# Beyond strength: integrating muscular quality, hemodynamics and force assessments in osteoarthritis

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## Summary

Our results suggest that muscle quality, torque, and muscle resaturation rate may play an important role in determining disease severity, functional capacity, and exercise tolerance in women with osteoarthritis (OA).

## Introduction

Skeletal muscle plays a complex role in health and disease and is increasingly recognized as a key factor in OA progression. However, research has primarily focused on mechanical aspects, with limited attention to the integration of muscle morphology and physiology. Previous studies have reported muscle composition changes with OA [1,2], but their impact on muscle hemodynamics and force production remains unclear. This study was aimed at investigating muscle quality, defined by muscle fibrosis and fat infiltration, measured via ultrasound, and its relationship with muscle resaturation rate and torque production. We also assessed if adding muscle quality and resaturation rate to a torque-based stepwise regression model improves predictions of OA severity, functional capacity, and exercise tolerance.

## Methods

We analyzed a convenience sample of 30 women with knee OA (Kellgren Lawrencegrade II-IV). Inclusion criteria: females, 50-75 years old. Ultrasound (LOGIC S7 Expert, GE, USA) was used to measure muscle quality, thickness, and subcutaneous fat. Echointensity was calculated with ImageJ and adjusted for fat interference [3]. Muscle oxygen saturation ($SmO_2$) was measured using NIRS (PortaLite, Artinis) during post-occlusion recovery. The gastrocnemius medialis was evaluated due to technical limitations associated with the thick subcutaneous fat in the thigh region. Knee extensor torque was measured using a Biodex device. Clinical severity was assessed with WOMAC, functional performance with the 30CST, and exercise tolerance with the PRETIE-Q. A hierarchical regression analysis was conducted, with age and waist circumference included as covariates to adjust the model. Entry/removal criteria were 0.05/ 0.20, respectively.

## Results and Discussion

Muscle quality from the tibialis anterior muscle had the strongest correlation with OA severity, possibly due to small variation in muscle architecture and its involvement in gait mechanics (Table 1). Adding vastus lateralis did not improve model performance. Muscle quality impairments extended to distal muscles, such as the biceps brachialis. We observed a negative correlation between gastrocnemius medialis echointensity and $SmO_2$ rate (r=-0.384, p=0.044), suggesting that greater fat infiltration and fibrosis are associated with slower muscle resaturation. Muscle quality was associated with knee extensor torque but not with specific torque. Including muscle quality and $SmO_2$ rate as predictors in the torque-based model improved its capacity to predict OA severity, functional capacity, and exercise tolerance, even after adjusting for age and BMI (Table 2).

**Table 1:** Ultrasound echointensity (EI) and muscle quality correlations with osteoarthritis (OA) severity WOMAC.

| Muscles | Mean EI | WOMAC |
|---|---|---|
| **Gastroc. medialis** | 179±19 | r= 0.25 |
| **Tibialis Anterior** | 163±22 | **r= 0.58*** |
| **Biceps femoris** | 155±18 | r= 0.16 |
| **Vastus lateralis** | 170±26 | **r= 0.41*** |
| **Biceps brachialis** | 151±15 | r= 0.22 |

**Table 2:** Predictive capacity ($R^2$) of regression models for clinically relevant OA outcomes using hierarchical analysis. *Predictors retained after adjusting models for age and waist circumference; (-) indicates exclusions after adjustments.

| Stepwise model for: | OA severity | Functional capacity | Exercise tolerance |
|---|---|---|---|
| INPUT VARIABLES | -TORQUE | ***TORQUE** | TORQUE |
| | RATE $SmO_2$ | ***RATE $SmO_2$** | ***RATE $SmO_2$** |
| | ***Muscle quality** | Muscle quality | Muscle quality |
| | Age | Age | Age |
| | ***Waist Circ.** | Waist Circ. | Waist Circ. |
| **$R^2$** | 0.49 | 0.53 | 0.20 |

## Conclusions

The tibialis anterior muscle's quality is a stronger predictor of OA severity than knee extensor torque, suggesting its potential as a diagnostic or screening marker. A slower rate of muscle oxygen resaturation is associated with poor muscle quality and with reduced exercise tolerance in women with OA. Functional capacity is determined by both mechanical and hemodynamic muscle factors, which should be considered in OA management. These associations persist even after adjusting for age and obesity/metabolic risk, suggesting broader applicability across populations

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## References

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