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Cremation Weights in East Tennessee*

ABSTRACT: In spite of increasing number of cremations in the U.S., little is known about weights of cremated remains. This research was undertaken in order to add to the limited literature on cremains weights and to explore variation. Weights of cremated remains were obtained from the East Tennessee Crematorium. The sample consists of 151 males and 155 females. Age, sex, and race were obtained for each individual. Males are about 1000 g heavier than females. Both sexes lose weight with age, but females lose weight at about twice the rate of males. East Tennessee cremation weights were compared with those from Florida reported by Warren and Maples, and those from Southern California reported by Sonek. East Tennessee results were also compared with an earlier study on ash weight of anatomical human skeletons carried out by Trotter and Hixon. East Tennessee cremations weigh about 500 g more than the samples from Florida and California, and about the same as the earlier anatomical samples. We hypothesize that variation reflects variation in body weight and activity. This variation must be taken into account when cremation weights are at issue.

KEYWORDS: forensic science, cremation, forensic anthropology, bone mass, sex dimorphism

Literature reporting weights of adult cremated remains is surprising sparse, and much of it consists only of rough approximations. For example, Iserson (1) reports a range of 3–9 lb, Quigley (2) a range of 6–12 lb, Carlson (3) a range of 3–7 lb, and Maples and Browning (4) a range of 2.2 to 8.8 lb. The only study in the primary literature we were able to locate reporting data from a specified sample in the U.S. is Warren and Maples (5). A few other data sources were located, and these will be discussed later.

The present study was stimulated by the involvement of one of us (WMB) in litigation surrounding cremated remains returned to families by the Tri-State crematorium in Noble, GA. Questions were raised during a deposition August 19, 2002 and a court hearing August 22, 2002, concerning cremation weights and whether the weights reported by Warren and Maples (5) could be extrapolated to other situations. This paper will present data and analysis of a sample obtained from the East Tennessee region and compare it with the available data in order to address the question of variability in cremains weight.

Materials and Methods

The weights of all the cremations were obtained by WMB between December 6, 2002 and July 23, 2003. All weights were taken on an OHAUS digital scale, Model CS5000 which was purchased new for this project. The scale measures in 1 g increments from 0 to 5000 g. The accuracy of the scales was checked monthly using certified weights from the Denver Instrument Company of 200 g (Serial No. 98-J36238-24) and 1000 g (Serial No. 98-J20326-5) at 200, 1000, and 1200 g.

All weights were recorded at the East Tennessee Cremation Company (ETCC) in Maryville, TN. The ETCC has two natural gas fired Industrial Engineering and Equipment Company (IEE) cremation furnaces in a small neat building at the edge of an industrial park near the Knoxville airport. ETCC is a clean and well managed facility that does approximately 1000 cremations per year.

All cremations are performed individually. Bodies arrive in a variety of clothing attire, from nude to completely dressed. Individuals who have died in a hospital often have on only a hospital gown, and occasionally the life support systems of plastic tubes and needles are still attached. Cremation is performed by placing the deceased in a casket or other container. The bodies arrive in a variety of containers from body bags through fancy and expensive wooden coffins. It is difficult to place body bags into the cremation chamber, the funeral industry's name for the furnace, so that almost all bodies are at least in a cardboard carton especially made for the cremation process. The cardboard container usually contains a pressboard or plywood bottom because the cardboard tends to bend or buckle under the weight of a body. If the body is leaking fluids, the cardboard bottom tends to break.

In most cases, the furnace temperature stays somewhere between 1600 and 1800 degrees Fahrenheit. The length of the cremation process varies depending on the size of the body and the bone structure. A dehydrated elderly person burns slower than a body with more fat. The usual cremation takes 2 to 3 h, comparable to the time required presented by Bohnert et al. (6). Following the cremation process, there is a cool down period of a few hours.

After the remains are cooled, they are removed from the cremation chamber. The burned bones inside clearly outline a human skeleton. The long bones are fractured but in most cases are intact and the rib cage still sketches the framework of the chest. The skull is fractured but may still be somewhat intact. It breaks into small pieces when the long handle metal broom is inserted to rake the cremains out of the cremation chamber.

The bone fragments and ashes are removed and placed on a worktable beneath a vented exhaust fan. Hinges, screws, staples and small nails that were part of the cardboard carton or wooden box are often mixed with the cremains. Often still burning pieces of plywood need to be removed along with charred pieces of burned plywood that will darken the final cremains if they are not removed. A heavy magnet is drawn through the cremains to remove all magnetic items. Many individuals today have orthopedic devices such

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as hip or knee replacements and various metal items and screws or bolts for the multitude of fracture repair devices. All of these metal items that could be detected, either visually or magnetically, are removed before the cremains are pulverized.

The final stage in the cremation process is the pulverization of the remaining pieces of bone. This was originally done by a hammer or board but the modern standard is a commercial pulverizer. ETCC has an IEE processor that resembles a soup kettle grafted on top of a garbage disposal. Essentially, it is an industrial size kitchen blender. The cremains, minus all the metal that could be detected, are put in the kettle and after the heavy top is secured, a switch is flipped and the fragments are reduced to a grainy powder in 60 s.

The processed cremains are then poured into a plastic bag positioned inside a rectangular plastic box measuring $90 \times 155 \times 210$ mL and a metal tag containing the name, date and sometimes the social security number of the deceased is placed into the bag and the bag is sealed tightly with a plastic cable tie. The box is then snapped shut. It is this box of cremains that was weighed. The plastic box, the plastic bag, cable tie and the name tag weighed 310 g. When the total weight is obtained, the 310 g are subtracted so that the weight reported here is the true weight of the cremation. During the weighing process, all cremains were weighed twice to eliminate any errors in recording.

Information obtained from each of the cremated individuals consists of age, sex, and race. It was not possible to obtain pre-cremation weight, but unusually heavy individuals were noted. Since few nonwhites were present in the sample, they were omitted and the analysis limited to whites. Also omitted were amputees. The final sample consists of 151 males and 155 females. Standard summary statistics were computed, and the relationship between age and cremains weight was investigated using linear regression.

Results

Table 1 presents the summary statistics for the present sample. The male sample is slightly younger than female, and heavier by over 1000 g. Figure 1 presents the relationship between age and weight, with fitted linear regression lines, and Table 2 gives the regression statistics and tests of significance. Both sexes exhibit statistically significant declines in weight with age. Females lose weight at almost twice the rate of males, 16.55 g vs. 8.19 g per year. The slopes of the two regression lines also differ significantly ($F = 5.14$, $P < 0.025$, df $= 1,302$), allowing rejection of the null hypothesis that the two sexes lose weight at the same rate.

Table 1 shows that the sexes differ by approximately 1000 g and Fig. 1 shows the sex distributions are to some extent distinct, especially in the older ages. Sex differences of this magnitude raise the question of whether sexes could be discriminated from their cremains weight. Because the sexes lose weight as they age, age must be controlled in some fashion. The different rate of change of the two sexes complicates this, because covariance adjustment to a common age is not possible. This question may be examined in a preliminary way by dividing the sample into broad age categories. Table 3 shows means and correct classification rates for three broad age categories. Sample sizes for the youngest category are small, so these results inspire little confidence. In the second category about $^3/_4$ are correctly classified, and in the oldest it rises to over 85%, suggesting that for those over 70 cremains weight alone can estimate sex as reliably as many morphologically complete

TABLE 1—*Descriptive statistics for age and weight of East Tennessee sample.*

	Males		Females	
	Age	Weight	Age	Weight
n	151	151	155	155
Mean	62.834	3379.768	70.680	2350.170
Median	65.0	3375.0	77.0	2260.00
Std	17.173	634.975	16.78	536.43
Minimum	18	1865.0	19	1050.0
Maximum	99	5379.0	98	4000.0

TABLE 2—*Regression equations of cremation weight on age.*

	Males		Females	
Statistic	Estimate	s.e.	Estimate	s.e.
Regression coefficient	−8.19*	2.95	−16.5507*	2.21
Constant	3894.17**	192.37	3520.036**	160.55
Correlation	0.2214*	. . .	.5179*	. . .

* $P < 0.01$.
** $P < 0.001$.

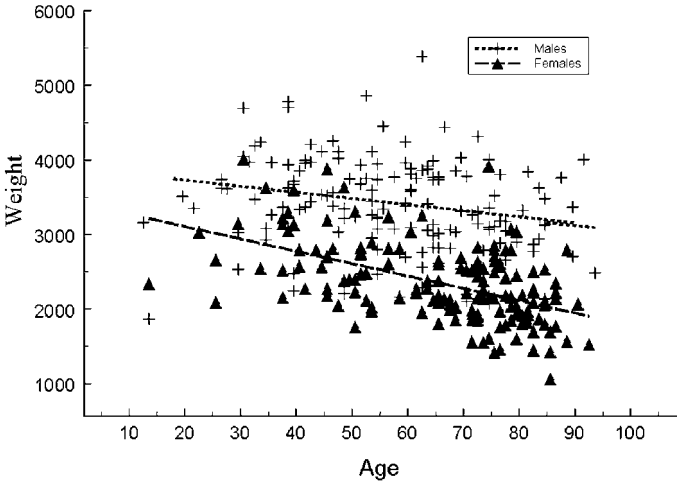

FIG. 1—*Plot of cremation weights (grams) on age for East Tennessee males and females.*

TABLE 3—*Classification of sex by age group using cremation weight.*

	Means by Age Group				Sex Classification by Age Group			
	Males		Females		Males		Females	
Age Group	*N*	Mean	*N*	Mean	No.	%	No.	%
17–39	15	3528.43	7	2821.43	11/15	73.3	6/7	85.7
40–69	80	3497.46	51	2667.47	60/80	75.0	39/51	76.5
70+	57	3167.42	97	2149.33	47/57	82.5	86/97	88.7

TABLE 4—*Comparison of East Tennessee and other samples.*

	Males			Females		
Group	*N*	Mean	S.D.	*N*	Mean	S.D.
E. Tenn.	151	3379.77	634.98	155	2350.17	536.43
Florida	50	2898.70	499.20	40	1829.38	406.53
California	76	2801.38	589.47	63	1874.87	528.82
Anatomical	30	3410	. . .	30	2297	. . .

skeletal elements. These results also demonstrate that age must be considered in evaluating cremains weights. For example, cremains weighing 3000 g could be consistent with a 30-year-old female or a 75-year-old male.

Discussion

The results reported above raise several issues regarding weights of cremated remains. Most important is the issue of variation among samples. The only published study on a U.S. sample of which we are aware is Warren and Maples (5). In addition to the formally published results, cremains weights from the San Diego, California area were distributed by the late Alexander Sonek in handout form in connection with his 1992 paper (7). The pooled sex mean of Sonek's data was included in Murad's (8) summary of forensic implications of cremation, but we have calculated the sex specific means and standard deviations. Criteria for inclusion of the Florida and California samples were the same as ours, limited to individuals 18 and over and excluding amputees and non-whites. Finally, Trotter and Hixon (9) presented ash weights of skeletons from anatomical specimens collected during the first half of the 20th century. These are not cremations in the usual sense, because soft tissue was removed and the skeletons reduced to a dry fat free state prior to burning. Ash weights should be comparable to cremation weights, because in both cases one is left with the inorganic component.

Summary statistics for these samples are presented in Table 4. Both Warren and Maples (5) and Sonek (7) are significantly lighter than our sample, ($t = 4.88$ and 5.73, for Warren and Maples, and $t = 6.63$ and 5.95 for Sonek, males and females respectively, $p < 0.001$ in all cases). Trotter and Hixon presented ash weights for both Blacks and Whites, but only their White data are presented in Table 4. Unlike the Florida and California cremation weights, Trotter and Hixon's ash weights are very similar to the cremation weights presented in the present study. They do not present standard deviations, so a test of significance is not possible, but a difference of 30 g and 50 g for males and females respectively, is not likely to be significant.

It is not immediately clear what accounts for the variation among samples presented in Table 4. One possibility concerns age differences among the samples. The mean age of both the Florida and California samples is slightly older than the our Tennessee sample: 66.34 and 74.06 years for Florida males and females respectively, and 64.11 and 75.65 for California males and females respectively. The maximum age difference is about 5 years (Tennessee vs. California females). Using the slope of the regression line in Table 2, assuming it applies to other groups, only accounts for about 80 g of the difference. We also controlled age by breaking the samples into 10 year age cohorts. The Florida and California age cohorts are lighter than their Tennessee counterparts. The anatomical sample age means are 63.5 and 63.8 for males and females respectively. Males are about the same as the present sample, and females are about 6 years younger. If the anatomical sample females were adjusted to our mean age, they would be about 100 g lighter, (using the regression slope in Table 2) still substantially heavier than Florida or California. Age differences therefore do not account for differences in cremains weight.

Another possibility, which we put forth in the spirit of a suggestion for future research, concerns regional variation in body mass. A relationship between bone mass and body weight has been established, to the point where femur cortical thickness can be used to estimate weight (10). The Center for Disease control statistics give an obesity rate for 1999 of 23% for Tennessee, 18.2% for Florida and 19.5% for California. The greater obesity rate in Tennessee would predict greater bone mass, which would be reflected in cremains weight.

The ash weight study presents a different situation. Since these skeletons were collected during the first half of the 20th century, giving them birth years from the mid 19th century to the early 20th century, they predate the obesity epidemic in America. However, it was also a time when Americans were considerably more active than they currently are. Activity may also maintain bone mass.

The loss of cremains weight with age seen in our data reflects the well-known loss of bone associated with aging, and the more rapid decline of cremains weight in females reflects the well-documented acceleration of bone loss with menopause. Trotter and Hixon report loss of ash weight at the rate of 15.6 g/year, not much different from our figure of 16.6 g/year in females. They detected no difference between races or sexes, possibly because sample sizes were smaller than ours.

What emerges from this analysis is that cremains weight varies, perhaps regionally, but insufficient evidence exists to specify any particular pattern of variation. The causes of variation remain to be identified, although factors that affect bone mass, such as activity and body weight, must play a role. It should be clear that variation in cremains weight should be treated as a problem in human variation to be examined and understood, and that forensic anthropologists and others concerned with cremains weight should be aware of this variation.

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