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Skeletal Estimation and Identification in American and East European Populations*

ABSTRACT: Forensic science is a fundamental transitional justice issue as it is imperative for providing physical evidence of crimes committed and a framework for interpreting evidence and prosecuting violations to International Humanitarian Law (IHL). The evaluation of evidence presented in IHL trials and the outcomes various rulings by such courts have in regard to the accuracy or validity of methods applied in future investigations is necessary to ensure scientific quality. Accounting for biological and statistical variation in the methods applied across populations and the ways in which such evidence is used in varying judicial systems is important because of the increasing amount of international forensic casework being done globally. Population variation or the perceived effect of such variation on the accuracy and reliability of methods is important as it may alter trial outcomes, and debates about the scientific basis for human variation are now making their way into international courtrooms. Anthropological data on population size (i.e., the minimum number of individuals in a grave), demographic structure (i.e., the age and sex distribution of victims), individual methods applied for identification, and general methods of excavation and trauma analysis have provided key evidence in cases of IHL. More generally, the question of population variation and the applicability of demographic methods for estimating individual and population variables is important for American and International casework in the face of regional population variation, immigrant populations, ethnic diversity, and secular changes. The reliability of various skeletal aging methods has been questioned in trials prosecuted by the International Criminal Tribunal for the Former Yugoslavia (ICTY) in *The Prosecutor of the Tribunal against Radislav Krstić* (Case No. IT-98-33, Trial Judgment) and again in the currently ongoing trial of *The Prosecutor of the Tribunal against Zdravko Tolimir, Radivolje Miletić, Milan Gvero, Vinko Pandurević, Ljubisa Beara, Vujadin Popović, Drago Nikolić, Milorad Trbić, Ljubomir Borovcanin* (IT-05-88-PT, Second Amended Indictment). Following the trial of General Krstić, a collaborative research project was developed between the Forensic Anthropology Center at The University of Tennessee (UT) and the United Nations, International Criminal Tribunal for the Former Yugoslavia, Office of the Prosecutor (ICTY). The purpose of that collaboration was to investigate methods used for the demographic analysis of forensic evidence and where appropriate to recalibrate methods for individual estimation of age, sex, and stature for specific use in the regions of the former Yugoslavia. The question of "local standards" and challenges to the reliability of current anthropological methods for biological profiling in international trials of IHL, as well as the performance of such methods to meet the evidentiary standards used by international tribunals is investigated. Anthropological methods for estimating demographic parameters are reviewed. An overview of the ICTY-UT collaboration for research aimed at addressing specific legal issues is discussed and sample reliability for Balkan aging research is tested. The methods currently used throughout the Balkans are discussed and estimated demographic parameters obtained through medico-legal death investigations are compared with identified cases. Based on this investigation, recommendations for improving international protocols for evidence collection, presentation, and research are outlined.

KEYWORDS: forensic science, Balkans, identification, population variation, human rights, transitional justice, age at death, sex estimation, stature

As postconflict societies transition to peace, issues of justice and accountability for crimes committed becomes a critical part of judicial and democratic reform. Luis Moreno Ocampo, Prosecutor for the International Criminal Court (1: 9) wrote: "Transitional justice, particularly transitional justice during ongoing conflict, is a new and rapidly evolving field that academics and practitioners are in the daily process of defining and developing. The ICC's (International Criminal Court) charge to implement and apply law where there is none is a complex and challenging undertaking, one which must also be part of study and debate…" Large-scale forensic investigations into massive human rights (HHRR) violations and war crimes have occurred through international tribunals and among emerging judicial systems incorporating science with law and judicial accountability in what may be called human rights enforcement, which is different from human rights reporting, and is increasingly becoming a key transitional justice issue. In the context of human rights reporting, forensic reports containing evidence of crimes were infrequently used in criminal trials against the alleged perpetrators (2). Such reports have been typically used to illustrate the offenses that occurred rather than to assist in punishing perpetrators. Through human rights enforcement, physical evidence of abuse, torture, and murder is systematically collected for the purpose of prosecuting the offenders. Kritz (3) wrote: "Establishing a full, official accounting of the past is increasingly seen as an important element to a successful democratic transition. Criminal trials are one way in which the facts and figures of past abuses may be established."

The role of forensic anthropology in the investigation of violations to International Humanitarian (IHL) or Human Rights Law (IHRL) has become increasingly prevalent and important since the

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International Criminal Tribunals of Rwanda (ICTR) and the former Yugoslavia (ICTY) were established which have examined thousands of cases representing more than 5000 people from Rwanda, Bosnia-Herzegovina (BiH), Croatia, and Kosovo. Essential evidence provided by anthropologists such as the estimation of the minimum number of individuals, excavation methods, population demographic profiling, and victim identification has been used in trials of genocide, war crimes and crimes against humanity. Central to the scientific role of anthropologists in these types of cases has been the construction of skeletal biographies to establish the initial parameters of identity, including the age-at-death, sex, and stature of unidentified remains.

Forensic anthropologists have traditionally used the biological profile to limit the pool of potential matches thereby establishing the first parameters of identity for the purpose of establishing a presumptive identification. Investigators subsequently rely on other methods and often on experts outside of anthropology, to establish the positive identification of an individual based on evidence such as an odontogram or DNA. Positive identifications in these examples are made after comparing known antemortem data about the decedent with the postmortem record. In the absence of such antemortem data, as is most typically the case in contexts of human rights abuses, armed conflict, extra-judicial executions, and terrorism, the repatriation of human remains to family members as well as official legal documents such as death certificates are based on positive and presumptive identifications. In these situations, the identification is typically based on a set of multiple lines of evidence such as the context, witness statements, the identification of clothing or personal artifacts, and other circumstantial evidence. Investigative findings are linked to biological parameters about the missing to narrow the list of possible matches. For any level of identification, the underlying assumption is that information obtained through the construction of the skeletal biography may be compared with information about the missing person (antemortem data). Antemortem data is collected from surviving family members or friends of the victim who may have personal knowledge of the deceased, as well as from various documentary evidence such as a birth certificate or other forms of identification papers. Specific ante- and postmortem data that link unique ante-mortem records with postmortem data, such as dental records, may lead to a positive identification which has been used for naming specific victims in a particular indictment. However, anthropological evidence at trial in the international criminal courts have also provided essential evidentiary value as to the collective identity of victims (i.e., what segment of the population they represent) and the estimated number of victims. Thereby, cases of genocide, war crimes, and other humanitarian laws challenge anthropologists as scientists to investigate and improve standard methods to ensure results that meet the judicial, evidentiary, and scientific requirements as established in the international courts.

The purpose of this research is to discuss the issue of "local standards" and challenges to the reliability of current anthropological methods for biological profiling in international trials of IHL, as well as the performance of such methods in meeting the evidentiary standards used internationally: (i) Anthropological methods for estimating demographic parameters, (ii) The ICTY-UT collaboration for research on population variation and associated sample reliability, (iii) The estimated demographic parameters obtained through medico-legal death investigations as compared with identified cases, and (v) Recommendations for improving international protocols for evidence collection, presentation, and research.

Skeletal Demography as a Legal Issue

In 1992, paleodemographers Wood, Harpending, Weiss, and Milner published a paper in *Current Anthropology* titled, "The osteological paradox: Problems of inferring prehistoric health from skeletal samples" (4). Wood and colleagues persuasively challenged interpretations drawn from cemetery samples and highlighted important biases in the methods used to estimate population size and the demographic profiles of cemetery populations. The debate that followed (5–9) has resulted in redefined theoretical frameworks and new statistical approaches that overcome the challenges that at times had blocked past researchers from drawing meaningful conclusions from skeletal data. More than a decade later, this same debate is being waged, but this time in international courtrooms far outside the halls of academia.

The Prosecutor v. Radislav Krstić (Case No. IT-98-33, Judgement, August 2, 2001; Appeals Chamber Judgement, April 19, 2004) has been an important case in the prosecution of genocide under IHL. The case relied heavily on anthropological and other forensic evidence and both the prosecution and defense had a vested interest in how key forensic evidence was interpreted as it related to the charges of genocide and war crimes (10). Specifically, during the Krstić trial, the defense team questioned the anthropological expert witness (Baraybar in court testimony for *Prosecutor v. Radislav Krstić* May 30, 2000, T. 3806) as to the following:

1. Why were there two methods for aging, American (11–14) and Balkan (15) methods?
2. The defense wanted to know if the Bosnian population aged faster than Americans.
3. Why did the aging methods for the two populations differ and which were reliable?
4. How were the age intervals constructed?
5. How was the number of victims in a grave calculated?
6. Were the individuals in the grave civilians or military personnel?
7. Were the individuals in the grave fighting or captured at the time of their deaths?
8. Were the individuals in the grave male or female and what were their exact ages?

Note that the methods in ICTY transcripts are referred to as "American" and "Balkan"; there is no reference to specific scientific methods by the defense lawyer. The notable exception to this is reference to the "Suchey-Brooks" method by prosecution witness, Baraybar, in his testimony. The methods listed here are based on those used in the standard ICTY protocol and the methods generally used by the ICTY throughout the Balkans, up to the time of the Krstić trial. The Krstić trial highlights important questions about population specific aging standards and identification methodology, but is not an isolated example of this. The identification, even the collective or group identity of victims, speaks to who the victims were and to the intention of a crime. Anthropological methods were again questioned during the currently ongoing trial of *The Prosecutor v. Popović* et al. *(IT-05-88-PT)* (16). As these examples illustrate, the methodological debates regarding the construction of population demography from skeletal remains have led to specific questions about human biology and population variation in court. As violations to IHL continue to be prosecuted in a wide variety of domestic, international, and hybrid courts (17) throughout South America, Africa and Asia, questions about the accuracy and reliability of anthropological or American standards for biological estimation applied to different populations are likely to continue to be

asked and may significantly influence what scientific or anthropological evidence is deemed admissible. The scientific literature addressing method calibration must be clear about what differences occur as a result of biological variation among populations versus variation resulting from the application of varied statistical models. As with any scientific method that is presented in court, there are scientific issues at play, as well as the interpretation of such evidence by the judges, attorneys, and other legal experts involved in the case. In other words, there are important scientific and biological issues in regard to a legal case, as well as the perception of that evidence by non-experts who hold a stake in how that perception is modeled.

The Applicability of Methods Used Internationally

Responding to the questions raised during the *Krstić* trial, the ICTY Office of the Prosecutor (OTP) developed an internal project by which standard methods could be calibrated for Balkan populations to test for and improve accuracy and reliability, as well as answer the fundamental underlying question, *Do populations age differently?* Data from evidence obtained by the ICTY through the course of their criminal investigations were used in a collaborative project between the OTP and the Forensic Anthropology Center (FAC) at the University of Tennessee. The primary objective of this investigation was to test the methods used to construct biological profiles of victims in the Balkans and to re-calibrate biological parameters for standard methods based on a set of Bayesian statistics. In addition to producing robust methods that met the legal requirements for scientific evidence in court, new aging calibrations could be applied to ongoing or unsolved cases retroactively to aid in the identification process.

The applicability of methods used to estimate the biological profile based on specific skeletal features (for example, the pubic symphysis, sternal rib, or teeth) was not challenged in court nor is it generally under debate within the scientific community, as far as we know. Rather, questions about the applicability of standard methods to biologically diverse populations is at issue, specifically, the reliability of methods applied across populations based on descriptive age parameters assigned to various phases or as derived from various methods of regression analyses (in the case of dental metrics or stature). Attempts to recalibrate standard methods to different populations have at times created erroneous interpretations about population variation because the age distribution of the samples were different (refer to the next section of this paper for a full discussion of statistical methods); therefore resulting interpretations of the data may have been based on statistical artifacts leaving the question as to actual biological variation unanswered.

The investigation by the UT-ICTY built on the anthropological methods traditionally used by the ICTY as outlined in their protocol, which were later adopted by the Office on Missing Persons and Forensics in Kosovo (UNMIK). The goals of the project were to provide the following: (i) Re-calibrated age intervals for American based aging methods used in the current protocols based on Bayesian statistical methods, (ii) New point estimates for age estimation that could be applied at the time of autopsy/examination to establish initial identity parameters, (iii) Revised methodology for accurate sexing and stature criteria, (iv) Revised aging and identification parameters for specific cases of unidentified victims from BiH that remained open, (v) A photo essay illustrating the morphological variation of various skeletal traits at different ages to serve as a guide for anthropologists in the field at the time of analysis; and (vi) Re-calibrated age parameters applied retrospectively to cases investigated by the ICTY that remained unidentified. In addition, two methods used in the United States, but not in the Balkans, were investigated and calibrated specifically for Balkan populations, including first rib morphology (18,19) and dental wear (20).

The body of work that has come out of the ICTY-UT collaboration extends beyond the borders of the former Yugoslavia in that it highlights important issues that may impact anthropologists working globally and will address those needs by providing new aging criteria and an applicable model of skeletal assessment for the creation of biological profiles that can be applied to other populations that: (i) Meets the most conservative evidentiary standards for the presentation of scientific evidence in court, (ii) Establishes criteria that are reliable, accounting for precision and error and thereby ensuring a high probability for positive identifications, (iii) Provides insight into long-standing anthropological questions about population variation in aging, and (iv) Contributes to our understanding of the effects of individual inter-observer variation in the formulation of new methodology and successful identification.

The Sample

Early in the investigative process, the OTP constructed a protocol outlining the anthropological methods that were to be used in the osteological analysis of human remains for the construction of biological profiles. As investigations continued over several years in diverse working environments and in response to a variety of contexts, this protocol was modified as necessary. Data used for the ICTY-UT research project came from evidence collected by the ICTY during its investigation, via The Hague following Chain of Custody. Permission to use this data was given by the ICTY to UT who entered into a working relationship with the expressed goal of sharing data and results that would aid OTP in their investigations as well as other agencies working on human identification in the region. An essential component of this effort was the publication of scientific findings to ensure the admissibility of any new method or revised biological parameters for existing methods in court.

Several types of data were used, coming from a variety of sources: (i) demographic (age and sex) information about victims of the conflict, (ii) antemortem data collected through the investigative and identification processes, (iii) data on skeletal features used for estimating biological profiles from autopsy records, (iv) skeletal biosamples consisting of pubic symphyses, sternal rib ends, or single rooted teeth, and (v) casts of the pubic symphyses. These data came from cases where identifications (presumptive or positive) were available and from a sample of unidentified cases. Casts of skeletal features used for estimating age were created when applicable and in some cases when it was not possible to make casts, skeletal biosamples for age estimation, as well as future DNA analyses, were collected during ICTY autopsies. The reason that so many presumptive and positive identifications were made in Kosovo, where the majority of identified cases come from, is due to the events that unfolded during the conflict that besieged that Province between 1998 and 1999. Unlike BiH and Croatia where numerous individuals were buried in mass graves, victims in Kosovo were often killed in or near their homes but were not buried. Subsequently, family members or members of the community returned to the area and buried the dead. As a result, the majority of graves exhumed and autopsied by the ICTY in 2000 were of individuals with presumptive identifications located in single interment graves within pre-existing cemeteries.

The antemortem information for cases from Kosovo was collected during the year 2000 by the Transcultural Psychosocial Organization (TPO) as part of a joint effort to identify the victims

that were unknown or to confirm the presumptive identity of those being exhumed. Antemortem data were available for more than 800 individuals, including the known ages-at-death, birth and death years, sex, and living stature. The age-at-death distribution of these individuals is used as the prior in the Bayesian statistical analyses. Refer to the next section, *Methodological Framework*, for details on how the known age distribution is applied statistically.

In contrast to Kosovo, the graves exhumed in BiH and Croatia by the ICTY were primarily mass graves and often included incomplete or commingled remains from secondary sites where mass graves were dug up and re-interred multiple times to hide the location of the graves. Thus, few individuals were either tentatively or positively identified during the field seasons of investigation in these regions. Data on the few cases in which tentative or positive identifications were made in the field are also included in this report. Antemortem information for these cases primarily came from documentary evidence such as identification papers and birth certificates, as well as some ethnographic interviews of surviving family members through ICTY investigations. It should be noted that the identification process in these areas is currently ongoing. Therefore, the new parameters for age, sex, and stature are being applied retroactively to previous cases that remain unidentified, as well as to current cases.

Sample Reliability

To demonstrate the reliability of the putative identifications used for age calibration in this project, Kimmerle and Konigsberg (21) calculated the likelihood ratio of how likely the observed "indicators" (rib phase, tooth wear, and tooth root translucency) are to occur if the identifications are correct, versus how likely they would occur from the population at large. This was done using a Bayesian analysis. The likelihood ratio is:

$$\mathrm{LR} = \frac{\Pr(\mathrm{Rib},\ \mathrm{Wear},\ \mathrm{Trans}|\mathrm{age})}{\int_{t=15}^{\omega} \Pr(\mathrm{Rib},\ \mathrm{Wear},\ \mathrm{Trans}|t) \times f(t)\mathrm{d}t} \qquad (1)$$

where "age" in the numerator is the known age for the putative ID, $f(t)$ is the age-at-death distribution for the "population at large," and Pr(Rib, Wear, Trans|t) is the conditional probability of being in the observed rib stage, wear stage, and having the observed proportion of tooth root translucency at exact age t. The term "dt" represents the definite integral across age from age 15 to the fixed point ω, which for this analysis was taken as 100 years. Figure 1 shows a sorted plot of the likelihood ratios for 603 individuals. The horizontal line is at 1.0 and represents "evens," or the case where the observed data are as likely to come from the "population at large" as they are to come from the identified individual. Of the 603 individuals, 93 (or about 15%) have a likelihood of less than 1.0. If the identifications were actually randomized, we would have expected more cases than the 15.0% to have LR less than 1.0 (refer to the Konigsberg et al. paper in this volume). Therefore, the sample of known individuals based on presumptive identifications is highly reliable.

It is worth noting that, to date, DNA tests for identification in Kosovo from presumptive identifications have resulted in a majority of positive matches. From a total of 120 cases of presumptively identified cases sent for DNA testing to corroborate identity, 107 were confirmed as positive (89.1%). This example is based on presumptive identifications for cases from 2002 to 2007. Note that cases are later in time than the sample used for study in the ICTY-UT project; however the high rate of correct classification supports the identification methodology employed through UN protocols (i.e., clothing, AM–PM comparisons, investigative, and exclusion. Refer to Baraybar of this volume for more information on the identification processes used in the Balkans). The correct classification immediately following the conflict in 2000 is likely to be even higher as many more of those cases were identified immediately following the deaths based on facial recognition by family members.

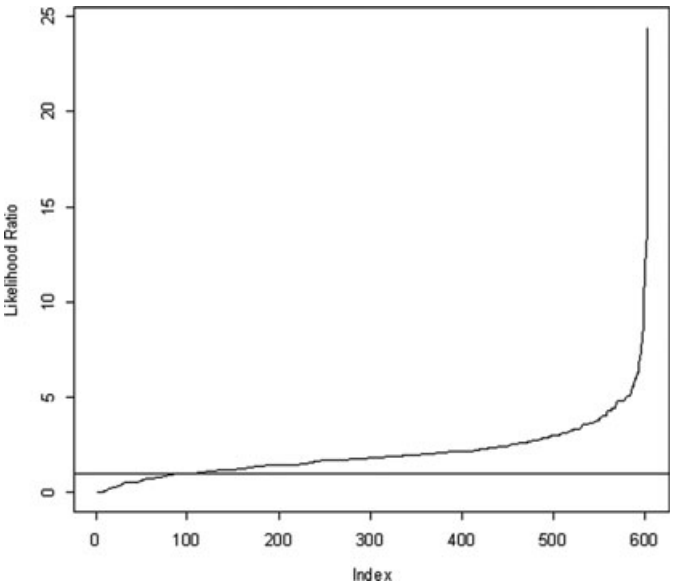

FIG. 1—*Plot of the sorted likelihood ratios for 603 identified cases. The likelihood ratio for each individual is the probability of obtaining the observed skeletal/dental age "markers" for the identified individual's age versus the probability of obtaining the "marker" data from the "population at large." The horizontal line is at 1.0 and represents the case of "evens," where the data are as likely from the identified individual as from the "population at large." Of the 603 individuals only 15% have a likelihood ratio of less than 1.0.*

A Review of Age-at-Death Estimation in the Balkans

Forensic anthropologists working in the Balkans and throughout the world primarily apply a set of American-based skeletal aging methods to estimate adult ages-at-death. These include methods that assess the morphology of the pubic symphysis (13,14) and the fourth sternal rib end (11,12). These methods consist of categorical phases based on morphological characteristics that change successively throughout adulthood and are classified into phases, which are each assigned a mean age and a broader age interval, based on the 90% or 95% confidence interval of the mean or standard deviations of the mean. These prescribed age intervals are derived from descriptive statistical parameters. Furthermore, these methods are primarily derived from American war dead, anatomical, historical, and forensic collections, for example the Robert J. Terry Anatomical Collection housed in Washington, DC; American war dead from the Korean War; and modern forensic remains such as those obtained through the Los Angeles Office of the Coroner in Los Angeles County, California.

The application of methods derived from one population and applied to different populations has been controversial and often leads to the reporting of high rates of inaccuracy (5,15,22,23). For example, Komar (23: 714) found that the known ages of only 42.4% of identified cases fell within the anthropological age ranges estimated by anthropologists working for Physicians for Human

Rights in BiH. Komar (23: 715) attributed the lack of accuracy in applying American standards to a Bosnian population to, "…the application of standards derived from North American skeletal samples to European contexts." Komar (23: 716) further stated that the standards, "…were created on North American samples and have not been adequately tested on Eastern European populations… ."

Research on biological and statistical variation in estimating biological parameters for identity have led to a revision of many of the American and European standards used across populations in the field of anthropology (24–27). Specifically for the Balkans, several studies have addressed the issue of American and Balkan aging differences and have offered new aging parameters derived from Balkan skeletal samples. A growing body of research in all aspects of biological profiling has occurred on Balkan populations since 1995, undertaken by numerous investigators from a variety of agencies in the pursuit of aiding the identification processes that are currently underway in those regions (15,28–41).

To assess the accuracy of the overall aging protocol currently used in the former Yugoslavia, the estimated anthropological age ranges are compared to the actual identified ages for 730 individuals. The actual ages of identified individuals fell within estimated anthropological ranges in 75.9% of cases from Kosovo constructed by anthropologists working for the ICTY during the field season of 2000. The difference between identified and estimated ages are calculated as the number of years the identified age falls outside of the estimated age range, either above or below the estimated range. Figure 2 demonstrates the accuracy of age estimation in Kosovo. The actual ages of identified individuals are plotted against the estimated anthropological age intervals. Among the 24.1% of cases where the actual age was outside of the estimated ranges, juveniles under 18 years, tend to be under-aged, adults under the age 50 tend to be over-aged, and adults over the age of 50 years tend to be under-aged.

In addition to the aging methods that rely on categorical phase data, the Lamendin dental technique (42) is also part of the current protocol used in the Balkans and regresses age on dental indicators (periodontosis, root height, and translucency of the root). The technique is derived from a sample of 208 dental patients in France, including males and females of both French and African ancestry. The Lamendin technique is commonly used with success throughout Europe and the United States. To test the accuracy of the Lamendin method on predicting age among the Kosovo sample, the rate of correct age estimation was reviewed. It should be pointed out that age estimation was based on a variety of skeletal and dental methods. This review compares only the parameters estimated from the Lamendin method to the overall estimated anthropological age interval. This point cannot be understated; anthropologists use a variety of methods to construct an overall age interval for an individual, and one method may fall within or outside of those parameters, which is not a measure of its accuracy or reliability of the whole age estimate. Rather, this exercise demonstrates how each specific method under review generally compares in actual cases.

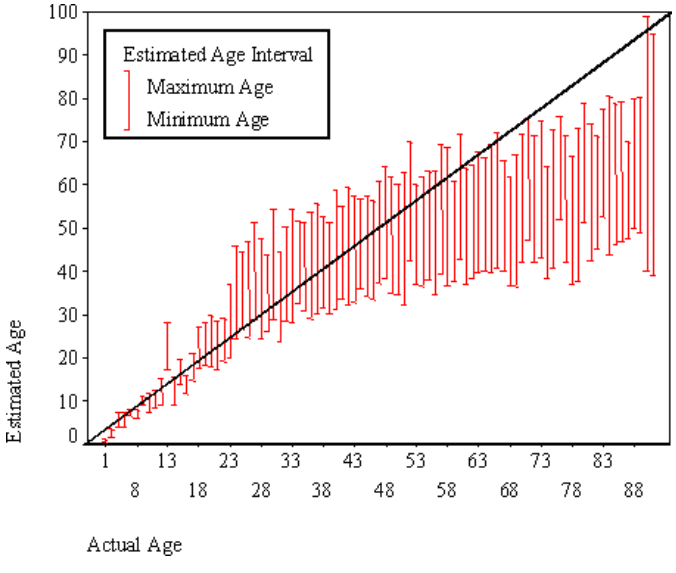

FIG. 2—*Accuracy of age estimation in Kosovo. The actual ages of identified individuals are plotted against the estimated anthropological age intervals. The estimated age interval (red line) represents the minimum and maximum age for each individual.*

Estimating age solely on the Lamendin dental technique, we find that the ages of 40.0% (179/448) of identified ICTY cases are misclassified with no difference in accuracy noted between males (misclassified 40.1% of cases) and females (misclassified 40.4% of cases). However, among the cases that are misclassified, 18.1% of identified ages are below the estimated age intervals among males, whereas 31.6% of female cases are below the estimated age interval. Most of the inaccuracy is in the 51–75 and 75+ year age cohorts. The standard error for these ages, as provided by Lamendin and co-authors is narrowest among individuals with estimated ages between 50–70 years, ranging from 6.3 to 7.3 years by decade. In contrast, younger aged individuals have a 15.5–24.8 year standard error. Likely, the narrower age ranges estimated for middle and older aged adults is leading to their high misclassification rate.

Finding that the method underestimates older aged adults may be an artifact of the statistical methodology used to establish age parameters, inverse calibration, where age is regressed onto dental metrics and the dental character is assumed to be dependent on age. This statistic is based on an informative prior, with the prior being a normal distribution from the reference sample therefore causing "regression to the mean" age of the reference sample. As a further result, the older aged individuals have artificially tighter age ranges (43).

Prince and Ubelaker tested the Lamendin technique on an American anatomical collection and found that it produced a reliable result with a slightly lower mean error and lower inter-observer error than the original study (44). Sarajlic and co-workers (35) further tested both the original Lamendin method and the re-calibrated Prince and Ubelaker method on a recent Bosnian forensic sample and found that the Prince and Ubelaker re-calibration produced even lower mean errors for Bosnians than the original Lamendin study.

A Review of Sex Estimation in the Balkans

Using the current protocol, the estimation of sex from skeletal remains is primarily based on the morphological characteristics of the skull and pelvis. The skeletal traits in question range on a five-point scale with male and female characterized at each end of the scale as described in Buikstra and Ubelaker (45). Using a five-scale system rather than a dichotomous male versus female trait approach, such as Phenice (46), accounts for the variation and degree of sexual dimorphism among diverse populations. Population variation in sexual dimorphism can pose a significant problem when applying one method across populations. For example, Ferllini found that applying American standards of sexing criteria to

Rwandan skulls was problematic because males and females were less robust than Americans:

"…in the morphological analysis, Rwandan male skulls exhibited marked frontal eminences, which are considered to be a female trait in Western skeletal samples. Additionally, craniometric analysis was applied to the skulls in question the measurements obtained being fed into the *Fordisc* computer program, which produces a statistical probability of the sex based on the measurements taken. The results would at times contradict the morphological analysis. As a result, the morphological analysis was considered to be the more reliable method." (47:296)

Since populations vary in sexual dimorphism (48–50), parameters for estimating each group are relative to the particular population in question.

In this investigation, it is apparent that the sex estimation parameters collected by the ICTY for individuals in Kosovo have an overall high rate of correct classification (95.2%, 932/979). Further, we find that the use of the pelvic morphology produces a slightly higher success rate for correct classification than cranial morphology with fewer remains classified as indeterminate. In Table 1, the anthropological estimation of male and female classifications is compared with the known sex of identified individuals. Using cranial morphology, 94.3% of individuals are correctly classified as male, 86.5% correctly classified as female, <1.0% incorrectly classified as either male or female, and 5.9% classified as indeterminate. If the pelvic morphology is considered exclusively, we find a similar, but slightly higher result; 98.1% individuals correctly classified as male, 91.0% correctly classified as female, again <1.0% incorrectly classified as either male or female, but only 2.6% classified as indeterminate.

A Review of Stature Estimation in the Balkans

The value of stature as a cornerstone of the biological profile of an individual rests on the assumption that there is an accurate record against which an estimation of that stature can be compared. It has been demonstrated by numerous researchers that records such as a driver's license generally do not accurately reflect the real height of an individual (51–54). Therefore, we must ask the question: *If the self-perception of stature is potentially biased, how un-biased is the perception of our own stature by others?*

In contexts outside the United States, where violations against IHL take place, the existence of antemortem documents containing biographical information is most often scarce and if present, serious doubts regarding the recorded stature should be cast. In these situations, the antemortem information is collected from survivors or relatives of the victims (37). For example the relative being interviewed may say, "my father was as tall as you are" or "he was shorter than me." In these situations, the interviewer will make an estimate of the stature being referred to and write it down as such. The remains of the victims that we examine may carry identification papers; however, it is not certain whether those papers belong to that individual. In addition, the information in those papers varies and may or may not include stature. More often, victims of HHRR violations or extra-judicial executions generally have their identity papers taken from them.

There are currently three formulae available for estimating skeletal stature in the former Yugoslavia. The Trotter and Gleser (55) method is the first technique developed for both males (n = 545) and females (n = 255). The male formula is based on the living statures of mid-20th century American male military personnel, whereas the female formulae are based on the cadaver statures recorded from a 19th and early 20th century American anatomical sample (the Robert J. Terry Collection housed at the Smithsonian Institution in Washington, DC). This method is calculated using inverse linear regression coefficients, where long bone length is used to predict height. Second, the Sarajlic (35) Bosnian formula for males (n = 50) is derived using the same methodology as Trotter and Gleser, but is based on a known, contemporary forensic collection from BiH. Third, the Ross and Konigsberg (36) formula for males (n = 177) is calculated using a different statistical approach than the previous two methods, a set of Bayesian statistical methods, which relies on an informative prior taken from the known distribution for young adult males from the Balkans.

In 2002, Baraybar and Kimmerle (37) presented a study comparing the three different stature methods to Croatian and Kosovan populations. The frequencies with which reported stature fell outside the estimated range varied from 39.0% to 57.0% when one standard error for each method was used. The Trotter and Gleser method produced the greatest frequency of error; however, one standard error has been repeatedly shown to be inadequate and numerous researchers, including Trotter herself in 1970, warned that two standard errors should be used. Applying two standard errors reduced the number of cases that fell outside of the range to less than 14%, which seemingly worked too well, with an 11.8 cm range. In over 90% of cases, the reported antemortem statures were greater than the maximum estimated value. In other words, all three formulae tended to underestimate the reported stature (Table 2).

Individuals with either the shortest or longest femora tended to have the same reported height. For the Croatian sample, the reported stature also has a greater mean, standard deviation, and range than the predicted estimates, which are shown here to underestimate stature on both the lower and higher ends of the range. We believe that this is likely an artifact of people's tendency to overestimate stature when trying to approximate someone's height.

TABLE 1—*Correct classification of sex estimation.*

	Identified Individuals	
Anthropological Estimates	Males (n = 421)	Females (n = 67)
Cranial morphology		
Estimated as male	397 (94.3)	2 (2.9)
Estimated as female	2 (<1)	58 (86.5)
Estimated as indeterminate	22 (5.2)	7 (10.6)
	Males (n = 424)	Females (n = 71)
Pelvic morphology		
Estimated as male	416 (98.1)	2 (3.1)
Estimated as female	2 (<1)	61 (91.0)
Estimated as indeterminate	6 (1.4)	7 (5.9)

Values given in parenthesis are in percentage.

TABLE 2—*Frequency of reported stature outside estimated stature range.*

Estimated Stature	±1 SE	±2 SE
Sample 1: Croatia		
Ross and Konigsberg	39.0% (32)	–
Trotter and Gleser	56.0% (46)	12.0% (10)
Sarajlic	41.5% (34)	–
Sample 2: Kosovo		
Ross and Konigsberg	49.0% (24)	–
Trotter and Gleser	57.0% (28)	14.0% (7)
Sarajlic	53.0% (26)	–

TABLE 3—*Differences between reported and estimated stature.*

Estimated Stature	Mean Difference (cm)	SD
Sample 1: Croatia		
Ross and Konigsberg	2.55	4.59
Trotter and Gleser	3.75	4.59
Sarajlic	4.34	4.87
Sample 2: Kosovo		
Ross and Konigsberg	2.9	5.47
Trotter and Gleser	3.5	5.72
Sarajlic	5.7	5.67

TABLE 4—*Paired* t*-tests comparing reported and estimated statures.*

Reported Versus Estimated Stature	*n*	df	*t*	*p*
Sample 1: Croatia				
Ross and Konigsberg	82	81	5.069	<0.001
Trotter and Gleser	82	81	7.436	<0.001
Sarajlic	82	81	8.112	<0.001
Sample 2: Kosovo				
Ross and Konigsberg	49	48	3.813	<0.001
Trotter and Gleser	49	48	4.379	<0.001
Sarajlic	49	48	7.000	<0.001

Finally, if we compare the three formulae, we find that the mean differences range from 2.5 to 4.3 cm (Table 3). The differences between the recorded antemortem height and the three predicted estimates are statistically significantly (Table 4).

A brief comparison of the three methods illustrates that the formulae for predicting stature, compared with the reported estimates produces mean differences of 2.5–4.3 cm for the Croatian sample and 2.9–5.7 cm for the Kosovan sample. The formulae provided by Ross and Konigsberg provides the closest measure of stature for both groups. This formula differs from the other two in that it is first, derived from a Balkan sample and second, based on a Bayesian statistical approach. While this confirms what we know about the considerable need for local standards, Sarajlic's formula was also derived from a Croatian sample, yet exhibits the greatest mean difference of 4.3 cm for Croatians and 5.7 cm for the Kosovo sample. Like Trotter and Gleser, his formula is derived from inverse calibration. While a mean difference of 2.5–2.9 cm may seem negligible, Baraybar and Kimmerle applied the same method of paired *t*-tests to the Kosovan sample, and came to the same conclusion—there are statistically significantly differences between recorded antemortem heights and the predicted statures using all three formulae.

This is not to say that these methods do not in and of themselves provide information as to the deceased's stature. Rather, the error is not in the method but in the antemortem data itself. The estimation of stature has long been considered one of the four cornerstones of the biological profile of an individual together with age, sex, and ancestry. In spite of the researchers who have pointed out the variability that exists in the stature records and in their incomparability with postmortem findings (51–54), the use of stature estimation has been highlighted as important in individual identification and over the years various methods have helped to strengthen this estimation. The areas that are most often the focus of research in regard to improving stature estimation are secular change, inter-population variation, and statistical methodology. While these issues are important considerations in any stature discussion (refer to Jantz and co-workers of this volume), the fourth issue is too often ignored—and that is the validity of the comparison between sources of data that do not correspond to one another, meaning witness accounts about biological parameters versus estimations of biological parameters derived from skeletal remains.

Conclusions and Recommendations of Best Practice

Biological profiles estimated from skeletal remains contribute to the process of identification for individual victims by establishing the first parameters of identity that lead to a tentative identification. In addition to providing resolution for families and restoring dignity and significance to victims, identification is important in the legal context as individuals are named in the indictments against suspected war criminals. Skeletal data also lead to the construction of the demographic profile of the population of victims and are important evidence in the prosecution of those indicted for violations of International Humanitarian Law, particularly genocide where the intent to destroy a group of people is at issue.

The results produced from the ICTY-UT collaboration are an unprecedented and comprehensive body of work that is applicable to investigators in the Balkan region and further impacts anthropologists working globally on HHRR cases by providing a model of skeletal assessment for the creation of biological profiles that can be applied to any population. One of the key components for anthropologists tackling these issues in the future should be to meet the requirements for the presentation of scientific evidence in court by providing probability statistics with each case and accounting for error. Scientific inquiry into the accuracy of anthropological data and methods ensures that the evidence is not exculpatory; refer to the Appeals Chamber Judgment of 19 April 2004, ruling on the identification and disclosure of exculpatory evidence in the Krstić case (10). Therefore, scientists have ethical obligations to present only the most accurate evidence and to report associated standard errors.

The objectives of the ICTY-UT project were to investigate population variation among Americans and East Europeans and to ensure that the scientific protocols used provide accurate and reliable estimations of the parameters of identity and the reconstruction of demographic profiles of victims that is based on probability statistics with the intention that anthropological evidence would remain a crucial part of the evidence presented in war crimes trials and lead to a greater number of victim identifications. It is demonstrated that the individual and population parameters estimated through the ICTY protocols are accurate and have been successful in achieving a high rate of successful identifications. The need to apply population specific methods can only serve to increase accuracy (as with the stature estimates produced from using Balkan data calibrated through Bayesian statistical models).

Future investigations aimed at improving methodology for the estimation of biological parameters is as much theoretical as it is mathematical. In other words, there should be a paradigm shift away from applying First World methodology globally towards developing an approach to the concept of identification that is relevant for the specific context, given the breadth of cultural, biological, and legal diversity; in addition to Bayesian statistical approaches for modeling demographic data. The value of an adaptable framework for human identification internationally applied is demonstrated through recent legal challenges that highlight differences between anthropological methods for estimating biological parameters and the applicability of antemortem data collected from survivors and family members.

What compounds the issue of identification is the general lack of knowledge about the parameters of the pool of victims. While mass disasters are generally finite events in time, space, and the number of victims involved, mass atrocities due to human rights violations and war occur over a long period of time, and may

involve hundreds of thousands of victims spanning large geographical areas. There is a false assumption that the pool of missing persons is known, when in fact, in most cases of HHRR the Missing are not known and include not only murdered victims but also internally displaced persons and foreign refugees. Notable examples of this are the Rwandan Genocide of 1994, the massacres in the Democratic Republic of Congo in 1997, the various conflicts in the territories of the former Yugoslavia, among others. Estimates of the number of dead as a consequence of the Rwandan Genocide alone vary between 800,000 and one million people.

The second challenge is whether or not the Missing have characteristics known to those individuals who are reporting that they are missing. Who knows your unique characteristics, for example your height, the number of caries you have or which joints are affected by osteoarthritis? In addition to knowing these biological characteristics, dental disease or skeletal pathology may change during the course of a conflict where people do not have access to medicine, dental care, or adequate nutrition. Therefore, even when pre-existing antemortem dental or health records do exist, they may have limited use due to changes that occur after years that health and dental care was absent or denied. Consequently, the problem facing investigators is not only one of reporting, but also biological parameters that change over time and access to that knowledge.

Finally, victims of HHRR violations or those who are intentionally targeted during an armed conflict are often not random; rather there may be a directional element in who is killed, depending on the context or nature of the armed conflict. As a result, the characteristics of the unidentified as well as the missing may be directional, particularly in regard to demography. A Bayesian statistical approach offers a mechanism to account for this element and to provide a level of certainty to demographic profiles or other interpretations drawn from skeletal data.

Disclaimer

This study does not represent in whole or in part the views of the United Nations but those of the authors.

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