Biological Health as a Possible Factor in the Estimation of Biological Parameters from the Human Skeleton

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Introduction

Forensic anthropology, and the broader discipline of biological anthropology, have traditionally focused on developing and testing methods for estimating biological parameters from unknown human skeletal remains. Less attention has been given to understanding the underlying factors influencing the biological processes and associated variation assessed by these methods. During life, the skeleton is not only a structural tissue but a living organ that functions as part of the endocrine system. As such, anthropologists must consider lifehistory of the individual including diet, activity, drug use, and overall health when analyzing skeletal morphologies. Here, we present the concept of biological health, or biological health status, as a factor to be considered in regard to both the estimation of the biological profile, as well as forensic anthropological analyses in general. We argue this is an important concept because it is directly tied to the lifehistory of the individual and can be reflected in various ways via the human skeleton. For example, osteitis pubis affects the pubic symphysis, often resulting from trauma to the area; a pathological process which is more commonly found in young athletes and may have an effect on pubic symphysis aging (e.g., Major and Helms 1997). Additionally, the effects of smoking have been noted in regard to an associated increased risk of developing osteoporosis and slowing the remodeling process during fracture healing (Patel et al. 2013), and drugs of abuse such as heroin have been associated with septic arthritis at the sternoclavicular joint (Barghi and Mirakbari 2010).

This presentation aims to review the medical and pharmaceutical literature on a number of drugs to explore which ones have the potential to affect bone, and in what way. Our goal is to develop a more holistic approach to examining human skeletal biology and biological morphologies by emphasizing how, as forensic anthropologists, we need to be aware of the influence of individual lifehistories and how they can impact our assessments from the human skeleton.

Materials and Methods

Here we focused primarily on the skeletal impacts of insults to biological health status, specifically in regard to drug use, and their potential to influence the estimation of age-at-death (including subadult age, via stature/bodysize) as well as expression of secondary sexual traits. In this first step to consider drugs that influence the skeleton, databases such as ScienceDirect, WileyOnline and Scopus were used to generate potential articles for review by using keywords such as: drug-induced, drug abuse, recreational drugs effects on bone, etc. With the use of journals such as Forensic Science International, Drug and Alcohol Dependence, Arthritis and Rheumatism, Journal of Clinical Neuroscience, and various other journals in pharmacology, as well medical volumes on topics such as the chemical basis of metabolism and bone resorption. Over 50 drugs were reviewed.

Results

From a search of over 50 drugs, it was found that anti-epileptic drugs, methamphetamine, cortisteroids, glucocorticoids, heroin, methadone, anti-depressants, anti-psychotic agents and others have been found to effect the human skeleton. These findings were compiled into a descriptive table, presenting an overview of the possible effects of drugs on human skeletal biology (Table 1).

Overall, multiple drugs have the potential to affect biological processes associated with the development of secondary sexual characteristics, skeletal morphologies associated with the estimation of age at death, and the general morbidity and frailty of individuals, which could have significant affects not just age at death, but overall mortality distributions. For example, numerous drugs including Thiazolidinedione affect metabolism; different changes to metabolism could result in osteoporosis or osteosclerosis, which in turn could have an impact on age at death estimates, likely resulting in overaging of an individual. Further, drug induced osteopenia and osteoporosis were evident in a large quantity of the drugs reviewed for this study, suggesting that the presence of osteoporosis, which is considered to reflect an older aged individual, may actually be more correlated to a certain medication or drug of abuse in modern populations. Finally, various drugs (e.g., heroin) were also associated with decreasing muscle mass and general wastage, which could affect the size and robusticity of skeletal remains and associated parameter estimates. Figure 1 provides a preliminary summary of the areas of the skeleton affected by the different drugs and in which way they may be affected.

Discussion/Conclusions

The human skeleton must be considered not simply the remains of a decedent, but also as preserved tissues which reflect complex in vivo interactions unique to the lifehistory of the individual. Previous authors have attempted to examine the macroscopic affects of drugs and alcohol on the human skeleton with mixed results (Passalacqua 2014 and references therein). Our survey of the clinical literature found numerous references to pathological skeletal changes associated or directly caused by drug use or abuse; however as a discipline, we have yet to fully examine the potential effects of drug use on large skeletal samples.

While we are not arguing that biological health should be added as a parameter to the biological profile, understanding the implications of biological health status and how the skeleton can be affected by an individuals' lifehistory is an important part of constructing an accurate biological profile.

Looking forward, the ability for skeletal biologists to examine the implications of drug use on large documented samples is currently hindered by the lack of well documented contemporary skeletal samples with medical histories. Some of the contemporary collections such as the WM Bass Collection and the Texas State University Donated Skeletal Collection do retain limited medical histories, however, we are also now seeing the generation of digital skeletal collections via clinical imaging (e.g., CT; MRI) of contemporary subjects. Such digital collection initiatives have the potential to enhance our understanding of human skeletal biology by generating collections of individuals which better represent individuals of all ages, sexes, and lifestyles, while compiling detailed lifehistories of donors. Such a study is currently in progress by Ms. Truesdell, and already she has found significant differences in pubic symphysis aging between users and non-users of some common drugs.

Table 1. Review of drugs and their documented effects on the human skeleton

Drug	Effect	Location
Anti-epileptic drugs (Chung & Ahn 1994; Revilla et al. 1995; Bowles 2012; Sakellarides et al. 2009)	Decrease in bone mineral density Increased risk of fracture	Not specific – Particularly spine and ribs
Methamphetamine (Buttner 2014; Tomita et al. 2014; Katsuragawa 1999)	Decrease in bone mineral density Altered bone metabolism	Not specific Dental implications
Corticosteroids (Spoelhof & Ray 2014, Bowles 2012)	Increased risk of osteoporosis Decrease in bone mineral density	Not specific
Glucocorticoids (Park et al. 2014)	Increase in bone mineral density – lumbar spine Increased risk of osteoporosis Increased risk of fracture	Not specific
Aromatase Inhibitors (Bundred 2009; Perez et al. 2006)	Reduced oestrogen/testosterone production Increased risk of osteoporosis Increased risk of fracture	Not specific
Depot Medroxyprogesterone Acetate (Bowles 2012)	Reduced oestrogen production Increased risk of fracture	Spine, pelvis, and calcaneus
Gonadotropin Releasing Hormone Agonist (Revilla et al. 1998)	Reduced oestrogen production Decrease in bone mineral density	Not Specific
Desomorphine (Grund et al. 2013; Poghosyan et al. 2014)	Destruction of hard and soft tissue (and associated necrosis)	Appendicular skeleton (limbs)
Heroin (Pedrazzoni et al. 1993; Miro et al. 1988; Wilczek & Stěpán 2003)	Reduced oestrogen production Increased risk of fracture	Ribs and spine Osteopenia in cortical bone
Methadone (Kim et al. 2006; Ioannidis et al. 2009)	Increased risk of osteoporosis Increased risk of fracture Decrease in bone mineral density	Not specific
Gastric Acid-Reducing Agents (Mattsson et al. 1991)	Decrease in bone mineral density Altered bone metabolism	Pelvis
Thyroid Replacement Therapy (Wexler & Sharretts 2007; Baran 2013)	Increased risk of osteoporosis Decrease in bone mineral density	Pelvis and forearm bones
Anti-depressants (Kurmanji et al. 2011; Bonnet et al. 2007)	Reduced oestrogen production Increased risk of fracture Decrease in bone mineral density	Not specific
Anti-psychotic agents (Naidoo et al. 2008; Aronson 2014)	Reduced oestrogen production Increased risk of fracture Decrease in bone mineral density	Ribs and spine
Thiazolidinedione (Hauner 2002; Bruedigam et al. 2009)	Altered bone metabolism Increased risk of fracture	Hips and extremities
Cocaine (Siegrist & Wiegand, 2014)	Infection Osteopenia Skeletal development	Alveolar bone Not specific
Nicotine (Broulik et al. 2007)	Decrease in bone mineral density	Not specific

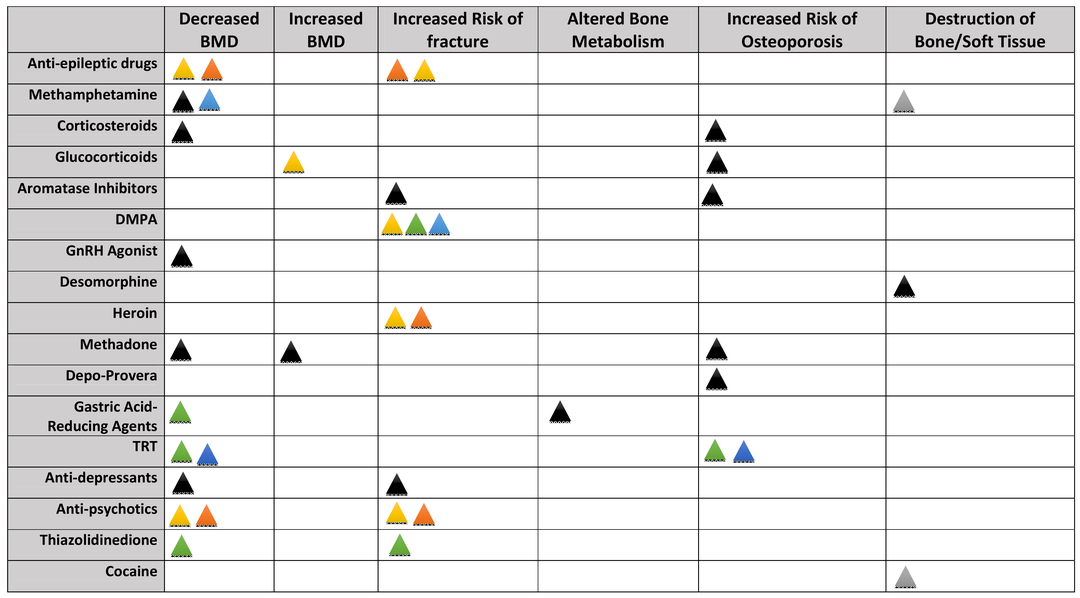

Figure 1. Table of different drugs effects
Triangle Color Key:
Grey – Mouth
Yellow – Spine
Orange – Ribs
Green – Pelvis
Black – Forearm
Blue – Calcaneus

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