QCT for Biomechanical Scaling

Rhylee DeCrane[1], Cameron R. 'Dale' Bass, PhD[1], Maria Ortiz-Paparoni[1], Jason Kait[1], Hattie Cutcliffe, PhD[1]

[1]Injury Biomechanics Laboratory, Department of Biomedical Engineering, Duke University, Durham, N.C.

Introduction

- Over human life span, Bone Mineral Density decreases
- This decrease leads to changes in different stress failures of different bone structures over time
- These changes need to be calculated and biomechanically scaled for cadaver testing
- Most cadavers' ages skew older than the average population
- QCT is used to create a BMD scaling factor that can also be used for yield stress failure at a later point
- This BMD scaling factor can be used Injury Risk Assessments for bone fractures for various ages that can also be translated to other age groups

Methods

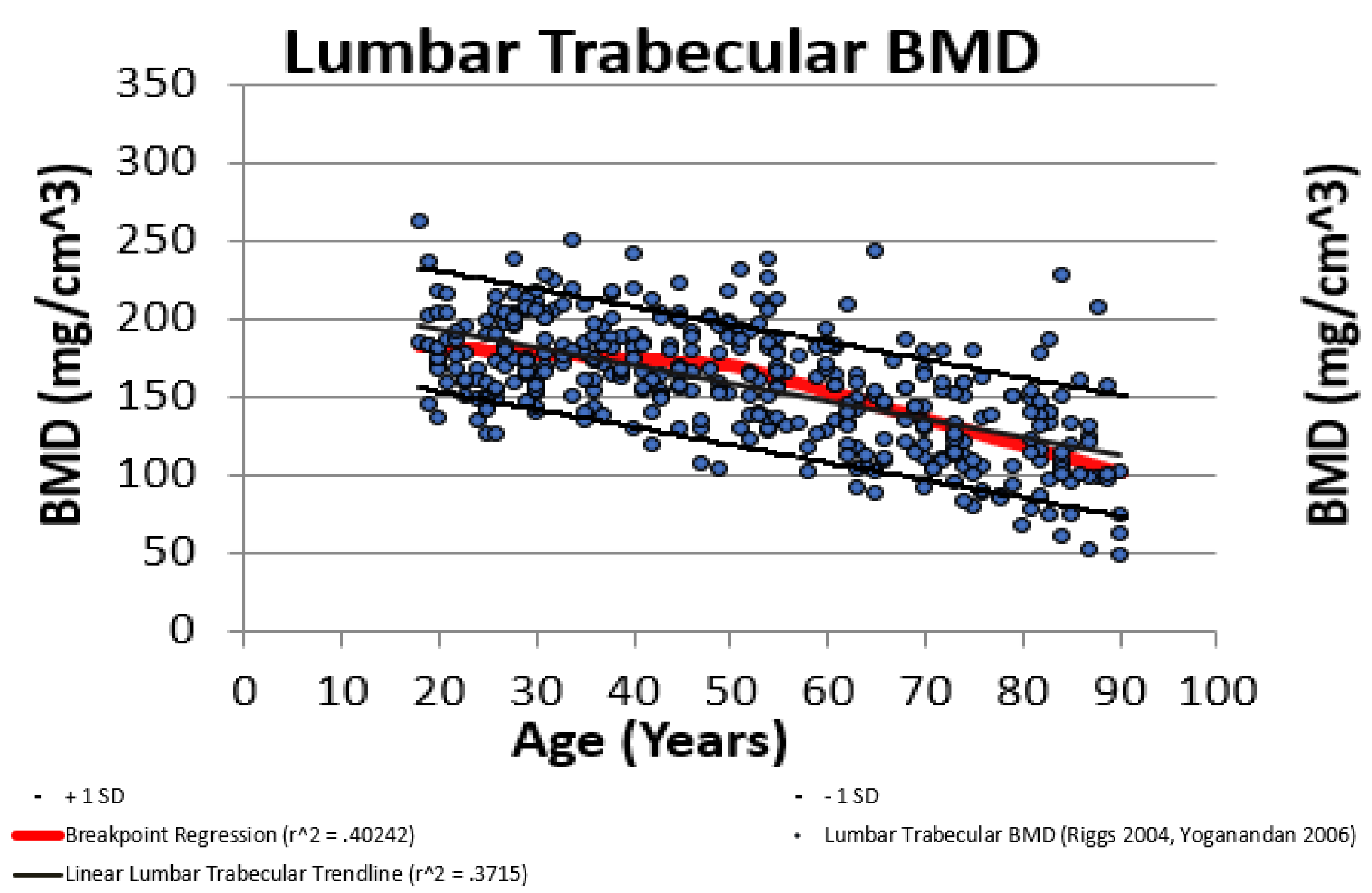
Data Collection:

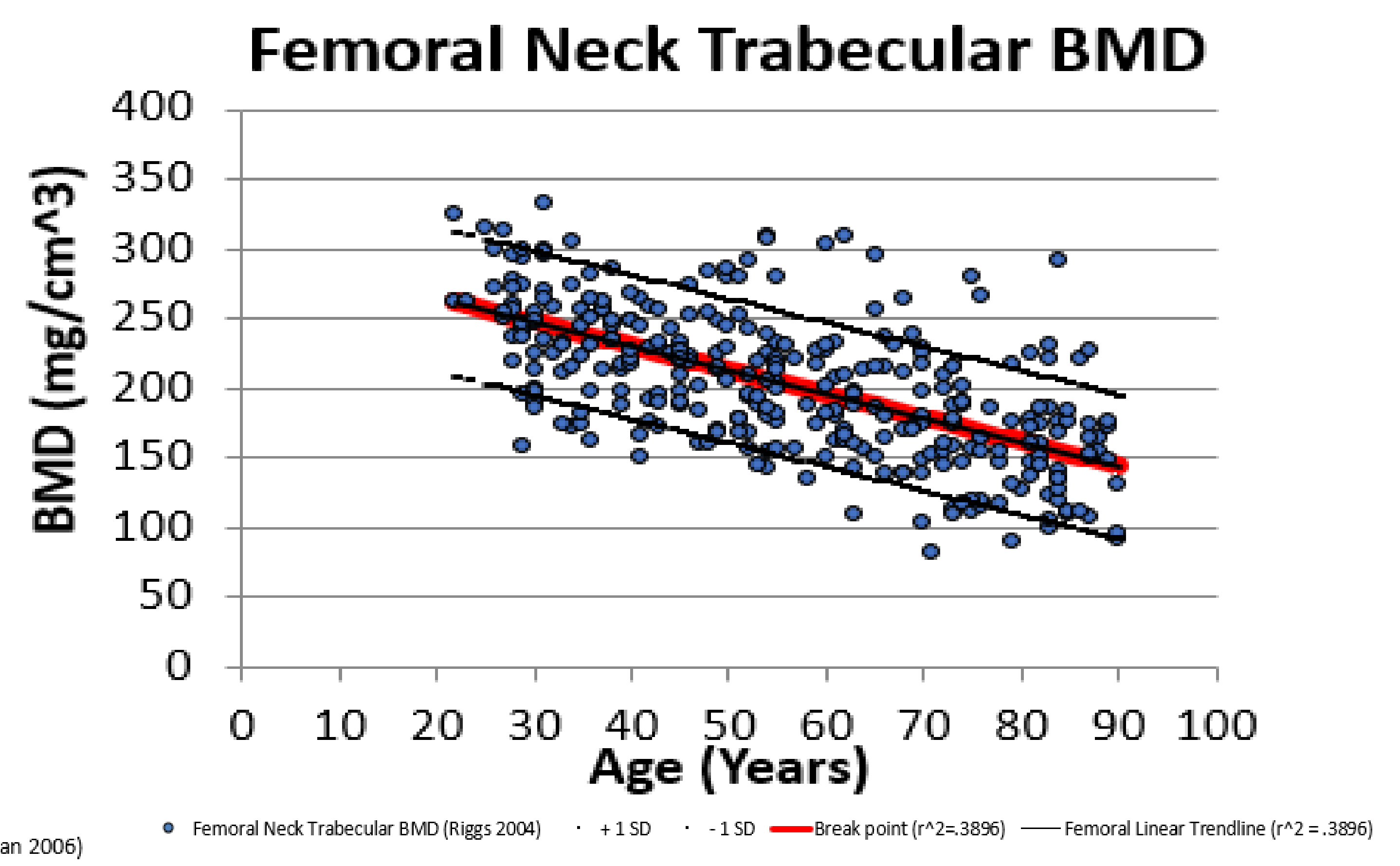
- Male lumbar BMD data from various age ranges was collected from Yoganandan 2006, Riggs 2004 and Bouxsein 2006
- Male femoral BMD data from various age ranges was collected from Riggs 2004
- These QCT scans were compared with calibration scans that used phantoms of different densities varying from trabecular densities to cortical densities

Statistical Analysis

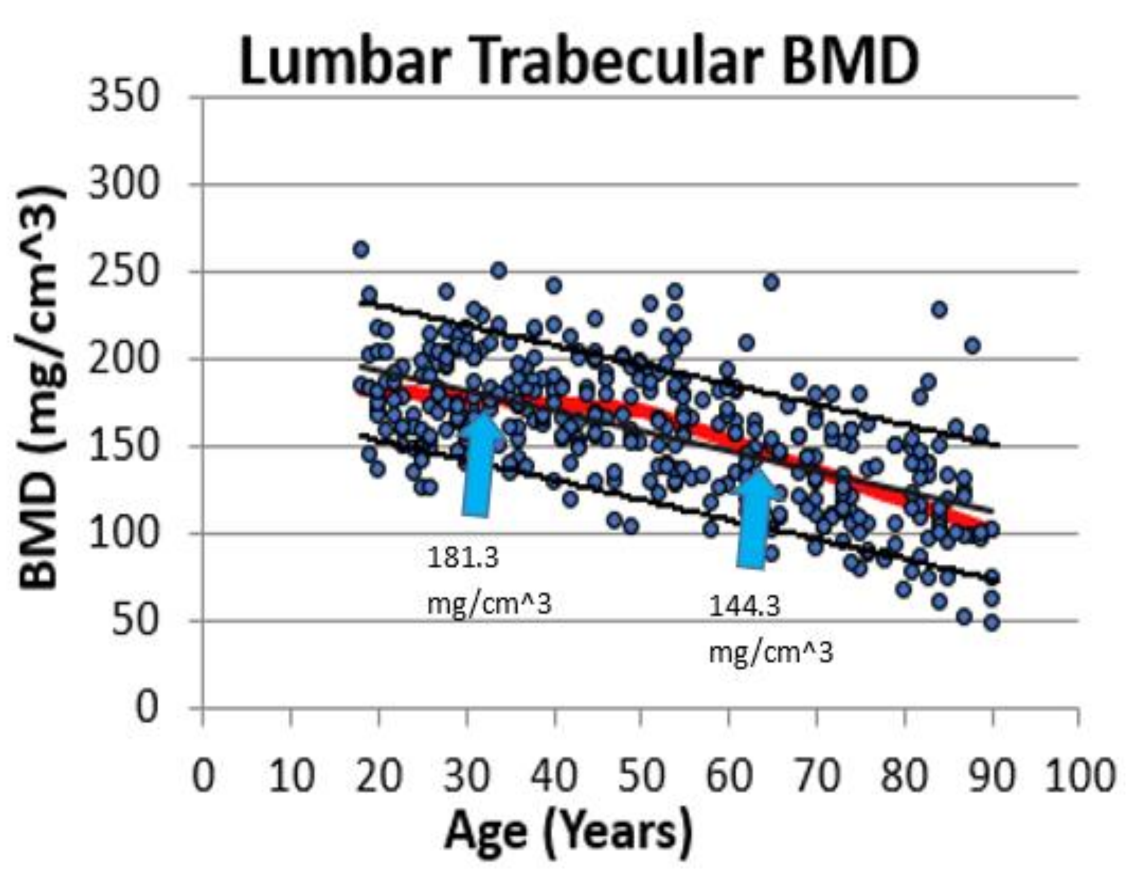
- Initially, a linear fit was found for the BMD data with each corresponding R^2, SSE, and SSR
- Next a breakpoint regression fit was found using optimization of the SSE of a line with one break
- R^2 and SSR were then also found
- Comparison of the two lines were made graphically and the results were recorded
- The statistical analysis was used for biomechanical analysis to allow translation from cadaveric populations to other human male age groups

Results

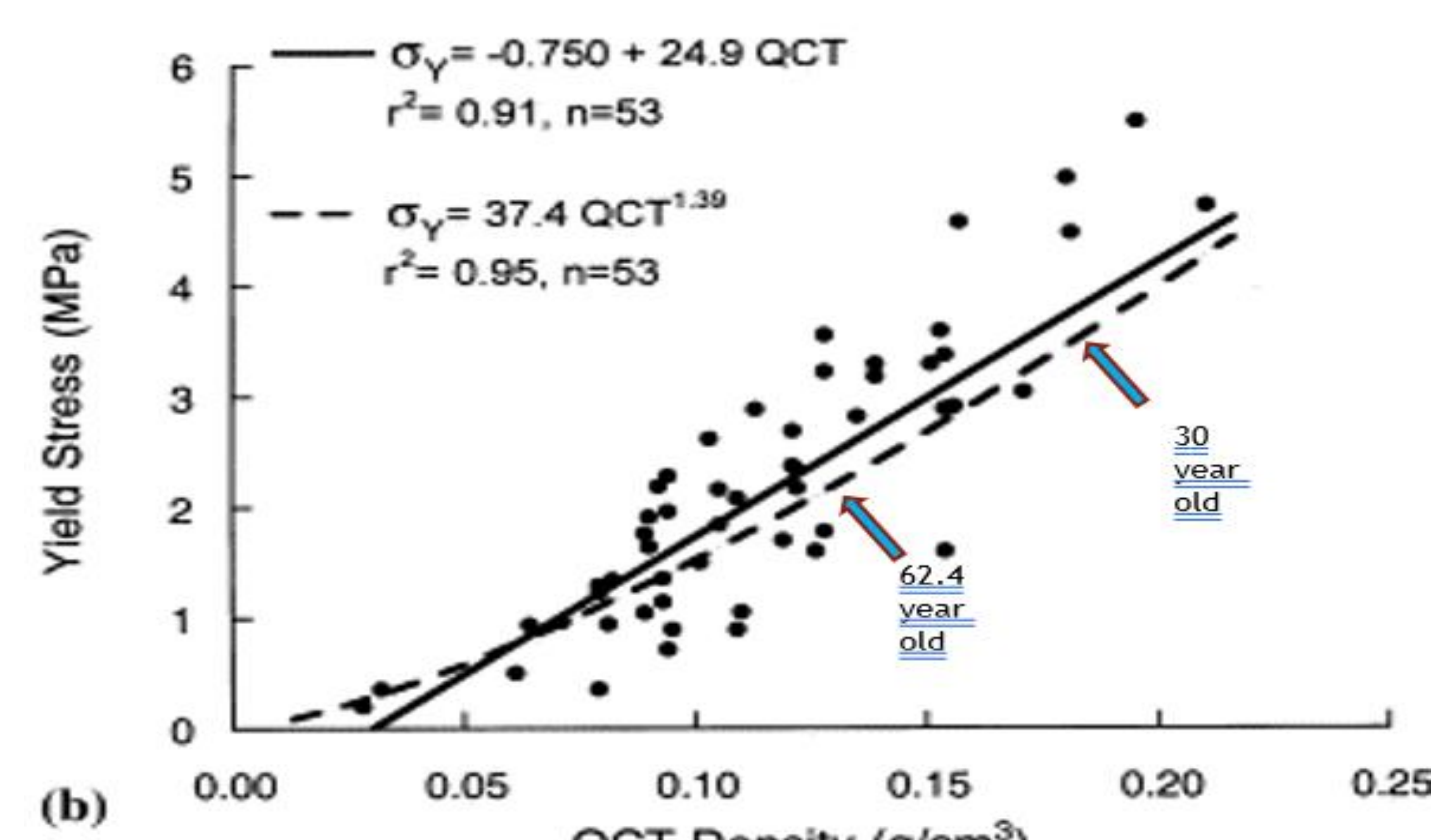




Biomechanical Bone Scaling



- Taking the lumbar trabecular breakpoint we found above, we can now biomechanically scale a cadaver specimen. We first find a 62.4 year old's BMD and scale it to estimate what his BMD would have been at 30 years old. Using this data and data that would be found during yield stress failure tests, we can estimate what the yield failure had been for this specimen at 30 years old.



Kopperdahl, et al., 2002

- Yield stress = 37.4 $QCT^{1.39}$
- Yield stress ratio = Reference/Actual
- $= (QCT_{ref} / QCT_{act})^{1.39}$
- $= (181.3/144.3)^{1.39}$
- = 1.37
- *This allows us to multiply the 62.4 year old's yield stress failure by 1.37*
- *to estimate what his yield stress failure would have been at 30 years of age*

Discussion and Conclusion

Discussion

- As seen, male lumbar BMD has a higher correlation to a break point regression that has a slow decline at younger ages but around 35-50 years old has a steeper decline
- This is not seen in the male femoral BMD data which has its highest correlation with a linear fit
- Taking this into consideration, these two bones will have different risk functions considering age
- These results suggest that other bone structures need to also have their own biomechanical scaling done to find their own risk functions
- Cadaver populations are often biased from their population age demographics by selection of the strongest ones based on cause of death and BMD

Conclusion

- Overall, the population-based scaling/normalization between age and BMD developed in this study is useful for the development of biomechanical risk functions that are appropriate to different populations
- This scaling, when augmented by individual specimen biomechanical scaling, provides better understanding of the age and condition related strength for injury risk assessment of bone failure
- Knowing the scaling between populations, we are better able to scale cadaver data between ages or between demographics with differing bony strengths, which will allow us to better the results from testing our often elderly cadavers

References

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