Musculoskeletal Manifestations of Diabetes Mellitus in the William M. Bass Donated Skeletal Collection

Introduction
Diabetes mellitus is a complicated disease and is divided into two types – Type 1 and Type 2. Type 2 diabetes (T2D) occurs most often, around 95% of all diabetes. Type 2 diabetes produce insulin but may not produce enough or their insulin receptors are deficient. They normally develop the disease after the age of 30, usually after 55. Because the development of T2D is a slow process, symptoms may not appear for many years after onset (Stalmather 1994). Any pathological findings for diabetes are not directly caused by diabetes, but are associated with the duration of diabetes, and are the result of chronic hyperglycemia. Figure 1 shows the process of diabetes leads to MSDs. Although AGEs accumulate in various tissues during normal aging, hyperglycemia accelerates the rate of AGE formation (Arkikla and Gautier 2003; Salo and Marklund 2005; Yamaguchi and Sugimoto 2011). The MSDs researched here are seen in Table 1 and Figures 2-12. This study builds on previous research using the Hamann-Todd and Terry Human Osteological Collections (Upson-Taboas n.d.) and has two objectives:

1. To conduct a further examination of skeletal material of known diabetic individuals to determine if the MSDs studied previously demonstrate similar associations with age, sex, diabetes, and each other.
2. To determine the best predictors for diabetes in the William M. Bass Donated Skeletal Collection.

Research Questions and Hypotheses
Research Question 1: Can the MSDs seen before also be seen in this collection?
Hypothesis 1: I hypothesize that the same MSDs can be seen in this collection.

Research Question 2: Will the predictors for the diabetes from Hamann-Todd and Terry collections be the same for the Bass collection?
Hypothesis 2: I hypothesize that the predictors will be the same – DISH, PN, and FRS, but may also include EXO.

Methods

• Comparative study of known diabetics and age/sex/race matched controls
• William M. Bass Donated Skeletal Collection (n=33, respectively)
• Cause of death in controls could not be directly related to diabetes, such as nephritis, heart disease, arteriosclerosis, myocarditis, or hypertension.
• All MSDs except FRs were scored as
  "0" = not present at all
  "1" = questionable present
  "2" = most likely present
  "3" = definitely present
FRs were scored for the total number of fractures found.
• Student’s two-way t-tests used to analyze average scores between diabetics and controls. Spearmann’s rank correlation used to analyze correlations between age, sex, and each of the MSDs. Multinomial logistic regression was used to determine the best predictors of diabetes.

Results

• The total average scores of diabetes-related MSDs were statistically more than in controls (P<0.001). Diabetics averaged higher scores for PD (P<0.007), LJM (P<0.0033), DISH (P<0.003), LEA (P<0.008), OA (P<0.001), and EXO (P<0.012).
• Spearmann’s rank correlation are shown in Table 2. No single MSD was related to age alone. HFI was related to sex alone, and FRS was related to diabetes alone.

Discussion
RQ1/H1: Supported – The MSDs seen in previous collections were also seen in this collection. It was the least observed MSD: G, AC, LJM, FT, and CTS were almost at the same rate and functionally present. At this point, AC could be better defined as arthritis specific to the shoulder joint and CTS for the wrist. LJM, FT, and G may not occur as often with diabetes as it is reported in the literature. Each MSD needs to be better defined before a more detailed analysis can be performed.

RQ2/H2: Not supported – The predictors for this collection were not the same as for the Hamann-Todd/Terry (HT/T) combined collections. PN was included in this model, but FRs and EXO were not, and DISH could be considered, but was also not included in the model. OA and CTS were included in this model, but were not in the previous model.

Conclusions and Future Directions
This study builds on Shannon May’s demonstration that no single variable can be used to predict diabetes mellitus in the William M. Bass Donated Skeletal Collection (2014). The predictive model established in this study could be applied to forensic, historical, and archaeological skeletal remains to evaluate the presence of diabetes mellitus. A more in-depth study would include more scoring for severity and variables for medical treatment, diet, activity levels, and social status.

Acknowledgments
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Sources Cited

Dr. Dawnie Steadman, the Director of the Forensic Anthropology Center at the University of Tennessee, Knoxville.

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Table 1: MSDs associated with diabetes mellitus

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<th>PD</th>
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Table 2: Spearmann’s rank correlation. Bold indicates PD/OA, Table 1D, * = strong correlation, ° = moderate correlation.