THE EFFECT OF TYPE II DIABETES MELLITUS ON BONE STRENGTH

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INTRODUCTION TO DIABETES MELLITUS

- **Diabetes mellitus** is characterized by insulin deficiencies which affect glucose metabolism.
- **Uncontrolled**, this disease can lead to many health issues.
- **There are multiple types of diabetes mellitus**
  - **Type I**
  - **Type II**

U.S. National Library of Medicine, 2019
INTRODUCTION TO BONE

- **Bone composition:**
  - Mineral
  - Collagen fibers
- **Bone is classified into 2 types:**
  - Trabecular
  - Cortical
- **Bone strength is determined by:**
  - Micro Architectural Properties
  - Quality of Tissue
  - Size

Willems et al, 2013
MOTIVATION FOR STUDY

• Over half a billion of the global population is diagnosed with type 2 diabetes mellitus

• Increased fracture rates and risk for osteoporosis
  • Bone mineral density (BMD)
QUASISTATIC MECHANICAL TEST (QMT)

- GOLD STANDARD METHOD FOR MEASURING BONE STRENGTH AND STIFFNESS
- EX VIVO
- FLEXURAL RIGIDITY \( (EI) = K_B \frac{L^3}{48} \)
CORTICAL BONES MECHANICS TECHNOLOGY (CBMT)

- Non-invasive method used on cortical bone in vivo to measure the mechanical properties
- 3-point bending test
GOAL OF THIS STUDY

• TO COMPARE THE EFFECTS OF ULNA INTEROSSEOUS DIAMETER (IOD), BODY MASS INDEX (BMI) AND AGE ON BONE STRENGTH, FLEXURAL RIGIDITY, BONE STIFFNESS, AND BONE DAMPING BETWEEN DIABETIC AND NON-DIABETIC MALE CADAVERIC HUMAN ARMS
METHODS


2. Measure IOD of ulnas

3. Pair male diabetic cadaveric arm with non-diabetic male cadaveric arm based on IOD, BMI, and age

4. Perform regressive analysis to determine influence of IOD, BMI, and age on peak moment ($M_{PEAK}$), flexural rigidity from QMT ($EI_{QMT}$), flexural rigidity from CBMT ($EI_{CBMT}$), bone stiffness ($K_B$), and bone damping ($B_B$)
RESULTS - INFLUENCE OF IOD

**M_{peak} vs IOD**

- **Non-Diabetic**
  - $y = 11x - 140$
  - $R^2 = 0.85$
  - SEE = 5.30 Nm

- **Diabetic**
  - $y = 3.3x$
  - $R^2 = 0.95$
  - SEE = 14.8 Nm

**EI_{CBMT} vs IOD**

- **Non-Diabetic**
  - $y = 2.7x$
  - $R^2 = 0.95$
  - SEE = 11.6 Nm$^2$

- **Diabetic**
  - $y = 2.4x$
  - $R^2 = 0.93$
  - SEE = 12.6 Nm$^2$
RESULTS - INFLUENCE OF IOD

**K₀ vs IOD**
- Non-Diabetic: $y = 27x + 380$
- Diabetic: $y = 5.5x$
- SEE = 14.39 N/mm

**$E_I$ vs IOD**
- Non-Diabetic: $y = 13x - 190$
- Diabetic: $y = 2.5x$
- SEE = 8.22 Nm²

**B₀ vs IOD**
- Non-Diabetic: $y = -10x + 230$
- Diabetic: $y = 1.6x$
- SEE = 11 N/(m/s)
RESULTS - INFLUENCE OF BMI

**M\text{peak} vs BMI**

- **Non-Diabetic**
  - $y = 2.1x$
  - $R^2 = 0.95$
  - SEE = 15.8 Nm

- **Diabetic**
  - $y = 2.0x$
  - $R^2 = 0.94$
  - SEE = 16.3 Nm

**EI\text{CBMT} vs BMI**

- **Non-Diabetic**
  - $y = 1.5x$
  - $R^2 = 0.95$
  - SEE = 11.4 Nm²

- **Diabetic**
  - $y = 1.4x$
  - $R^2 = 0.91$
  - SEE = 14.9 Nm²
RESULTS - INFLUENCE OF BMI

**ElQMT vs BMI**
- **Non-Diabetic**
  - $y = 1.6x$
  - $R^2 = 0.93$
  - SEE $= 14.7 \text{ Nm}^2$
- **Diabetic**
  - $y = -0.2x + 50$
  - $R^2 = 0.01$
  - SEE $= 10.7 \text{ Nm}^2$

**K₀ vs BMI**
- **Non-Diabetic**
  - $y = 3.5x$
  - $R^2 = 0.91$
  - SEE $= 34.6 \text{ N/mm}$
- **Diabetic**
  - $y = 3.3x$
  - $R^2 = 0.94$
  - SEE $= 27.5 \text{ N/mm}$

**B₀ vs BMI**
- **Non-Diabetic Comparison**
  - $y = 1.4x$
  - $R^2 = 0.79$
  - SEE $= 23 \text{ N/(m/s)}$
- **Diabetic**
  - $y = 1.0x$
  - $R^2 = 0.85$
  - SEE $= 13 \text{ N/(m/s)}$
RESULTS - INFLUENCE OF AGE

**M_{peak} vs Age**

- **Non-Diabetic**
  - $y = -0.4x + 90$
  - $R^2 = 0.08$
  - SEE = 20.2 Nm

- **Diabetic**
  - $y = -0.2x + 70$
  - $R^2 = 0.03$
  - SEE = 15.4 Nm

**E_{CBMT} vs Age**

- **Non-Diabetic**
  - $y = 0.70x$
  - $R^2 = 0.88$
  - SEE = 19.7 Nm$^2$

- **Diabetic**
  - $y = 0.59x$
  - $R^2 = 0.90$
  - SEE = 15.0 Nm$^2$
**RESULTS - INFLUENCE OF AGE**

- **$K_b$ vs Age**
  - **Diabetic**: $y = 1.4x$, $R^2 = 0.92$, SEE = 47.4 N/mm
  - **Non-Diabetic**: $y = 1.5x$, $R^2 = 0.85$, SEE = 31.9 N/mm

- **$E_{GMT}$ vs Age**
  - **Non-Diabetic**: $y = 0.7x$, $R^2 = 0.86$, SEE = 22.5 Nm²

- **$B_o$ vs Age**
  - **Diabetic**: $y = 0.63x$, $R^2 = 0.93$, SEE = 13.3 Nm²
  - **Non-Diabetic Comparison**: $y = 0.60x$, $R^2 = 0.73$, SEE = 28 N/(m/s)
SIGNIFICANCE

• DIABETES DOES HAVE A REDUCING EFFECT ON THE INFLUENCE OF IOD ON $M_{\text{PEAK}}$ OR BONE STRENGTH, $E_{I\text{QMT}}$, $K_B$ AND $B_B$. IOD IS AN ASPECT OF BONE GEOMETRY UNLIKE BMI OR AGE. THIS MEANS THAT THE ABILITY OF BONE GEOMETRY TO PREDICT $M_{\text{PEAK}}$ IS LOST IN DIABETES.

• WITH BMI, NO EFFECT OF DIABETES WAS OBSERVED EXCEPT THAT DIABETES REDUCED THE INFLUENCE OF BMI ON $E_{I\text{QMT}}$ AND $B_B$.

• AGE WAS A VERY WEAK PREDICTOR OF ULNA STRENGTH, ALONG WITH HIGH SEES, BECAUSE OF THE MANY DIFFERENT SIZES AND BODY TYPES ASSOCIATED WITH EVERY AGE. DIABETES HAD A REDUCING EFFECT ON THE INFLUENCE OF AGE ON $B_B$. 
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REFERENCES


