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The Children of Spring Street: Rickets in an Early Nineteenth-Century Urban Congregation

Meredith A. B. Ellis

This paper examines the prevalence of rickets, or vitamin D deficiency, in the subadult skeletal remains from the burial vaults of the Spring Street Presbyterian Church of New York City. The burial vaults of the church were active from approximately 1820–1846 and contain the remains of at least 86 subadults (minimum number of individuals count [MNI] of left tibiae). Over 34% of the subadult tibiae in this collection display pathology consistent with vitamin D deficiency. Since vitamin D is acquired through access to sunlight and specific foods, a high rate of rickets can give clues about living conditions, parenting strategies, and children's behavior in this population. The urbanizing landscape of early 19th-century New York City and the associated cultural changes make this an interesting case study for exploring the relationship between biology and the environment in children's lives.

Cet article porte sur la prévalence du rachitisme, ou carence en vitamine D, chez les enfants de la Spring Street Presbyterian Church à New York. Les caveaux de l'église, utilisés entre 1820 et 1846, contiennent les restes humains d'au moins 86 individus immatures (NMI calculé avec les tibias gauches). Plus de 31% des tibias immatures de cette collection montrent des signes de pathologies liées à des carences en vitamine D. Puisque la vitamine D est acquise par l'exposition au soleil et par certains types d'aliments, un taux élevé de rachitisme peut nous donner des indices sur les conditions de vie, les stratégies parentales et le comportement des enfants dans la population. Le paysage urbanisé de New York au début du XIXe siècle et les changements culturels qui y sont associés rendent cette étude de cas particulièrement intéressante pour étudier les relations entre la biologie humaine et l'environnement dans la vie de ces enfants.

Introduction

Children represent a group of people that are ubiquitous in society and yet often overlooked in history. They are active agents in creating the worlds they inhabit and recipients of the worlds of their parents. Yet, recognizing children in the past has remained a challenge. Children are a special subset of society and are subject to specific rules, institutions, practices, and disciplines that influence how environments affect them and how they respond. As Baxter emphasizes, "The definition of the child's world focuses not on children but on the relationships children have with adults, other children, and the environment" (Baxter 2005: 1). Recent developments in archaeology have focused attention on children, making them a more visible component of inquiry (see, for instance, Baxter 2005).

To bioarchaeologists, children are perhaps less "invisible." Their physical remains ensure that they too are a part of the story that is told about the past. Subadult remains, moreover, can contribute much to our understanding of a population as a whole. Traditional analyses of subadult remains have focused primarily on children as a litmus test of a failing or compromised society.

Their remains are used to discuss the health and demography of the population as a whole. The focus on subadult remains is often methodological, and they are used to establish or evaluate new ways to determine age, sex, and ancestry. Subadult remains are not usually valued for their interpretative potential and are particularly undervalued in life-history analyses, which see their lives as truncated or failed. Yet the rapid turnover of growing subadult bone provides an excellent biocultural record of the natural and social environments in which the children lived.

Given the narrow time frame during which the Spring Street burial vaults were used (a mere 26 years), the subadult remains should reveal a great deal about a particular moment in the history of the church as well as in the history of the city itself. Unlike their parents, many of whom were born and raised outside the city, these children are more likely to have been raised in the neighborhood of the church¹, and, as such, their remains should reflect the socioeconomic circumstances of the church parishioners more directly than those of adults.

¹ This hypothesis will be evaluated in the future with isotope analysis.

This paper will focus on one metabolic condition, rickets, which is widespread in the subadult remains from the Spring Street Presbyterian Church burial vaults. Rickets, or vitamin D deficiency, is an excellent way to examine more than just the biology of a population, as this condition develops in relationship to biology, environmental variables, and sociocultural factors.

Vitamin D Deficiency

Over the past 20 years, more attention has been placed on understanding, diagnosing, and recording rickets (e.g., Ortner and Mays 1998; Lewis 2002; Pinhasi et al. 2006; Mays, Brickley, and Ives 2006, 2009; Pinhasi, White, and Ogden 2006; Schultz, Timme, and Schmidt-Schultz 2007; Brickley and Ives 2008). Bioarchaeologists have become more attuned to both the effects of rickets on bone and the sociocultural connotations of the disease's presence in a collection. The fact that rickets is caused by inadequacies in the diet and/or a lack of exposure to sunlight makes this condition particularly telling regarding the environment in which children are raised.

Rickets is a vitamin D deficiency that affects bone growth. Lack of vitamin D causes insufficient mineralization of newly formed bone, which leaves visible marks on the skeleton while the condition is active and healing (Mays, Brickley, and Ives 2009: 406). Vitamin D is acquired in two ways. The vitamin can be consumed; it is prevalent in the fat of some animal products (Steinbock 1976: 263) and fish oils (Roberts and Manchester 2005: 239). Most vitamin D, however, is synthesized by ultraviolet (UV) rays, that is, sunlight (Roberts and Manchester 2005: 239). UVB radiation is absorbed by the skin via 7-dehydrocholesterol, which allows for the synthesis of vitamin D (Holick 2008: S183). For such synthesis to occur, the individual must also be consuming adequate levels of calcium and phosphorus (Roberts and Manchester 2005: 239).

A number of important socioeconomic factors, therefore, affect historical cases of rickets: access to necessary foods, exposure to sunlight, constraints of living and working conditions, and the amount of melanin—which blocks UV light—in the skin. People with darker skin in northern latitudes require

approximately 5 to 10 times the exposure time to sunlight to produce similar levels of vitamin D as those with lighter pigmentation (Holick 2008: 185). It is estimated today that 54% of those of Hispanic and African ancestry living in the United States are vitamin D deficient (Holick 2008: 186–187). Recent debates in the *American Journal of Physical Anthropology* have questioned just how much melanin and, in turn, skin color affect vitamin D deficiency (Chaplin and Jablonski 2009; Robins 2009). Other factors mentioned previously may, in fact, be more important to understanding this vitamin deficiency, including cultural factors such as the choice of clothing, overcrowded living conditions, smog from industrialization, and labor patterns that limit exposure to sunlight (Brickley and Ives 2008: 93–95). Nutritional factors for infants and children can also be particularly important, as deficient breast milk, weaning stress, and diarrheal diseases can all contribute to a vitamin D deficiency (Brickley and Ives 2008: 93).

Visible changes to the skeleton of a subadult with rickets is caused by the failure of new bone to mineralize. New bone tissue is weakened. The rapid turnover of subadult bone means that this unmineralized osteoid can build up very quickly (Ortner and Mays 1998: 46). This results in porous, expanded, and frayed bone near the metaphyses, or growth plates; bowing of bone under the body's weight; and porosity along surfaces that are under pressure (Brickley and Ives 2008: 97; Mays, Brickley, and Ives 2009: 406). Areas that are most often affected include long bones and ribs, as well as the mandible, the ilia, and the cranium (Mays, Brickley, and Ives 2006: 363). Long bones are particularly useful for recognizing rickets in skeletal remains because their bowed appearance and metaphyseal changes are quite distinct. Depending on when onset of the disease occurs, arm bones or leg bones may be more affected (crawling vs. walking) (Ortner and Mays 1998).

Research also suggests that vitamin D may play a role in other biological processes. Vitamin D's functions also include immune-system regulation and anticancer actions (Lin and White 2003; Tavera-Mendoza and White 2007). A deficiency in vitamin D may aid cancer growth in certain regions and may limit the functionality of the immune system

(Tavera-Mendoza and White 2007). Children with rickets, therefore, might have compromised immune systems, making them more vulnerable to infectious-disease outbreaks of the type common in New York City in the 19th century (Werner and Novak, this volume).

Finally, recognizing rickets in skeletal remains is compounded by the fact that metabolic conditions are often found together. Individuals with a vitamin D deficiency may also be deficient in vitamin C and vitamin B12, both of which leave skeletal markers similar to those found in rickets, thus complicating correlations of specific skeletal markers to specific etiologies (Ortner and Mays 1998: 45; Brickley and Ives 2008). Nevertheless, it is a worthwhile exercise to analyze, record, and report cases of rickets in populations as the implications of the condition can reveal much about deficiencies in children's lives.

Historical Background

In the winter of 2006/2007, Bayrock/Sapir Organization began removal of a parking lot at the corner of Spring and Varick streets in New York City. The construction company was building a new condominium and hotel tower and, in the process, hit a series of underground burial vaults from a historic church. Archaeologists removed discrete burials and numerous commingled remains from the site that had once been home to the Spring Street Presbyterian Church. The four burial vaults associated with the church were in use from roughly 1820 to 1846 (Mooney et al. 2008; White and Mooney, this volume). At least 86 of the individuals represented by the largely commingled series are those of subadults, based on an MNI of left tibiae². Analysis of the remains

² The MNI for the subadult population as a whole may change once MNI calculations are completed for the other elements.

has been undertaken since 2007 at Utica College and Syracuse University. This paper reports on the remains of the children's tibiae from the collection.³

The lives and bodies of the children were shaped in part by the church as well as by the urbanizing landscape that soon engulfed the neighborhood. The Spring Street Presbyterian Church opened its doors for worship in April 1811, four years after two missionaries decided that the hinterland of New York City needed its own Presbyterian church (Moment 1886). The congregation first came together in rented rooms and then built a permanent structure that opened in 1811. Preliminary archival research indicates that the land for the church was purchased from the Trinity Church Corporation and was somehow connected to a woman named Jane who lived on the property and grew and sold fruit from orchards on the land (Meade 2008: II-1).

Just a few years later, the church was in the middle of the growing city, the target of abolitionist riots, and home to the urban middling and working classes that lived in the area (FIG. 1). During the early 1800s, the church was led by two abolitionist pastors, Samuel H. Cox and Henry G. Ludlow. Both advocated for the immediate emancipation of slaves and participated in abolition organizations in the city. Rev. Cox left the congregation in 1825 to move farther downtown and open a new church, the Laight Street Church. Rev. Ludlow officially took over in 1828 and stayed until 1837 (Alexander 1887: 43–46). When the congregation reconstituted the church in 1825 after Cox's departure, the congregants said that they wanted "a free church for the people" (Moment 1886: 12). Rev. Ludlow noted that when he took over the church was comprised of some 300 souls "most of whom belong to that class of person who cannot afford to purchase or hire a pew in our city churches" (Ludlow 1828). This observation is important for understanding the lives of the children in this collection, as the congregation appears to have been drawn from the local neighborhood with its mix of middling- and working-class families.

³ Please note that analysis has continued since the filing of the official report on the site with the state of New York in December of 2008. This paper reflects the most current data on the subadult remains as of April 2012. It is believed at this time that all subadults are accounted for, although analysis of the adults in this collection is on-going.

The city was undergoing rapid expansion and growth at this time, including the development of slum neighborhoods, new social classes, and a constant influx of immigrants from both overseas and from the rural countryside. The meeting minutes of the church document that many new members of the congregation came from upstate New York, New Jersey, New England, and abroad (Spring Street Presbyterian Church 1811–1825, 1825–1841). The congregants brought with them the skeletal signatures of their own childhoods experienced elsewhere and raised children in this new urban landscape, a landscape that reflected a particular neighborhood. The Eighth Ward of New York City was urban and multiracial (FIG. 1). Development along Spring Street itself included the presence of a market at the docks from at least 1810 until its closing in 1829 (Common Council 1931: 6.195); the opening of a firehouse and school space in 1810 (Common Council 1931: 10.150–151); Dietz's Tannery and Glue Factory, which moved uptown in 1833 (Dietz and Dietz 1914); and two blocks of "known prostitution" (Homerberger 2005). Census data indicate that within the ward were a variety of households, including both European American and African American nuclear families and extended families; families with live-in domestic servants; and boardinghouses (Meade 2008; Werner and Novak, this volume).

Records indicate that the burial vaults were in use during the time of Rev. Cox and Rev. Ludlow, with the first mention of the vaults appearing in 1820 and the last coffin plate dated 1846 (Meade 2008; White and Mooney, this volume). Two vaults were originally built, and in 1831 two more were added (Meade 2008: II-8). The cost of interment in the vaults ranged from \$2.00 for children under the age of 1, to \$10.00 for adults over the age of 15 (Meade 2008: II-9). The church and its leaders pushed the boundaries of racial politics by engaging with the major concerns of abolitionists, advocating for an end to segregated seating, offering communion to all congregants, and calling for racial equality. One historian of the church noted that "[i]t has frequently been said of the Spring Street Church that it has lived dangerously. It has certainly lived strenuously and courageously. It has kept the faith" (Hintz 1951: 3). The church's

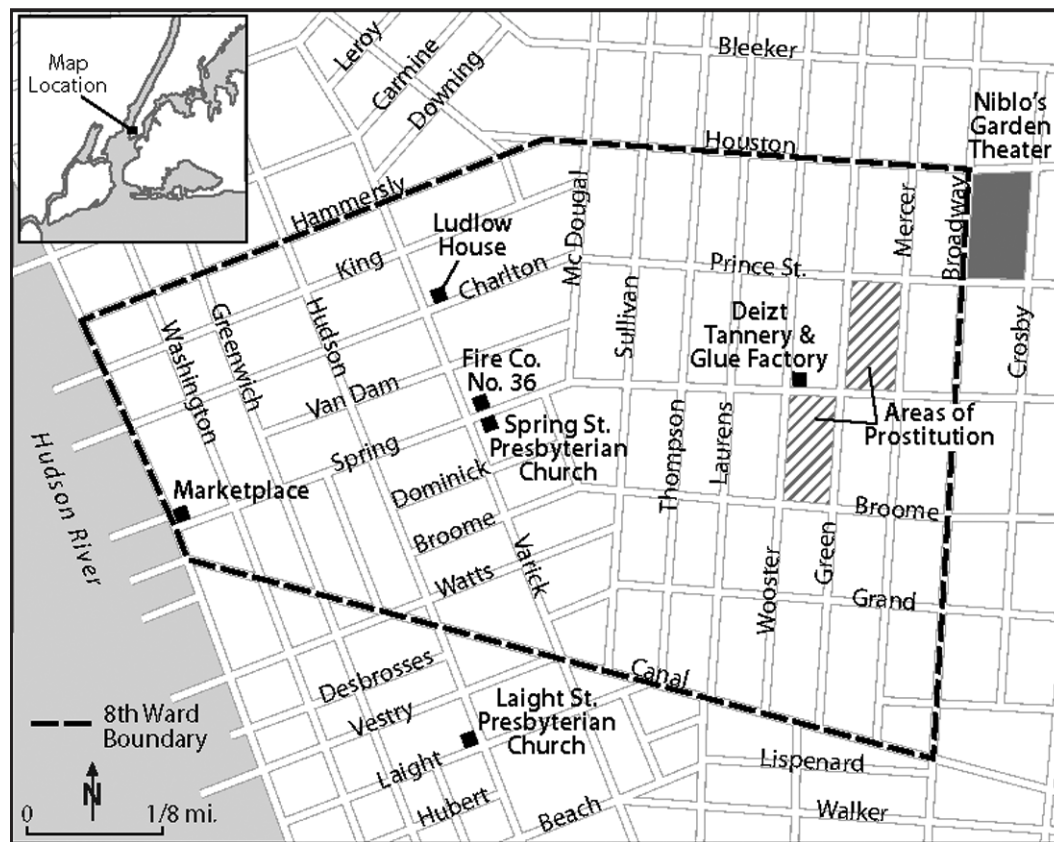


Figure 1. Map of the 8th Ward of New York City, 1811–1843. (Image courtesy of Joseph Stoll.)

politics during the 1820s and 1830s concur with such an assessment.

The church is perhaps best remembered during this time period for the damage done to it during the 1834 race riots. It was part of what was called the “Year of Riots,” with the city marked by unrest due to election riots, the Stonecutter’s Riot, and nationwide rioting over political and economic issues (Reitano 2006: 42–43). During the race riots, homes and businesses of African Americans and abolitionists were targeted. Rev. Ludlow’s home was attacked, as was the Spring Street Presbyterian Church, on rumors that Rev. Ludlow was performing interracial marriages (*Journal of Commerce* July 12, 1834: 2).

After the riots, Rev. Ludlow released a disclaimer that was published in multiple newspapers. In the disclaimer, he writes that he never performed or supported interracial marriages (*Christian Advocate and Journal*, August 1834: 195). Whether that is true or not, it is clear that the environment that the pastors and congregants of the Spring Street Presbyterian Church were creating was pushing the boundaries too far for some.

It is known from historical records that the church was indeed multiracial, with both European American and African American congregants in attendance. While debates took place over whether seating should be desegregated, African Americans were certainly part of the church and likely interred in the burial vaults. Additionally, the church ran a multiracial Sunday school, one of the first in the city. The school opened no later than 1818 and from its outset was multiracial. By 1828 the church was running an infant class, only the second to open in New York City. For some time that class met in the fire station across the street, before eventually moving into the church proper in 1832 (Moment 1886: 13–14).

These children faced many challenges in the new urban environment. Kenneth Scott, in his compilation, *Coroners’ Reports, New York City, 1823–1842*, writes, “For many, life in the metropolis was difficult. ... The young were very vulnerable” (Scott 1989: 1–2). For the children of the Spring Street Presbyterian Church, this was undoubtedly true. Historical records indicate that in 1820 the infant mortality rate in New York City was around 130 deaths per 1,000 live births and continued to climb during

the century (Smillie 1976: 202). According to the *Coroners’ Reports*, the most commonly recorded known cause of death for children under the age of 17 was drowning, followed by accidental burning, and suffocation or being “overlaid” by a parent (Scott 1989). The expanding urban environment in New York City presented many physical dangers to children. In addition, waves of infectious disease hit the city, including cholera and scarlet fever. Most frequently, however, the coroner recorded the cause of death as from “diseases unknown” (Scott 1989). Stresses such as weaning, nutritional deficiency, and infectious disease certainly played a role in childhood-mortality rates.

While there is little information about the congregants themselves preserved in the archival records of the church, it is known from the pastor’s writings that the congregation was vulnerable to the same factors as others in the city. In a letter to his mother dated January 18, 1832, Rev. Ludlow wrote of the death of three of Rev. Cox’s children during a scarlet fever outbreak and their burial in the vaults of the Spring Street Presbyterian Church:

Our city is still [missing word] with scarlet fever. Our dear friend Rev Dr Cox buried in our graves four coffins. Alexander Jackson (Mr. Dr. Ward’s brother) and 3 children died in about 3 weeks. This influence has been very general + very fatal. (Ludlow 1832a)

In fact, we know that Rev. Cox lost those three children in three days that January (Cox, Cox, and Cox 1912: 92). Just five months later, on June 25, 1832, Rev. Ludlow writes to his mother again, this time about the death of his own child shortly after birth:

Thus dear Mother has the cloud passed and sunshine throws its radiance around us. Our little Son was a fine boy and practical love desires his society. But God has done right—and acted in love, by taking him away. We were all together unprepared to receive such a blessing. [word missing] educate him if he had been orphaned. Our sin too needed the blow which had been inflicted. If God in mercy accompanies + with the influence of his Spirit we shall doubtful find that his mercy was greater in taking than in giving. (Ludlow 1832b)

These letters provide intimate insights on the tragic, yet common nature of children’s deaths in the congregation; so too do the sub-adult skeletal remains. In their skeletons, a

Table 1. Pathology of left tibiae with rickets

Element	Age	Bowing	Compression porosity	Metaphyseal fraying/ expansion	Metaphyseal fracturing	Lack of calcification
V1. SUBTIB 02L	2.5–4.5	X	X	X	-	-
V2. IND A	Birth–0.5	-	-	X	-	X
V4.FS21.SUBTIB 03L	0.5–1.5	X	X	X	-	-
V4.FS22.SUBTIB 36L	4.5–5.5	X	X	-	-	-
V4.FS22.SUBTIB 38L	2.5–3.5	X	X	-	-	-
V4.FS22.SUBTIB 39L	0.5–1.5	X	X	X	-	-
V4.FS22.SUBTIB 40L	0.5–1.5	X	X	X	-	-
V4.FS22.SUBTIB 41L	0.5–1.5	X	X	X	-	-
V4.FS22.SUBTIB 42L	0.5–1.5	X	X	-	-	-
V4.FS22.SUBTIB 49L	Unknown	-	X	X	-	-
V4.FS22.SUBTIB 50L	Birth–1.5	X	X	X	-	-
V4.FS22.SUBTIB 54L	Unknown	X	X	X	-	-
V4.FS22.SUBTIB 63L	Birth–3.5	X	X	-	-	-
V4.FS37.SUBTIB 03L	0.5–1.5	X	X	X	--	-
V4.FS37.SUBTIB 04L	0.5–1.5	X	X	X	-	-
V4.FS37.SUBTIB 07L	Birth–0.5	X	X	-	-	-
V4.FS37.SUBTIB 09L	1.5–2.5	X	X	X	X	-
V4.FS37.SUBTIB 10L	0.5–1.5	X	X	-	-	-
V4.FS54.SUBTIB 01L	Birth–0.5	X	X	X	-	-
V4.FS55.SUBTIB 01L	0.5–1.5	X	X	-	-	-
V4.FS55.SUBTIB 02L	Birth–0.5	X	X	X	-	-
V4.FS156.SUBTIB 01L	0.5–1.5	X	X	-	-	-
V4. IND BBB	0.5–1.5	X	X	X	-	-
V4. IND DDD	0.5–1.5	N/A	-	X	X	X
V4. IND EEE	0.5–1.5	N/A	-	X	-	X
V4. IND FFF	3.5–4.5	X	X	-	-	-
V4. IND YYY	2.5–3.5	X	X	-	-	-
V4. IND TTTT	4.5–6.5	X	X	-	-	-
V4. BURIAL 1-4I	4.5–5.5	X	X	-	-	-
V4. BURIAL 1-4F	0.5–1.5	X	-	X	-	X

variety of pathological conditions can be seen, including general indicators of stress such as periostitis, and more diagnostic conditions like vitamin C deficiency, vitamin D deficiency, and vitamin B12 deficiency. These metabolic conditions reveal that the children of the congregation did not have adequate access to necessary nutrients and vitamins. By focusing on one of these metabolic conditions, rickets and vitamin D deficiency, a closer exploration of these children's lives can begin.

Materials and Methods

An estimated 200 to 250 burials were excavated from the vaults of the Spring Street Presbyterian Church. Of those, at least 86 (MNI based on left tibiae) are from subadults under the age of 15.5. As the church changed burial price rates from that for children to that for adults after the age of 15, I have used this age to represent the culturally defined transition from subadult to adult in the skeletal remains. Most elements from this collection are commingled, with few discrete individuals present. Because of the high number of tibiae, along with the visible effects of vitamin D deficiency, this element will be the focus my analysis herein. Preservation of tibiae is good to

excellent, which facilitates observation of pathological changes to the bone surface (Mays, Brickley, and Ives 2006).

For two discrete individuals dental calcification and long-bone metrics were used to establish age (Moorrees, Fanning, and Hunt 1963a, 1963b; Kosa 1989; Ubelaker 1989). As most tibiae could not be associated with other elements, however, age estimation is primarily derived from long-bone length (Kosa 1989; Ubelaker 1989). It is estimated at this time that approximately half the remains from these vaults are those of subadults⁴. The age breakdown of the children is particularly telling (FIG. 2). Of the 86 subadult tibiae, 63, or 73.25%, are aged 6.5 years or younger. Of

⁴ The skeletal counts for this series are not complete due to on-going analysis of "disassociated" elements and those remains screened from the vault fill. During excavation, 62 discrete individual interments were identified (Mooney et al. 2008). Laboratory analysis of these designated burials identified further commingling and, when sorted, a total of 93 individuals were detailed in the final report (Crist et al. 2008: D.11). Since this time, elements that were designated as "disassociated" during excavation or were collected from fill soils have been sorted and analyzed. Analyses of these remains have added a substantial number of individuals to the counts of adults and subadults, but particularly to the latter (Crist, this volume; Ellis, this volume). It is estimated that when this analysis is complete, some 200 to 250 individuals will be accounted for in the vaults.

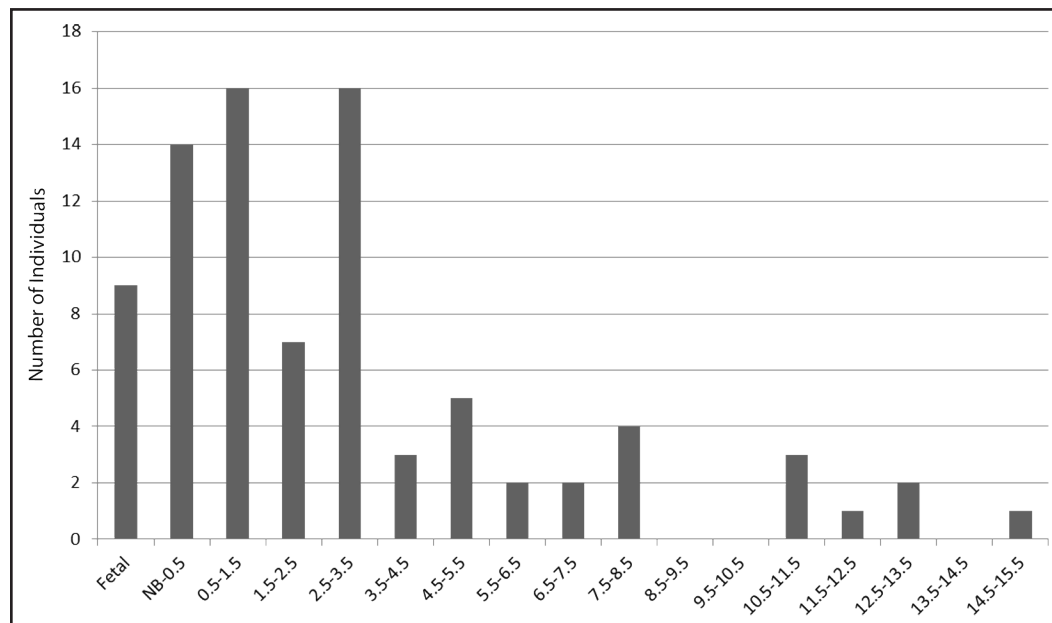


Figure 2. Age distribution of left tibiae (Figure by Meredith A.B. Ellis, 2012)



Figure 3. Radiograph of bowed tibia. (Image courtesy of Oneida Medical Imaging.)



Figure 4. Bowed left tibia and fibula. (Image courtesy of Anthony Faulkner.)

those, 36, or 57.14%, are infants (newborn through 1.5 years of age). Only six subadults are between the ages of 6.5 and 15.5 years (6.97%). Children seem to have been most vulnerable early in life, particularly around the age of weaning and up through childhood and early adolescence. No attempt was made to estimate sex or ancestry from these elements.

Visible markers of vitamin D deficiency were documented for each element. Pathological changes to bone were noted using visual examination, including the use of a ring light when necessary. Radiographs were also

taken of all pathological tibiae in antero-posterior and medio-lateral positions. Specific features were coded for presence, including flaring, expansion, and fraying of metaphyses; cupping, compression, and fracturing of metaphyses; bowing of diaphyses; widespread porosity of cortical bone; and porosity along the surface under compression. Following Brickley and Ives (2008: 104–105), multiple features needed to be present for a vitamin D deficiency to be recorded (TAB. 1). Because in most cases tibiae could not be reassociated with other elements, the diagnosis of vitamin

Table 2. Comparative populations with rickets

Site Name	Dates	Total number of individuals	Total number of subadults	Total with rickets (percentage)
Christ Church Spitalfields, England	1727–1859	938	186	14 (7.5%)
St. Martin's Church Birmingham, England	1800s	857	164	21 (12.8%)
First African Baptist Church Philadelphia, Pennsylvania	1825–1842	135	60	1 (1.7%)

D deficiency was confined to the presence or absence of characteristics defined for the tibiae.

Results

Macroscopic observations are summarized in Table 1. In the Spring Street Presbyterian Church subadults, rickets is common. Of the 86 left tibiae, 30, or 34.88% exhibit characteristics consistent with rickets (TAB. 1). Just over half of those elements ($n=15$) have bowing, porosity, and metaphyseal fraying (FIG. 3 AND 4). In addition, four tibiae show a complete lack of calcification of osteoid, resulting in an element that is rough and porous (FIG. 5). Also present were two tibiae with compression fractures of the proximal metaphyses along with other diagnostic features of rickets (FIG. 6).

When the frequency of rickets in the Spring Street series is compared to the other contemporaneous sites (TAB. 2), it is clear that number of subadults affected in this urban population is high. Both St. Martin's Church

and Spitalfields in London, England, are sites that are frequently cited as having high numbers of cases of rickets (St. Martin's, 12.8%; Spitalfields, 7.5%) (Lewis 2002; Mays, Brickley, and Ives 2009). Yet the Spring Street Church far exceeds both sites in the percentage of the subadults affected.

Discussion

The fact that over 34% of the subadult tibiae in the vaults of the Spring Street Presbyterian Church show signs of rickets suggests that vitamin D deficiency was common in the congregation. A number of factors could have contributed to the prevalence of this condition. First, limited exposure to sunlight may have played a role. Most cases of rickets reported in the literature come from historical populations, particularly urban populations during the Industrial Revolution (TAB. 2). The urban industrial environment would have limited exposure to sunlight both through

working practices and pollution production. In contrast to these populations, sites like the 14th-century Grasshopper Pueblo in the American Southwest have only three cases of rickets out of 369 subadult burials (Schultz, Timme, and Schmidt-Schultz 2007: 371–372). The children living at a site like the Grasshopper Pueblo would have had more-adequate exposure to sunlight than children growing up in a crowded, industrial, urban center, thus making them less likely to be vitamin D deficient.

Brickley and Ives (2008: 80) report that today New York City receives an average of 2,557 hours of sunlight a year. For people living in crowded, industrial, 19th-century New York City, that number could have been much lower. Individuals confined indoors in homes, schools, and workplaces for most of the day would have been exposed to far fewer hours of sunlight. The authors also report that infants need to have skin exposed to approximately 104 hours of sunlight a year (assuming adequate nutrition), and that number increases with age, up to 1,825 hours of sunlight for adults (Brickley and Ives 2008: 77). It is not difficult to imagine conditions under which individuals attending the Spring Street Presbyterian Church in New York City would have had inadequate opportunities for sunlight exposure. Mays and colleagues cite research that suggests rickets was a common seasonal condition "in industrial centres of temperate Europe, with active disease peaking in the winter months of low sun" (Mays, Brickley, and Ives 2009: 413). The same could have been true for industrial areas in the United States, particularly as New York City is 11° farther north than London. In addition, Lewis writes that sickly children in industrial England were often kept covered and indoors, thus making them even more susceptible to vitamin D deficiency (Lewis 2002: 221). Similar behavioral patterns must be considered as a factor for families in industrial New York City as well.

A second factor influencing the high number of cases of rickets in the Spring Street individuals could be related to ancestry. As previously mentioned, there are good historical accounts supporting the fact that individuals of African ancestry were among the congregants of the church. The church's radical

abolitionist ideology fostered an integrated, multiracial church, Sunday school, and burial site. There are also suggestive skeletal indicators of African ancestry in some individuals buried in the vaults.⁵ Chaplin and Jablonski (2009) write that in experimental studies, darkly pigmented skin prevents low doses of UVB, such as might be found in northern latitudes, from raising vitamin D to adequate levels. Thus, those children who had more melanin would have been more at risk (Chaplin and Jablonski 2009).

A third factor contributing to the high frequency of rickets may have been the children's diet. Given that there are multiple cases of vitamin C and vitamin B12 deficiency apparent in the subadult remains, poor nutrition in general may have been a reality for a portion of the children in this congregation. Historical research suggests that the population of the church would have been from a variety of social classes, including the lower and working classes, so evidence of nutritional deficiencies would not be surprising. At this time in New York City, there was a general transition from a home and workshop apprenticeship-based system to a market-driven system. In this new reality, labor was hired out, and the value of children contributing to home labor was devalued against their value as productive members of the market system (Sellers 1994). Similarly, infants may have been subjected to earlier weaning and weaning stress as women too were entering the market workforce (Lewis 2002, 2010).

Additionally, there is tantalizing evidence that the church may have been participating in reform ideologies that involved dietary restrictions in an attempt to perfect the body. Through their connections to reform figures like Lewis and Arthur Tappan, there is the potential that the pastors of the Spring Street Presbyterian Church may have been involved in body-reform movements that called for restricted diets (Abzug 1994: 177). These diets excluded hot foods, meats, and alcohol, and could easily lead to nutritional deficiencies among their followers. A testimonial from a woman who grew up on one of these restricted diets notes that she was allowed to

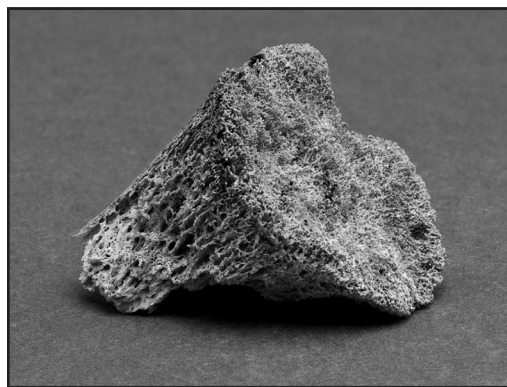


Figure 5. Tibia with lack of calcified osteoid. (Image courtesy of Anthony Faulkner.)

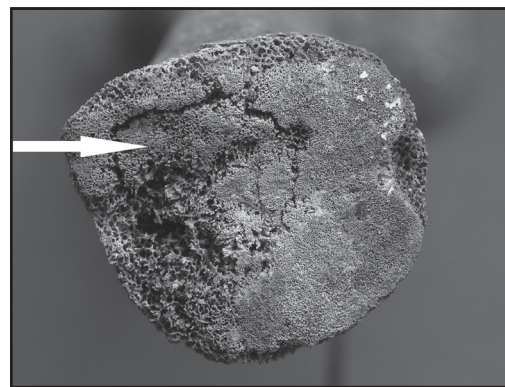


Figure 6. Compression fracture of proximal metaphysis. (Image courtesy of Anthony Faulkner.)

⁵ Such skeletal markers are problematic at best and future molecular analysis will help further our understanding of ancestry in the skeletal remains.

eat only bread and vegetables and dr[i]nk water. ... we became more dyspeptic, however, and, of course, thought we must diet more rigidly; we partook of but one meal in twenty-four hours, and this consisted of a thin slice of bread, about three inches square, without water. ... Thus we passed most of our early years, as many can attest, in hunger, pain, weakness, and starvation. (Griffith 2004: 75)

Children raised on this diet and infants nursed by mothers on such a diet could have manifestations of nutritional deficiencies in the skeleton. Additional parenting behavior can exacerbate vitamin D deficiency. A 17th-century case from St. Mary's City, Maryland, illustrates this; an infant was found with rickets that appears to be from, in part, the practice of swaddling, which prohibited access to sunlight. Swaddling, combined with nutritional deficiencies, appears to have been the cause of this infant's vitamin D deficiency (Douglas Owsley 2011, pers. comm., Smithsonian Institution 2012). Cultural patterns of dress may be important factors, particularly for those with the condition at an early age.

Conclusion

These three possible explanations for the high rate of rickets in the Spring Street congregation—ancestry, living conditions, and diet—likely all played a role in the deficiencies observed in the subadult skeletons. The synergistic effects of biology, environment, and culture in this case illustrate how important it is to examine patterns of pathology in their social and historical contexts. The ancestry of the congregants may affect their ability to absorb UV radiation. The location of New York City may hamper individuals' ability to get adequate access to sunlight. And cultural factors of diet, clothing, and living and working behaviors may determine how much vitamin D one receives. All of these factors must be considered together to understand fully the occurrence of rickets in the children of this congregation. This particular historical setting gives us some clues to how life was lived for these congregants. Some of what the church was preaching to its congregants is known—body reform and restricted diets, parenting behaviors, inclusion—yet what was actually practiced remains more elusive.

And yet, it is worth remembering that while a third of the children buried in the

vaults show signs of rickets, two-thirds do not. The rapidly urbanizing landscape of New York City; the influx of immigrants from upstate, out of state, and overseas; and the shifting economic situation of those working in the market environment meant that the lives of city families and their children were varied. The Eighth Ward in particular, with its mix of middle-class and working-class homes and European Americans and African American residents, would have seen a range of living conditions and diets, and thus a variety of childhood experiences. Such variety is certainly manifest in the children's remains interred in the Spring Street vaults. For at least one third of them, it is obvious that there were deficiencies and inadequacies that may have contributed to their truncated lives and untimely deaths.

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