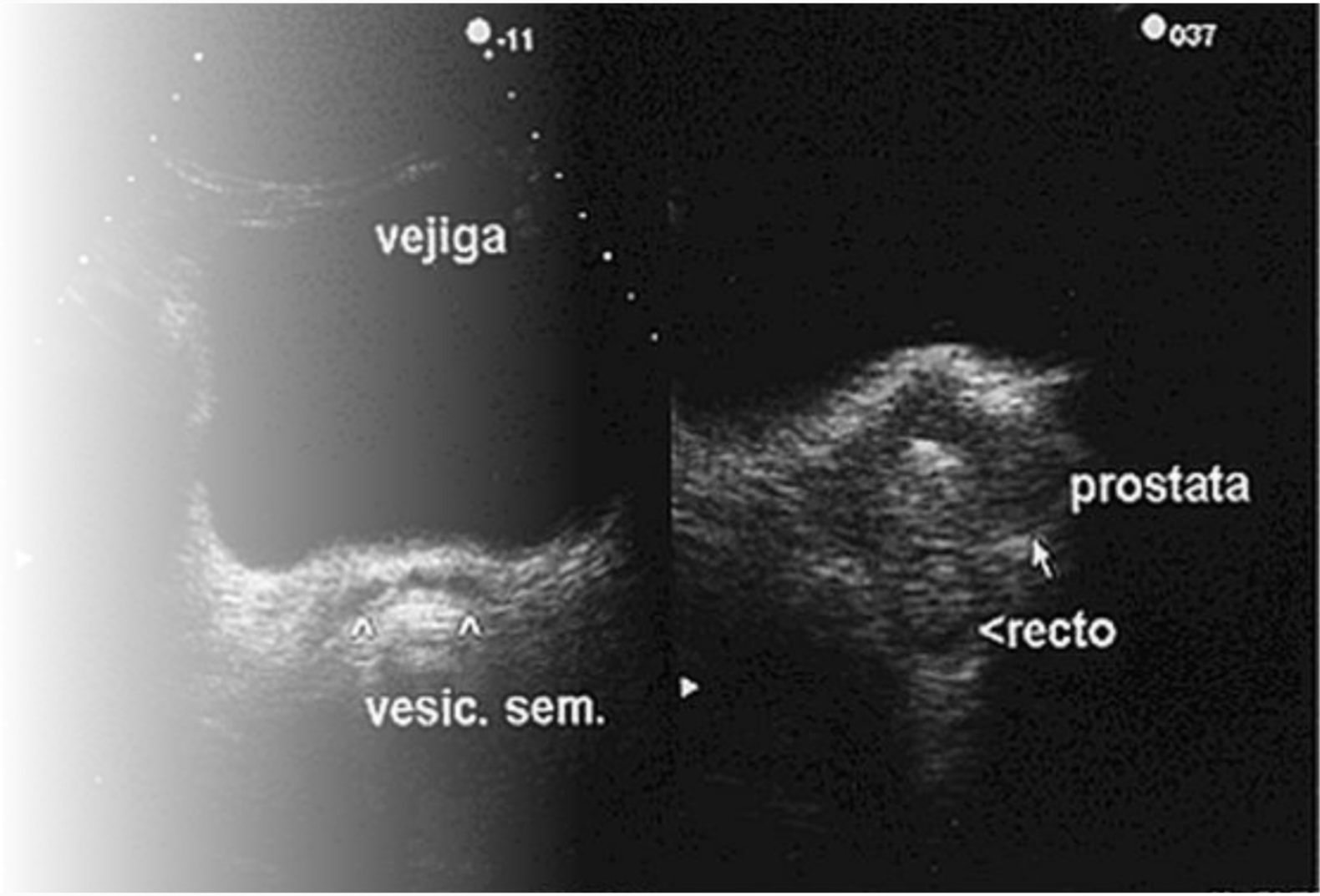
Maintain perpendicular orientation of the probe for optimal image clarity.

Dynamic Probe Movements

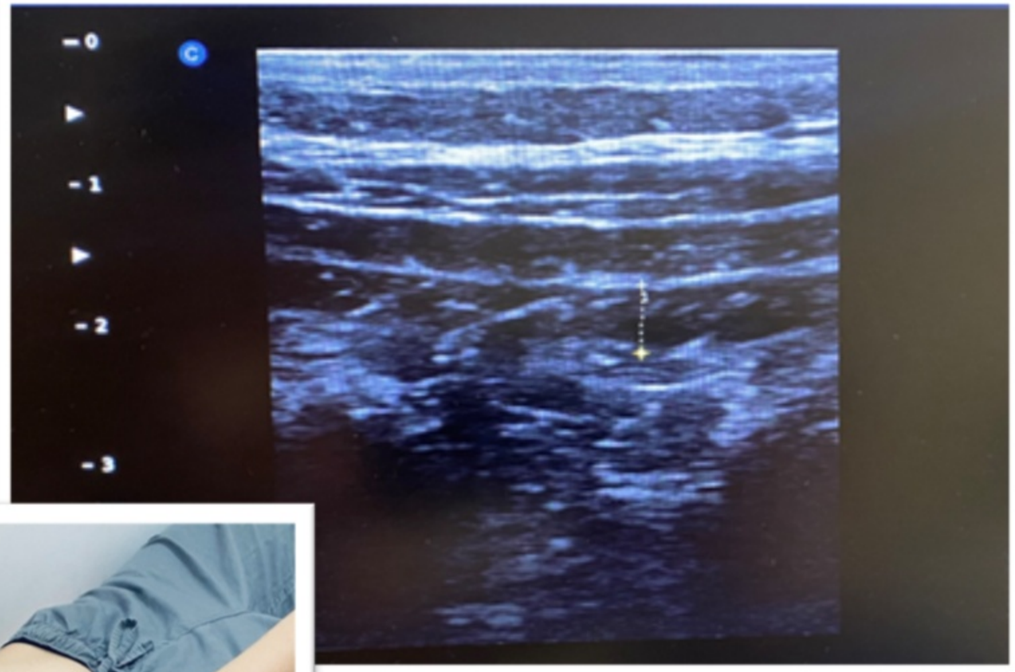
- Slide: Move the probe smoothly across the skin surface.
- Sweep: Rotate the probe while keeping its center point fixed.
- Rotation: Pivot the probe around its central axis.
- Heel-Toe: Angle the probe up and down by tilting one end.

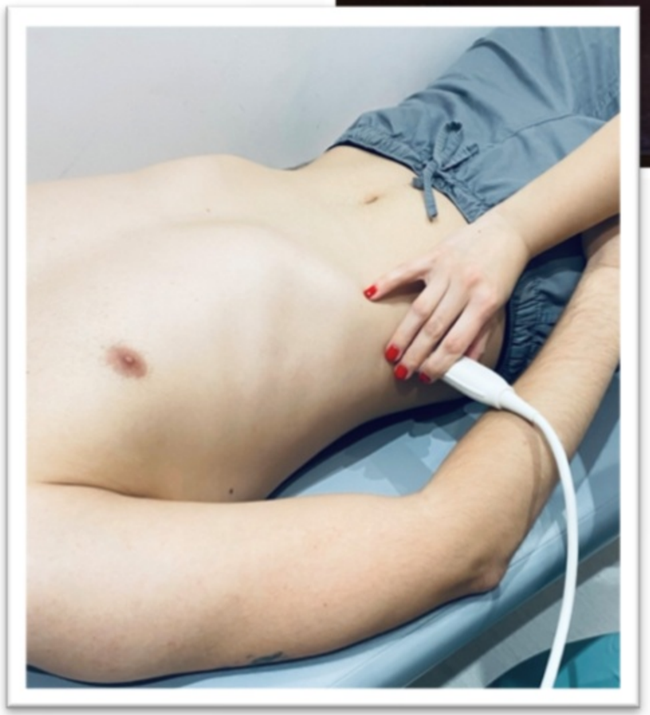
The Rule of Functional Imaging

Beyond observing static anatomical structures, the primary goal is to actively observe and assess tissue behavior during functional tasks and contractions.



Assessing Transversus Abdominis (TrA)

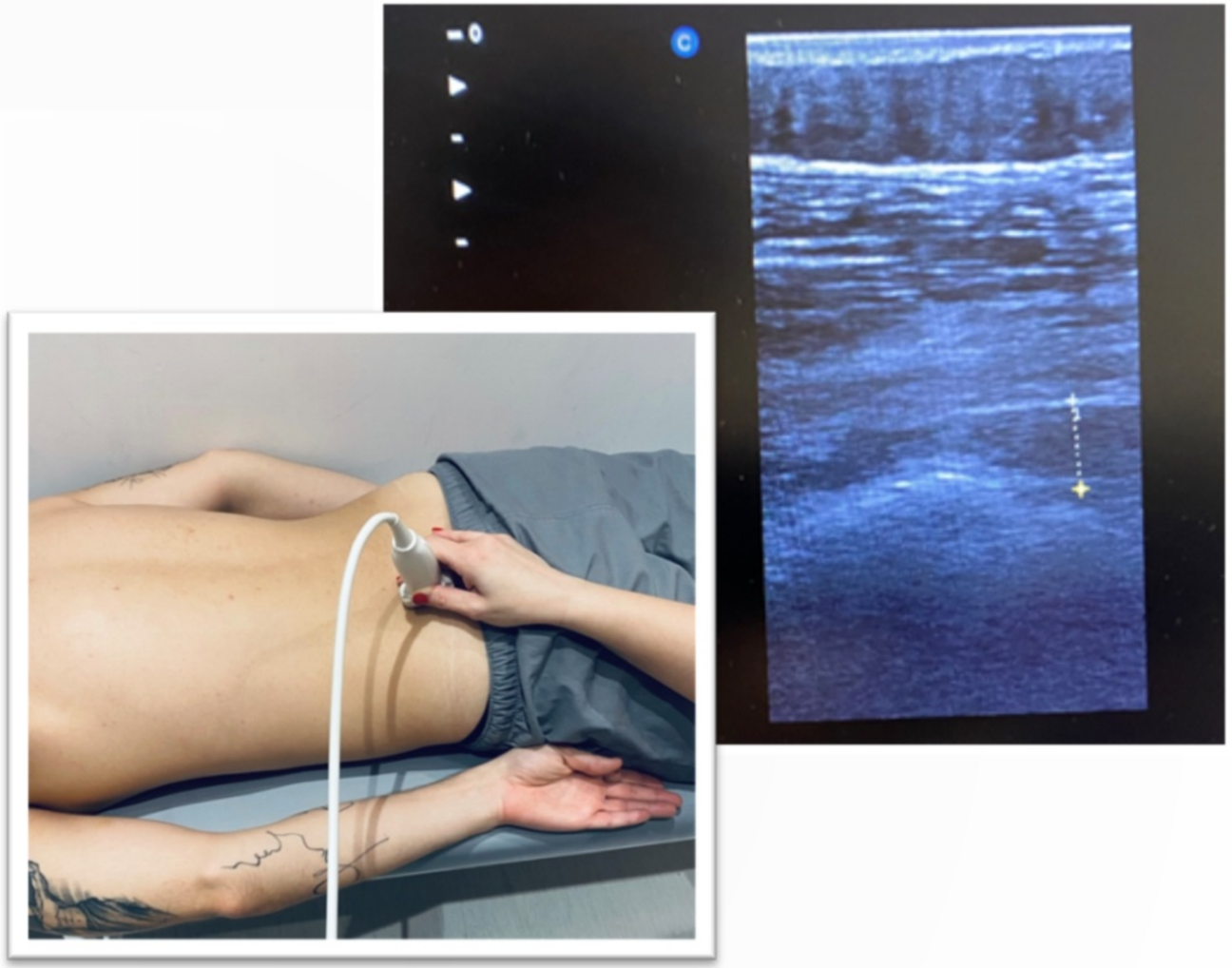




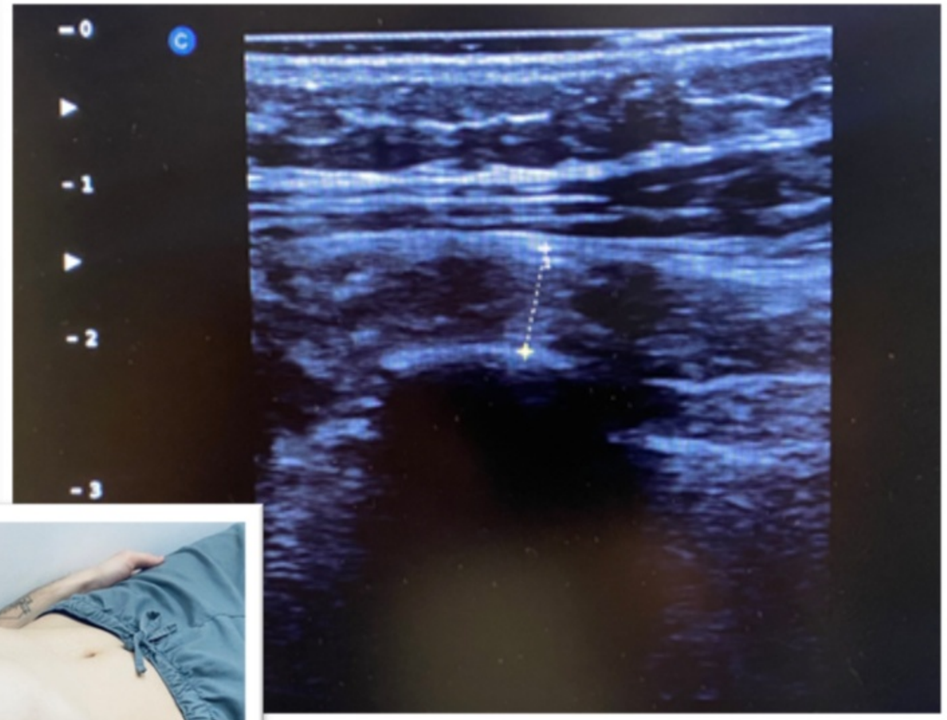
Position: Supine, hips flexed ~60°. Probe Placement: Midaxillary line, between iliac crest and rib margin, transverse orientation. Image: Identify EO, IO, and the deepest TrA layer. Activation: 'Draw in lower abdomen without pelvic movement'. Assess for thickness increase and controlled contraction. Errors include EO substitution, pelvic movement, or excessive probe pressure.

Assessing Multifidus Muscle

Position: Prone, neutral lumbar spine. Probe Placement: L5 level, lateral to spinous process, slight medial tilt. Image: Muscle adjacent to facet joint; bony landmark is critical. Activation: 'Gently contract lower back without movement'. Common errors are wrong landmark identification, excessive pressure, or global back contraction.



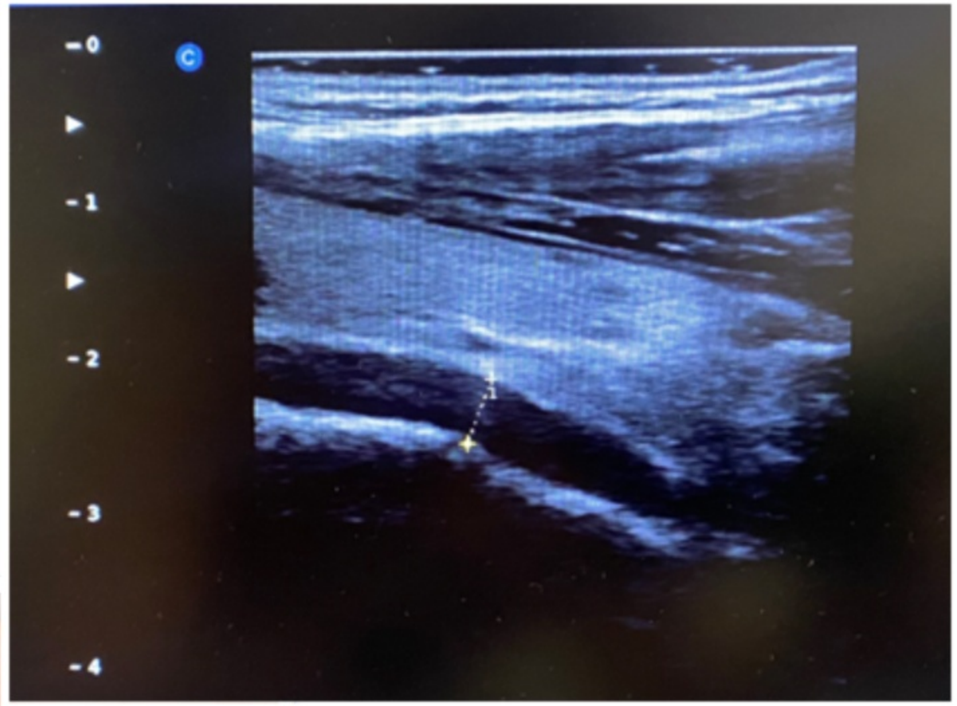
Assessing Serratus Anterior

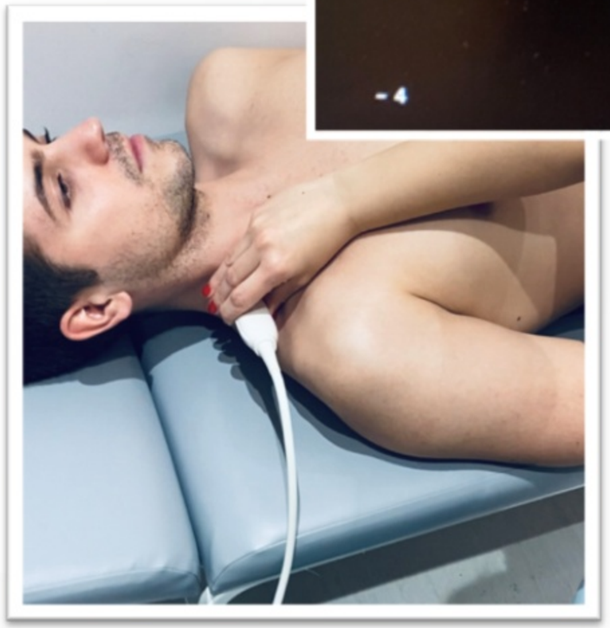


Position: Supine, arm elevated ~60°. Probe Placement: Midaxillary line, at rib level. Activation: Instruct patient to 'Reach forward without elevating shoulder'. Assess for active movement and scapular stabilization, not just muscle thickness. Errors include upper trapezius dominance or a lack of proper scapular motion.

Assessing Longus Colli

Position: Supine, neutral head position. Probe Placement: Lateral to trachea, longitudinal orientation. Activation: Instruct patient to 'Perform gentle nodding motion'. Be mindful of errors like global neck flexion or image distortion from excessive probe pressure.

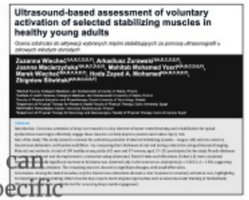




Research: Voluntary Muscle Activation

Can patients voluntarily activate spinal stabilizing muscles?

Question


Ultrasound-based assessment of voluntary activation of selected stabilizing muscles in healthy young adults

Investigate if patients can voluntarily activate specific spinal stabilizing muscles through verbal cueing.

Method

Study with n=109 subjects, comparing muscle thickness at rest vs. during contraction using ultrasound measurement.

Result

Only the Transversus Abdominis (TrA) showed significant activation, while Multifidus, Serratus, and Longus Colli did not.

Interpretation

Verbal cueing alone is often insufficient for eliciting voluntary activation of most deep stabilizing muscles.

Question

Investigate if patients can voluntarily activate specific spinal stabilizing muscles through verbal cueing.

Ultrasound-based assessment of voluntary activation of selected stabilizing muscles in healthy young adults

Ocena zdolności do aktywacji wybranych mięśni stabilizujących za pomocą ultrasonografii u zdrowych młodych dorosłych

Zuzanna Wiecheć[1(A,B,C,D,E,F)], Arkadiusz Żurawski[2(A,B,C,D,E,F)], Joanna Macierzyńska[3(A,B,C,D,E,F)], Mahitab Mohamed Yosri[4(A,B,C,D,E,F)], Marek Wiecheć[5(A,B,C,D,E,F)], Hoda Zayed A. Mohamed[6(A,B,C,D,E,F)], Zbigniew Śliwiński[2(A,B,C,D,E,F)]

[1]Medical Faculty, Collegium Medicum, Jan Kochanowski University of Kielce, Poland
[2]Institute of Health Science, Collegium Medicum, Jan Kochanowski University of Kielce, Poland
[3]Faculty of Physical Education and Physiotherapy, Opole University of Technology, Poland
[4]Department of Physical Therapy for Women's Health Faculty of Physical Therapy, Cairo University, Egypt
[5]MARKMED Rehabilitation Center, Ostrowiec Świetokrzyski, Poland
[6]Department of Physical Therapy for Neurology and Neurosurgery, Faculty of Physical Therapy, Cairo University, Egypt

Abstract

Introduction. Conscious activation of deep core muscles is a key element of motor control training and rehabilitation for spinal dysfunctions. Learning to effectively engage these muscles can help improve posture and reduce injury risk.

Aim of the study. This study aimed to evaluate the activation potential of selected stabilizing muscles – longus colli, serratus anterior, transversus abdominis, and lumbar multifidus – by comparing their thickness at rest and during contraction using ultrasound imaging.

Material and methods. A total of 109 healthy young adults (42 men and 67 women, aged 19–25) participated in the study. Muscle thickness was measured at rest and during isometric contraction using ultrasound. Paired t-tests and effect sizes (Cohen's d) were calculated.

Results. A statistically significant increase in thickness was observed only in the transversus abdominis ($p = 0.0012$; $d = 1.48$), suggesting effective voluntary activation. The remaining muscles showed no significant changes, with small effect sizes.

Conclusions. Among the tested muscles, only the transversus abdominis showed a clear response to voluntary activation cues, highlighting its importance in core training. Other muscles may require more targeted approaches such as neuromuscular training or biofeedback. Ultrasound proved to be a reliable tool for assessing deep muscle engagement.

Method

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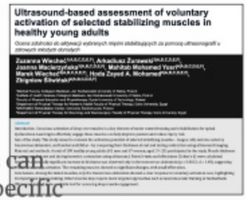
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Research: Ultrasound Reliability

Assessing the consistency of ultrasound measurements

Methodology

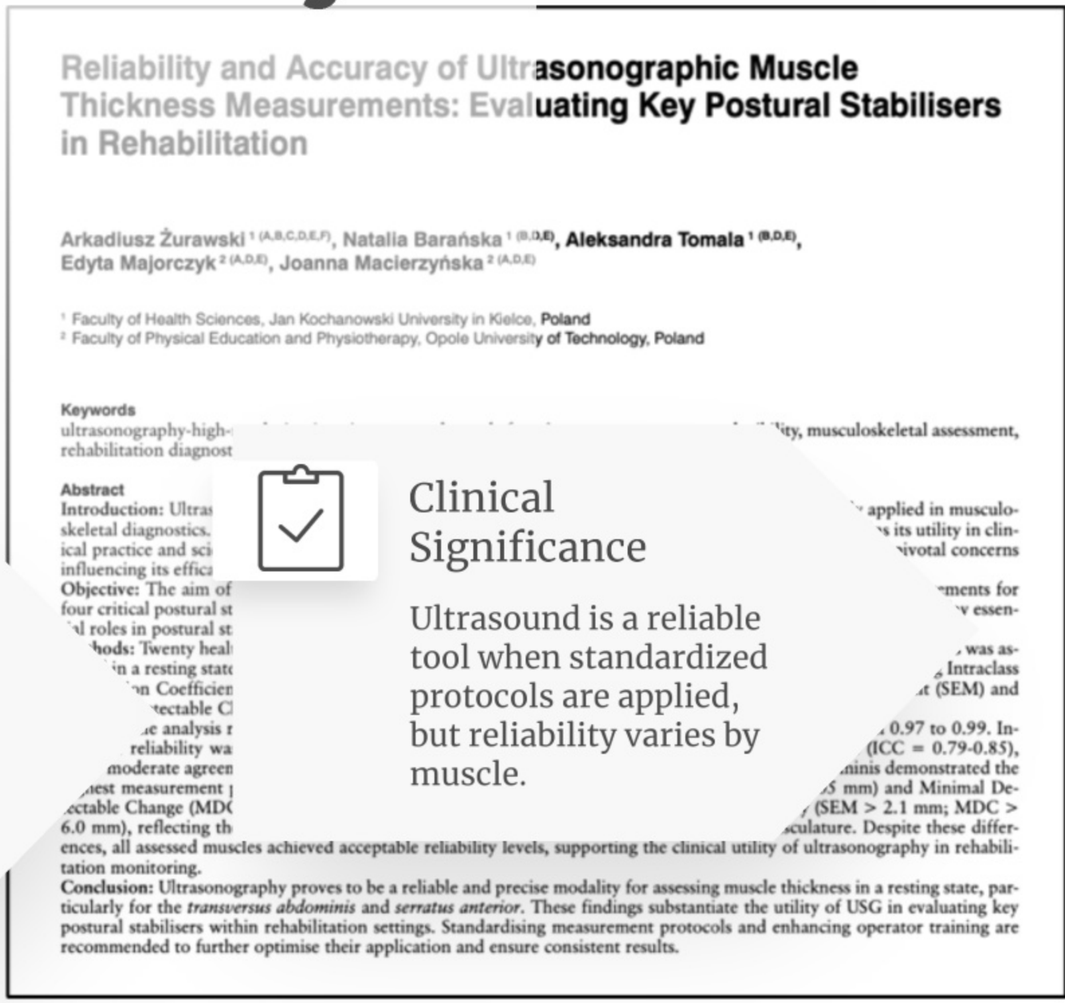
Standardized protocols applied by experienced operators to minimize variability in measurements.

Key Findings

Achieved high intra-rater reliability (ICC 0.97–0.99), though multifidus showed the highest variability.

Clinical Significance

Ultrasound is a reliable tool when standardized protocols are applied, but reliability varies by muscle.



Reliability and Accuracy of Ultrasonographic Muscle Thickness Measurements: Evaluating Key Postural Stabilisers in Rehabilitation

Arkadiusz Żurawski [1 (A,B,C,D,E,F)], Natalia Barańska [1 (B,D,E)], Aleksandra Tomala [1 (B,D,E)], Edyta Majorczyk [2 (A,D,E)], Joanna Macierzyńska [2 (A,D,E)]

[1] Faculty of Health Sciences, Jan Kochanowski University in Kielce, Poland
[2] Faculty of Physical Education and Physiotherapy, Opole University of Technology, Poland

Keywords
ultrasonography-high- ity, musculoskeletal assessment, rehabilitation diagnost

Abstract
Introduction: Ultra applied in musculo- skeletal diagnostics. s its utility in clin- ical practice and sci ivotal concerns influencing its effica
Objective: The aim of ements for four critical postural st v essen- l roles in postural st
hods: Twenty heal was as- in a resting state Intraclass n Coefficien t (SEM) and tectable C e analysis r 0.97 to 0.99. In- reliability wa (ICC = 0.79-0.85), moderate agreen inis demonstrated the est measurement mm) and Minimal De- ectable Change (MDC (SEM > 2.1 mm; MDC > 6.0 mm), reflecting th sculature. Despite these differ- ences, all assessed muscles achieved acceptable reliability levels, supporting the clinical utility of ultrasonography in rehabilitation monitoring.
Conclusion: Ultrasonography proves to be a reliable and precise modality for assessing muscle thickness in a resting state, particularly for the *transversus abdominis* and *serratus anterior*. These findings substantiate the utility of USG in evaluating key postural stabilisers within rehabilitation settings. Standardising measurement protocols and enhancing operator training are recommended to further optimise their application and ensure consistent results.

Methodology

Standardized protocols applied by experienced operators to minimize variability in measurements.

Key Findings

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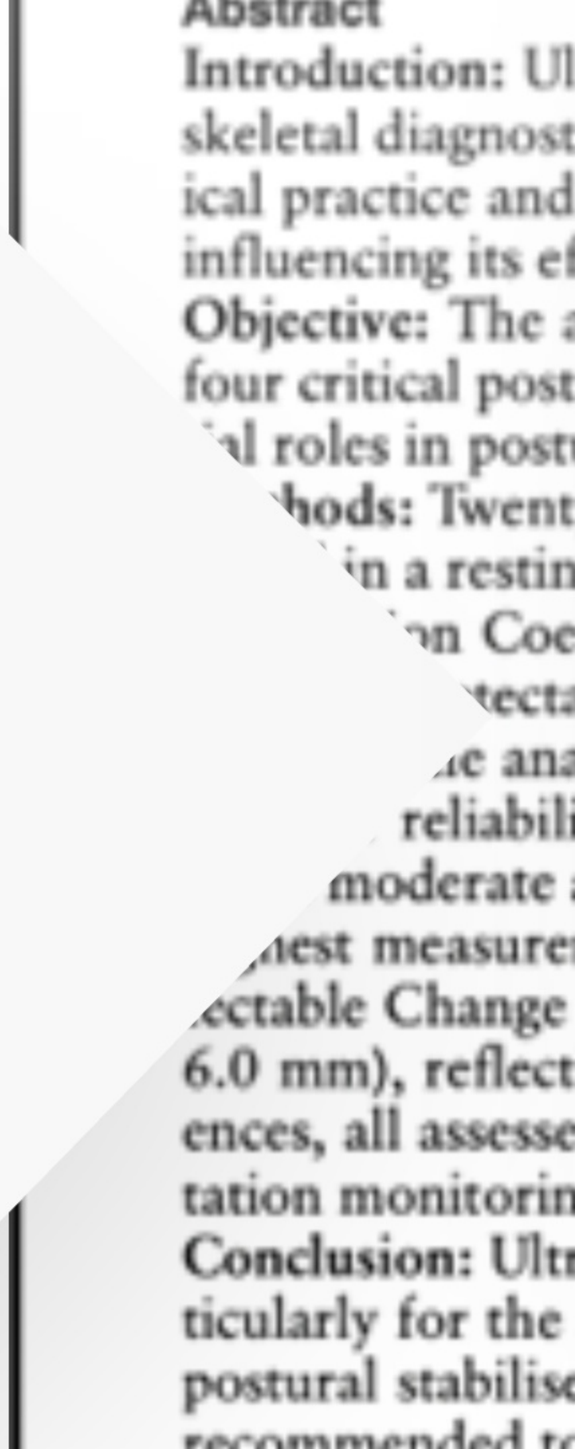

Clinical Significance

Ultrasound is a reliable tool when standardized protocols are applied, but reliability varies by muscle.

How to Apply Ultrasound in Clinic

- Objectively assess muscle activation patterns and recruitment strategies.
- Guide and refine targeted exercise interventions for specific muscles.
- Monitor patient progress and adaptation over time with objective data.

Clinical Ultrasound Checklist

- Select the correct ultrasound probe for the target anatomical area.
- Adjust machine settings for optimal image quality (gain, depth, focus).
- Ensure a stable and clear image before attempting any interpretation.
- Always compare muscle behavior at rest versus during contraction for functional assessment.

Final Message: Verify, Don't Assume

If you do not directly observe muscle activation using ultrasound, it is critical not to assume that it exists. Objective verification is key to effective treatment and rehabilitation.

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