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# The Echogenic Appearance of the Diabetic Deltoid Muscle on Shoulder Ultrasound: Is This Simply from Adipose Tissue Infiltration, Can This Appearance Predict Type 2 Diabetes and Be Used to Detect Pre-Diabetes?

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Muscle on Shoulder Ultrasound:  
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Can This Appearance Predict Type 2 Diabetes and  
Be Used to Detect Pre-Diabetes?**

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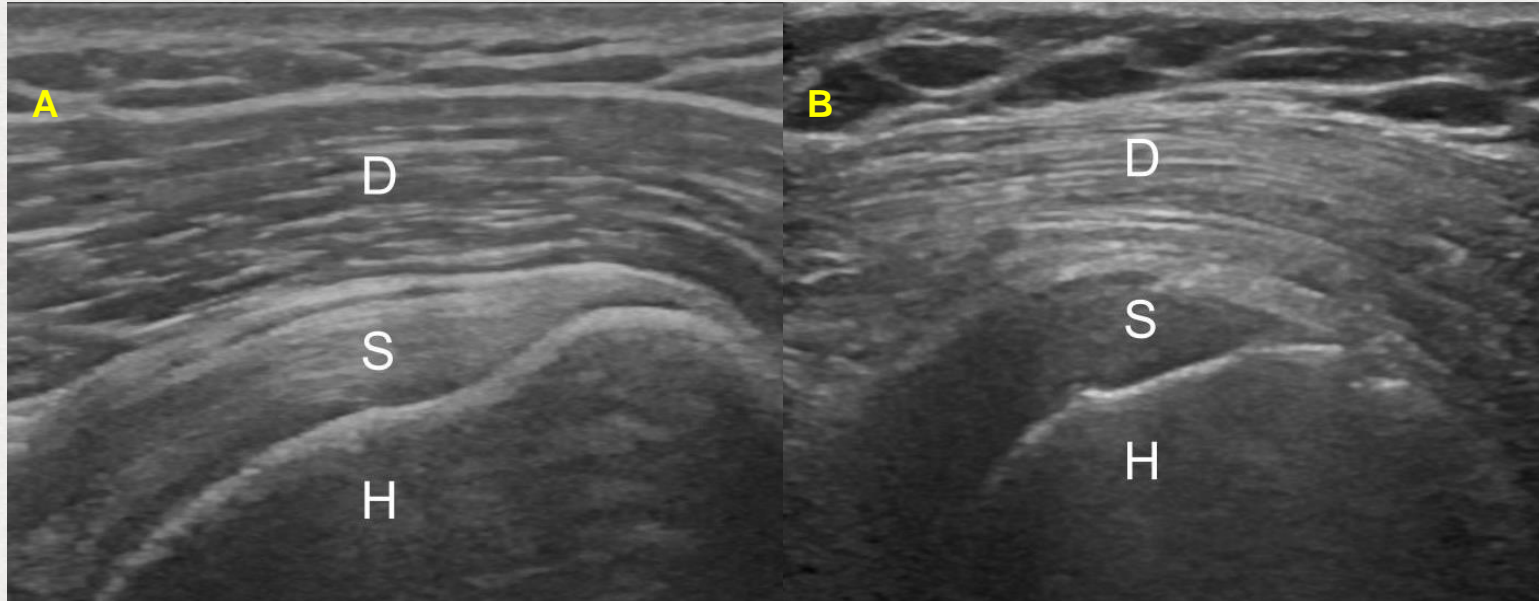


all for you

# Introduction- Ultrasound and Diabetes

- Musculoskeletal ultrasound (MSK US) use has significantly increased over the past two decades<sup>1</sup>
  - Particularly for evaluation of pain and rotator cuff pathology<sup>2,3</sup>
- Lower cost, accessibility, and dynamic capabilities with the opportunity for direct patient care are reasons it has become the modality of choice at multiple institutions
- Approximately 9.4% of the U.S. population and 382 million people globally are affected by diabetes<sup>4</sup>
- Age related rotator cuff degeneration is more common in diabetics<sup>14</sup>

# Reversal of the Deltoid Muscle to Rotator Cuff Tendon Gradient



**Image A :** Normal gradient of the hypoechoic deltoid muscle to the hyperechoic supraspinatus tendon

**Image B:** Reversal of the normal gradient in a type 2 diabetic patient

**Figure 1: US images of the shoulder in the modified long axis**

D - Deltoid, S - Supraspinatus, H - Humerus

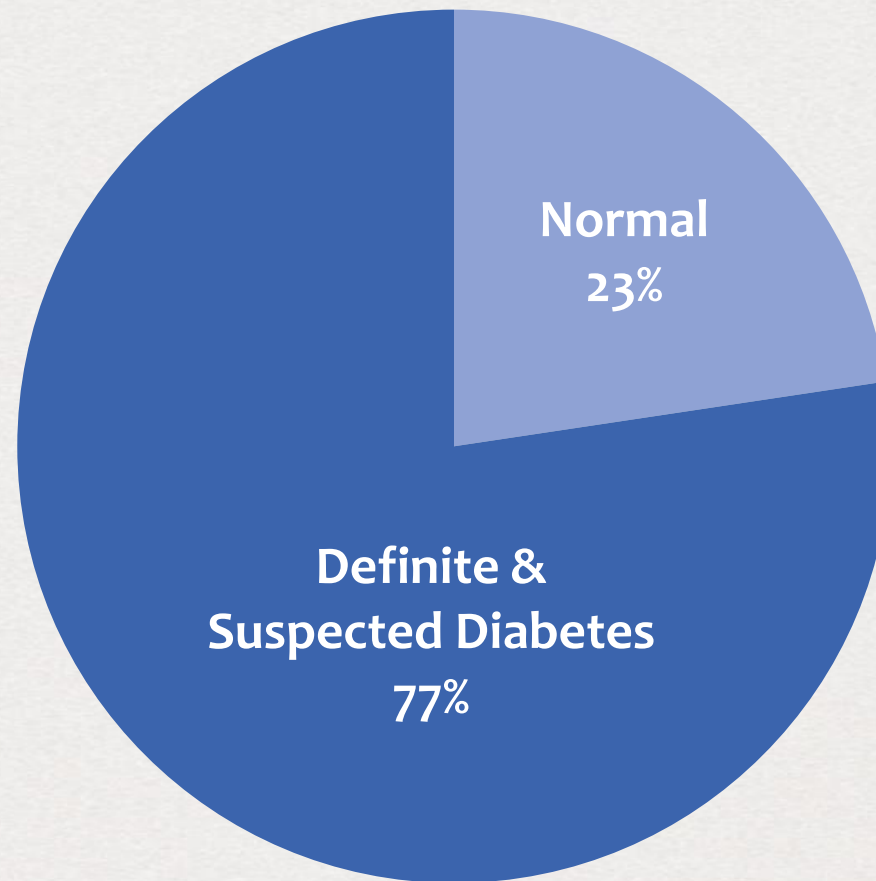
# Methods

- **Subjects:** Retrospective chart review of patients having undergone shoulder ultrasound from 2005-2017
  - 124 type 2 diabetics, 13 pre-diabetics, 49 obese non-diabetics
- **Sonographic Evaluation:** De-identified images of diabetic, pre-diabetic, and obese non-diabetics were randomly ordered by a radiologist not involved in the blinded review.
  - Single short-axis image of the deltoid muscle overlying the anterior proximal humerus at the level of the bicipital groove
- **Blinded Image Review:** IRB approval was obtained
  - Two MSK radiologists blindly reviewed 186 US images of the deltoid muscle and using deltoid muscle echogenicity as criteria, assigned each patient to one of three categories: normal, suspected diabetes, or definite diabetes
  - In the event of a discrepancy, a third MSK radiologist served as arbitrator

# Results- Diabetic Patients

- Consensus diagnosis of ‘definite diabetes’, based on a hyperechoic deltoid muscle on US, proved a **powerful predictor of positive diabetes status**
  - 89% positive predictive value
    - 70 of 79 ‘definite diabetes’ diagnoses accurate
  - 77% sensitivity
    - 106 of 137 diabetics designated ‘suspected’ or ‘definite diabetes’
- A hyperechoic deltoid muscle on US was also a powerful predictor of pre-diabetes
  - 100% sensitivity
    - 13 of 13 pre-diabetics given consensus diagnosis of ‘suspected diabetes’ or ‘definite diabetes’
  - 77% sensitivity
    - 10 of 13 pre-diabetics were given a ‘definite diabetes’ designation

# Figure 5: Diabetes Sensitivity



106 of 137 diabetics designated 'suspected' or 'definite diabetes'

# Results- Obese Non-Diabetic Patients

- MSK radiologists appropriately withheld diagnosis of ‘definite diabetes’ in obese non-diabetic patients
  - 82% specificity
    - 40 of 49 obese non-diabetics accurately characterized as not having ‘definite diabetes’
- BMI cannot solely explain the hyperechoic deltoid muscle on US



# Discussion- Ultrasound to Diagnose Diabetes, Pre-Diabetes?

- First large study demonstrating increased echogenicity of the deltoid muscle as a strong predictor of type 2 diabetes
- With increasing utilization of MSK US, there is new opportunity for detection of undiagnosed type 2 diabetes
  - Nearly one in four diabetic individuals in America are left undiagnosed<sup>4</sup>
  - Anecdotally, at our institution this has resulted in new diagnoses of diabetes
- Study showed that increased echogenicity of the deltoid muscle can be used to detect early insulin resistance or pre-diabetes
  - An estimated 84.1 million American adults are pre-diabetic
    - 90% are completely unaware of their pre-diabetic status<sup>4,10</sup>
  - Earlier identification could help delay or halt progression of disease

# Discussion- Adipose Infiltration, Glycogen Storage

- Studies have shown that diabetic individuals are more likely to be obese, have increased adipose infiltration of muscle, and decreased intramuscular glycogen levels<sup>34</sup>
- Glucose (glycogen) in the liver and muscles is the body's primary source of energy and aids in prevention of hypoglycemia. Insulin regulates glycogen storage and synthesis.
- Muscle is believed to represent the principal site of insulin resistance in type 2 diabetics<sup>32,33</sup>
- Studies have shown that US can be used to detect adipose infiltration and glycogen depletion in muscle<sup>16-18, 23</sup>
- Despite these confounders, our study demonstrates increased echogenicity is more pronounced in type 2 diabetics whether non-obese or obese

# Conclusion

- The hyperechoic US appearance of the deltoid muscle is a strong predictor of type 2 diabetes and early insulin resistance (pre-diabetes)
- Limitations include reliance on subjective determination of deltoid muscle echogenicity
  - A fact mitigated by the use of three MSK radiologists
- Decreased intramuscular glycogen due to insulin resistance is the likely cause of the hyperechoic appearance of the deltoid muscle
- Additional questions arise regarding appropriate time to initiate treatment for pre-diabetes in the presence of this sub-clinical finding