

Daubert and the Effect on Biological Profile Research

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ABSTRACT: As a core component of casework, methods for estimating the biological profile must meet current legal standards to be admissible as part of a forensic anthropologist's expert witness testimony. Since the 1993 US Supreme Court *Daubert* decision, forensic anthropologists have voiced concern that methods relying on subjective or qualitative data might now be at risk of judicial exclusion. This research used a bibliometric approach to assess whether current forensic anthropology research has shifted toward the use of more objective and/or quantitative data. Forensic anthropology articles published in the *Journal of Forensic Sciences* between 1972 and 2020 were reviewed ($n = 1,142$), with data collected on each article's topic, use of different data types, and inclusion of observer error studies. A subset of articles focusing on methods for estimating the four main parameters of the biological profile (age, sex, ancestry/population affinity, stature) was analyzed using chi-square tests for trend in proportions. Age and sex estimation articles showed a significant shift toward more quantitative data ($p < 0.001$), although no biological profile subtopic showed a significant shift toward more objective data. While this may seem to be a surprising result, a deeper review of current legal standards and standards of practice suggests that *Daubert* does not require significant changes to how forensic anthropologists approach research design and method development. So long as the principles of good science are followed, the continued reliance on qualitative data should not be a concern from the standpoint of evidentiary admissibility.

KEYWORDS: forensic anthropology; biological profile; admissibility standards; research methodology

Introduction

Since its inception as a recognized scientific discipline, forensic anthropology has existed under the medicolegal framework to assist law enforcement in the recovery, identification, and analyses of human skeletal remains. As a result, forensic anthropologists are frequently called upon to present the results of their work within a court of law as expert witnesses. An expert witness is someone qualified by some combination of knowledge, skill, experience, training, and/or education and who may be called upon to testify if their scientific knowledge would help either the judge or jury to better understand the issues in question or the evidence being presented (Fed. R. Evid. 702 (2011)).

When a forensic anthropologist is called upon to testify in a court of law as to their expert opinion, the estimation of the biological profile is rarely at issue (Lesciotto 2015). However, estimations of the biological profile are a core component of a forensic anthropological case analysis. Anthropologists

may perform a full biological profile estimation while waiting for DNA analyses or perform confirmatory analyses when law enforcement has a presumptive identification at the onset of the case. By the time a case reaches the courtroom, in the vast majority of instances, the identity of the decedent typically has been established based on forensic anthropology or odontology analyses, DNA results, or other methods, or has been stipulated to by the prosecution and defense. Forensic anthropologists are currently much more likely to be called upon to testify regarding skeletal trauma, taphonomic analyses, and estimations of the postmortem interval (Lesciotto 2015). However, forensic anthropologists must still strive to use validated biological profile methods that meet or exceed current legal admissibility standards. While biological profile analyses may not be a focus of any anticipated expert testimony, if these analyses appear anywhere within the expert report or case documentation, the use of any unproven or unreliable biological profile estimation methods could potentially be used to discredit the anthropologist or form the basis of a motion to exclude them as an expert witness.

When testifying, forensic anthropologists are subjected to the same standards as any other expert witness. Comprehensive analyses of the relevant case law have previously been published (see, e.g., Christensen 2004; Christensen & Crowder 2009; Fradella et al. 2004; Grivas & Komar 2008), so only a brief review is provided here. Objections to an expert witness typically assert flaws in one of three areas

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(Lesciotto 2015). First, opposing counsel may question whether an individual has the necessary knowledge, skills, or training to be qualified as an expert witness. Second, the reliability of the methods or techniques used by the expert to arrive at their opinions and conclusions may be called into question. Third, even if a witness is qualified as an expert and used reliable methods, there may still be an argument that the expert's opinions are not relevant to the issues in question in that specific case. Forensic anthropologists are most typically challenged on the second issue, on the basis of whether their methods are sufficiently reliable (Fed. R. Evid. 702 (2011); Lesciotto 2015).

Prior to 1993, when evaluating the reliability of expert witness testimony, most courts in the United States relied upon the 1923 Supreme Court *Frye v. United States* standard that the techniques and methods used by an expert witness to arrive at their conclusions must have been "generally accepted" within the relevant scientific field (293 F. 1013 (CADC 1923)). This "general acceptance" standard was later called into question, and the US Supreme Court again addressed the issue of reliability in evaluating whether an expert witness's testimony is admissible in *Daubert v. Merrill Dow Pharmaceuticals, Inc.* (509 US 579 (1993)).

The *Daubert* decision clarified that the *Frye* "general acceptance" standard had been superseded by the adoption of Federal Rules of Evidence (FRE) 702 (509 US 579 (1993)). The Court bluntly stated that nothing in the text of FRE 702 established "general acceptance" as a prerequisite for admissibility, nor was there any indication that this was the intent behind adopting FRE 702. Instead, when assessing the admissibility of expert witness testimony under FRE 702, the Court instructed judges to evaluate whether the expert's underlying reasoning or methodology was scientifically valid and properly applied through a flexible inquiry. This inquiry could examine a number of factors, including whether the technique or method has previously been tested, has standards for carrying out the technique or method, has been subjected to peer review and publication, has a known error rate, or is accepted within the relevant scientific field (509 US at 593–94 (1993)).

Subsequent decisions by the US Supreme Court have clarified and reinforced the ruling in *Daubert*. In 1997, *General Electric Co. v. Joiner* stated that, as part of their "gatekeeper" role, judges were permitted to assess whether the methods used by an expert adequately supported the conclusions drawn (522 US 136 (1997)). The 1999 *Kumho Tire Co. v. Carmichael* decision clarified that, while *Daubert* applied to all expert testimony, the factors listed in *Daubert* might not apply in all cases (526 US 137 (1999)). For example, when appropriate, expert testimony could also be based on observations or case studies, which provided additional levels of flexibility for judges evaluating more specialized expert witness testimony.

While the *Daubert* decision was issued in 1993, forensic science in general and forensic anthropology more specifically took significant time before seriously considering the potential impact (Holland & Crowder 2019). Two major events may have provided the stimulus for undertaking a more serious evaluation of the potential impact of *Daubert* on forensic anthropology. First, in a 2002 case from the Eastern District of Pennsylvania, a district court judge initially ruled that, while fingerprint examiners would be permitted to testify as to the similarities and differences between a latent print and the fingerprint of a particular individual, they would not be permitted to testify as to whether or not a latent print was a match to the print of a specific person (*United States v. Llera Plaza*, 179 F. Supp. 2d 492 (2002)). This finding was based on an analysis of the *Daubert* factors. This analysis concluded that, while the specific method of assessing fingerprints used in the case was generally accepted within the American fingerprint examiner community, the method did not adequately satisfy the factors of being subjected to scientific testing, being peer reviewed, having a defined error rate, or operating under accepted standards of method performance (179 F. Supp. 2d 492 (2002)). After additional briefings and hearings, the district court judge quickly reversed their ruling (*United States v. Llera Plaza*, 188 F. Supp. 2d 549 (2002)), but the shockwaves of potential implications within the broader field of forensic science had already begun (e.g., Christensen 2004; Holland & Crowder 2019).

Second, the National Academy of Sciences 2009 report, "Strengthening Forensic Science in the United States" ("NAS Report"), emphasized the importance of *Daubert* in relation to the forensic sciences (National Research Council 2009). Specifically, the NAS Report notes the fundamental problem of forensic science experts presenting evidence to judges and lawyers who frequently lack the scientific expertise necessary to properly evaluate the admissibility of that evidence (National Research Council 2009). However, developing solutions to this problem is complicated by the variable nature of how *Daubert*-type evidentiary challenges are handled at the trial court level. While some courts conduct formal *Daubert* hearings with published opinions reporting the outcome, others will handle *Daubert* objections in the moment, without formally recorded documentation (National Research Council 2009). This variation muddies the understanding of how evidentiary challenges are typically handled; however, the NAS Report still concludes that there is a "tremendous need" for improvement within the forensic sciences, placing at least part of the burden of ensuring the admissibility of forensic methods on the practitioners who are developing and applying those methods to casework (National Research Council 2009). This burden is encapsulated within the report's concluding recommendations, which include the need for improved studies to establish the scientific bases

and validity—as well as the quantification of both reliability and accuracy—of forensic methods (National Research Council 2009).

The first mentions of *Daubert* in forensic anthropology articles published in the *Journal of Forensic Sciences* occurred in 2004, with discussions of how the use of cranial suture patterns and frontal sinus outlines for positive identification might fare under the new admissibility standard (Christensen 2004; Rogers & Allard 2004). Since then, *Daubert* and the NAS Report have frequently been cited in forensic anthropology articles, and forensic anthropologists anticipated significant impacts on the field, with some predicting a fundamental paradigm shift in research and method development within forensic anthropology (see, e.g., Christensen 2004; Christensen & Crowder 2009; Dirkmaat et al. 2008; Dirkmaat & Cabo 2012; Grivas & Komar 2008; Rogers & Allard 2004; Ross & Kimmerle 2009). Many publications cited *Daubert* in the need for forensic anthropology as a field to move toward more quantitative and objective methods in order to avoid the potential risk of judicial exclusion (e.g., Cameriere et al. 2005; Casado 2017; Christensen 2005; Cox et al. 2009; Dirkmaat et al. 2008; Maier et al. 2015). Subsequent research found a relatively low number of evidentiary exclusions aimed at forensic anthropologists and asked whether this might be the result of the anticipated paradigm shift and the field's self-regulated response to *Daubert* in moving away from subjective and qualitative methods and toward objective and quantitative methods (Lesciotto 2015).

This research tests the hypothesis that forensic anthropology research has shifted in response to the *Daubert* decision by moving away from qualitative, subjective methods and toward a greater emphasis on quantitative, objective methods with known error rates. Given the common inclusion of biological profile estimation within forensic anthropological casework, this study focused on research directed toward methods used to estimate the primary areas of the biological profile: age, sex, ancestry or population affinity, and stature.

Materials and Methods

To test the hypothesis of this study, an inclusive review of forensic anthropology articles published in the *Journal of Forensic Sciences* (*JFS*) between 1972 and 2020 was conducted. While articles relating to forensic anthropology are often published in many other academic journals, *JFS* is the official publication of the American Academy of Forensic Sciences, with wide representation of the United States within its readership and contributing authors. As *Daubert* is a legal standard uniquely applicable within the US legal system, *JFS* was selected as an appropriate data source for this study. The first issue of *JFS* was published in 1956 by

Callaghan & Company; however, volumes 1 to 17 of *JFS* are neither digitally searchable nor readily available and were therefore excluded from this study.

From 1972 through 2005, *JFS* was published by the American Society for Testing Materials International (ASTM). Prior to mid-2002, ASTM did not include topic categories (e.g., Anthropology, Criminalistics, etc.) in either the Table of Contents or individual papers. Therefore, two searches were conducted to identify articles with a forensic anthropology focus published in *JFS* between 1972 and 2002: (1) all titles were reviewed for potential relevance to forensic anthropology and (2) the full text of all articles was searched for the terms “anthropology,” “bone,” “skeleton,” and “skeletal,” with results being further assessed for relevance. Starting in mid-2002 (Volume 47, Issue 4), ASTM began adding categories, including Anthropology, to the *JFS* Table of Contents. All articles listed under the “Anthropology” category in the Table of Contents from 2002 (Issue 4) through 2005 (Issue 6) were included in the initial data set. Since the beginning of 2006, *JFS* has been published by John Wiley & Sons, Ltd., which continued to publish articles listed under discipline-specific categories in the Table of Contents. All articles listed under the “Anthropology” or “Physical Anthropology” categories were added to the initial data set, including articles that were cross-listed with additional disciplines. Letters to the editor, author responses, and book reviews were excluded.

This search strategy resulted in an initial data set of 1,257 articles identified for further review (Fig. 1). The abstract of each article was reviewed to confirm the article's topical relevance to forensic anthropology. Articles published prior to 1980 did not include abstracts, requiring full-text review to determine relevance. At this stage of review, 115 articles were excluded due to topical focus outside of the traditional boundaries of forensic anthropology. The majority of the excluded articles were related to forensic odontology or dental anthropology. While dental analyses are frequently a part of casework or research, forensic odontology or dental anthropology articles were excluded to focus on articles related to skeletal analyses typically performed by forensic anthropologists. Other excluded topics included forensic entomology, forensic botany, and forensic hair analysis. These exclusions resulted in a final sample of 1,142 articles.

The abstract and title page of the final sample of 1,142 articles were used to record the following data: first author, year, title, keywords, category of article if noted by the publisher (e.g., Research Paper, Case Study, Technical Note, etc.), table of contents discipline category (e.g., Anthropology or Physical Anthropology, if provided), and topic within forensic anthropology (e.g., biological profile, trauma, etc.). Each article's topic within forensic anthropology was coded based on the strategy of Bethard and DiGangi (2019), with minor modifications (Table 1).

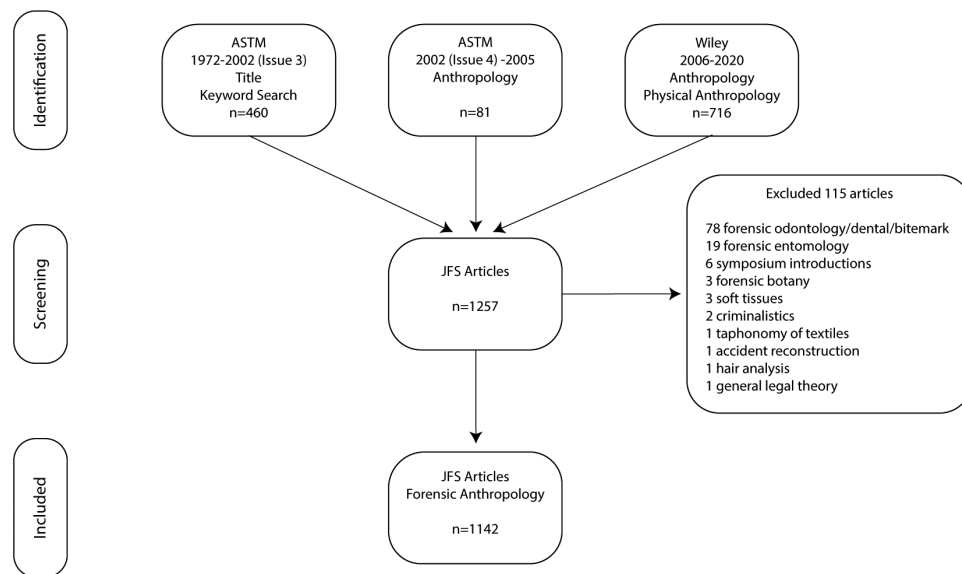


FIG. 1—Identification and screening process for articles published in the Journal of Forensic Sciences from 1972–2020 for inclusion in this study.

TABLE 1—Frequency of topic categories of forensic anthropology articles published in the Journal of Forensic Sciences from January 1972 to December 2020.

Topic	Frequency (n)	Percent
Biological Profile	411	36.0
Taphonomy/Postmortem Interval	132	11.5
Trauma/Toolmarks	128	11.2
Positive Identification	103	9.0
Facial Approximation	99	8.7
History	36	3.2
Field Methods/Forensic Archaeology	35	3.1
Osteometrics/Laboratory Procedures	31	2.7
Isotopes/Elemental Composition	27	2.4
Skeletal Pathology/Variation	27	2.4
Histology/Bone Anatomy/Bone Identification	25	2.2
DNA Analyses	19	1.7
Commingling	19	1.7
Human Rights/Humanitarian Issues	13	1.1
Processing/Maceration	13	1.1
Legal Issues	11	1.0
Ethics/Theory	9	0.8
Secular Change	4	0.4
Total	1,142	100

Articles focusing on the biological profile were further categorized by subtopic (Table 2). Subsequent analyses focused on the main four parameters of the biological profile: age, sex, ancestry or population affinity, and stature.

Abstracts were additionally evaluated to assess the approach of each article: analytical method, descriptive study, case study, field/lab protocol, historical perspective, review paper, or theoretical paper. Descriptive studies were defined as articles that presented some type of data but did not provide a specific method that could be implemented as part of a forensic anthropological assessment. As an example, an article that presented a new method or attempted to validate

an existing method for how to estimate age based on pubic symphyseal morphology would be coded as a “method” study, while an article that presented data on the distribution of age estimates based on pubic symphyseal morphology in a specific population would be coded as a “descriptive” study.

All biological profile articles categorized as “method” studies ($n = 349$) were then further evaluated to determine the type of data collected: objective vs. subjective and quantitative vs. qualitative. For the purposes of this study, the determination of whether data were considered quantitative or qualitative in nature depended on whether there was structure to the data being collected. To be coded as a

TABLE 2—Frequency of biological profile subtopic categories in articles published in the *Journal of Forensic Sciences* from January 1972 to December 2020.

Biological Profile Subtopic	Frequency (n)	Percent
Sex	161	39.2
Age	144	35.0
Ancestry/Population Affinity	46	11.2
Stature	45	10.9
Body Mass	6	1.5
Handedness	5	1.2
Parturition	4	1.0
Total	411	100

TABLE 3—Examples of data types that would be coded as objective vs. subjective and quantitative vs. qualitative for purposes of this study.

	Quantitative	Qualitative
Objective	The length of the bone is 207 mm.	The ossification centers have fused.
Subjective	On a scale of 1 to 5, the mastoid process is a 3.	The pubic symphysis has a billowy surface.

quantitative study, the data had to allow for some type of quantitative data analysis (i.e., the data were recorded as a number). Both osteological measurements (e.g., metrics) and numerical scoring systems based on skeletal morphology (e.g., ordinal categories) were considered quantitative data. In contrast, qualitative studies recorded data with no numerical attribute or inherent structure, including text or narrative descriptions or recording a feature or trait as either “present” or “absent.”

Classification of a study as either objective or subjective related to whether the data collected were definitive in some manner. Studies coded as objective included those that collected measurement data or the presence of an empirical trait. Subjective studies included those that used text-based descriptions of features or numerical scoring systems to describe variation in skeletal morphological traits. Representative examples of how articles were coded according to this framework are provided in Table 3. Based on this coding scheme, studies could be coded as quantitative-objective, quantitative-subjective, qualitative-objective, qualitative-subjective, or collecting multiple types of data.

Each of the biological profile “methods” articles in the data set was also evaluated as to whether inter- and/or intra-observer error data were collected. For this study, interobserver error data involved the comparison of two or more independent observers following the same method applied to the same sample, while intraobserver error data involved the comparison of two or more trials conducted by a single observer following the same method applied to the same sample. Each article was coded as having included an interobserver error study, an intraobserver error study, both types of error studies, or neither type of error study.

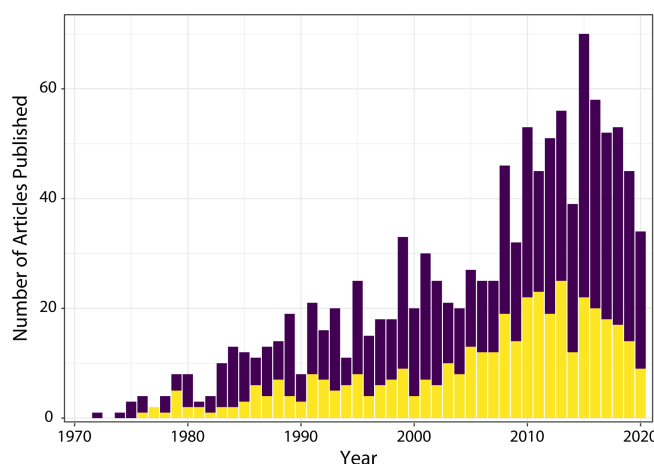


FIG. 2—The number of forensic anthropology articles published each year in the *Journal of Forensic Sciences* from 1972–2020, with articles focusing on the biological profile highlighted in yellow.

Following coding of the entire set of biological profile “methods” articles, the data were tested using chi-square tests for trend in proportions, also known as a Cochran–Armitage trend test, to determine whether the use of specific data types or assessment of intra- or interobserver error rates had changed generally over time. The data were then binned into pre- and post-*Daubert* groups to assess the potential for a more specific, direct effect of *Daubert* on forensic anthropology research, and chi-square tests of homogeneity were used. The division between the pre- and post-*Daubert* groups was set at 2004 rather than 1993 when the *Daubert* decision was issued, as 2004 represents the first citation of *Daubert* within a forensic anthropology article published in *JFS*. All statistical analyses were performed using RStudio (2022).

Results

General trends in *JFS* forensic anthropology publications

The number of forensic anthropology articles published in *JFS* varied from a single article in 1972, to a high of 70 articles in 2015, and back down to 34 articles in 2020. Throughout this time, articles focusing on the biological profile have maintained a steady presence, comprising roughly one-third of forensic anthropology articles (Fig. 2).

The main parameters of the biological profile (age, sex, ancestry or population affinity, and stature) were further examined, and several trends were noted (Fig. 3). The average number of articles published each year related to age and

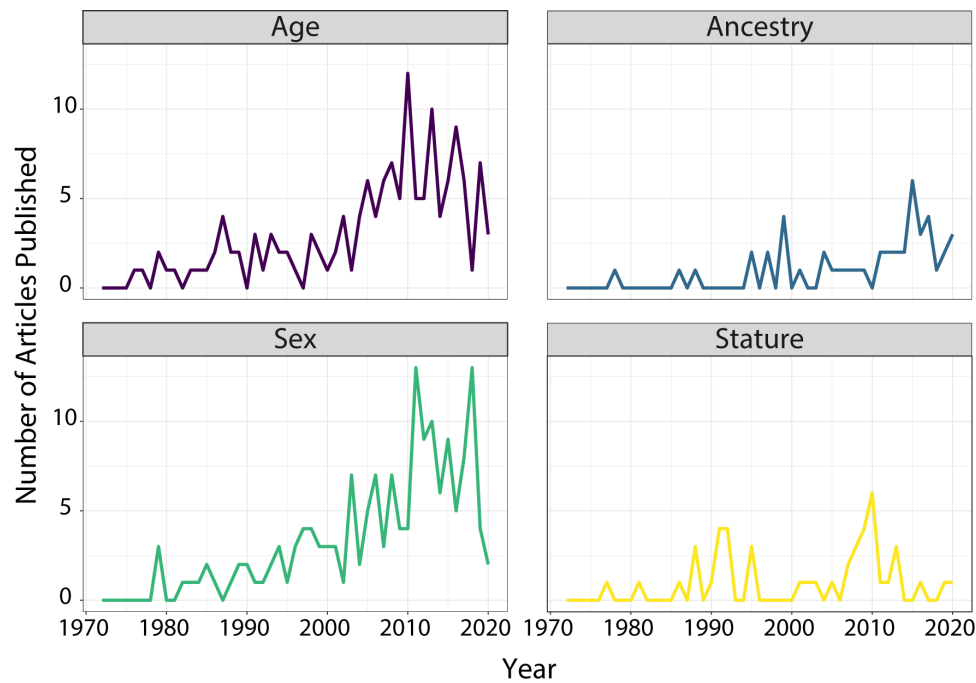


FIG. 3—The number of biological profile articles focusing on age, sex, ancestry/population affinity, and stature published each year in the *Journal of Forensic Sciences* from 1972–2020.

TABLE 4—Number of biological profile method articles, divided by those focusing on age, sex, ancestry/population affinity, and stature, that collected objective vs. subjective and quantitative vs. qualitative data.

	Objective	Subjective	Combination	Quantitative	Qualitative	Combination
Age	33	81	8	96	22	4
Sex	122	26	4	134	16	2
Ancestry	23	9	3	30	2	3
Stature	40	0	0	40	0	0

sex had a steadier progression through the span of *JFS*, with more significant increases in publication numbers after 2000. Ancestry/population affinity and stature research had seen lower overall publication numbers and experienced relative spikes and plateaus. Ancestry/population affinity publications increased in number during the 1990s and again in the 2010s, while stature publications saw relative increases during 1985–1995 and 2005–2015.

Has there been a shift toward more quantitative or objective methods?

Each article was evaluated as to whether the type of data collected were objective, subjective, or a combination of both types of data, as well as whether the data were quantitative, qualitative, or a combination, following the definitions provided previously (Table 4). All the articles presenting or testing a method for estimating stature were coded as both objective and quantitative, given the universal use of

osteological measurements. Sex and ancestry/population affinity estimation articles were most frequently coded as objective and quantitative, while age estimation articles were most frequently coded as subjective and quantitative.

Chi-square tests for trend in proportions were used to examine whether there had been a significant change in the proportion of biological profile articles using quantitative vs. qualitative data and objective vs. subjective data between 1972 and 2020 (Figs. 4 and 5). Chi-square tests of homogeneity were used to examine whether there was a significant change in the use of these data types when comparing between pre- and post-*Daubert* time frames. Although *Daubert* was issued in 1993, for this study, the post-*Daubert* time frame was marked by 2004, when *Daubert* first began being cited within the forensic anthropological literature published in *JFS*.

From 1972 to 2020, chi-square tests for trend in proportions showed a significant decrease in the proportion of articles using qualitative data in methods for estimating age and

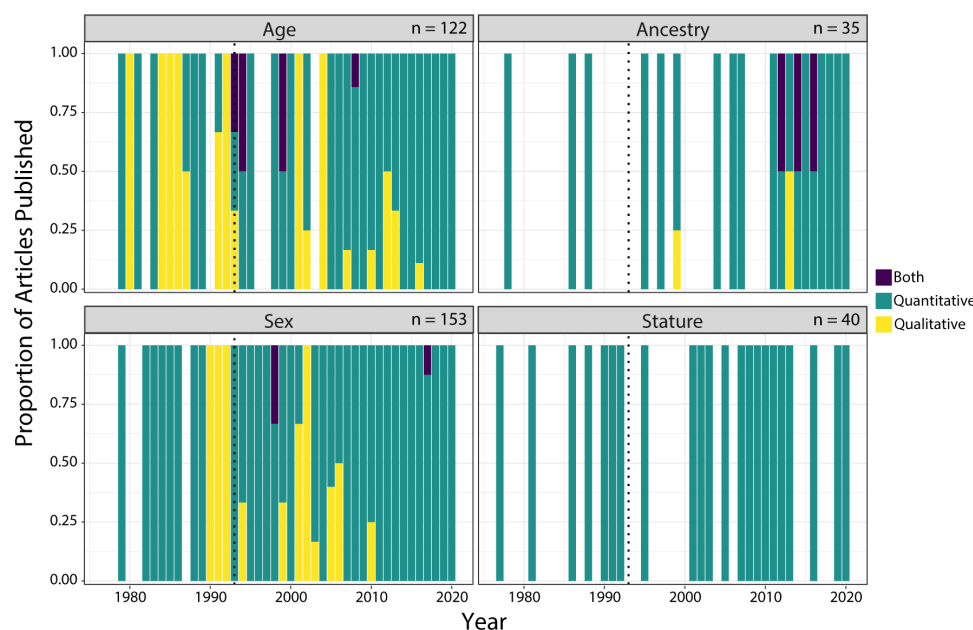


FIG. 4—Proportion of biological profile methods articles published in the Journal of Forensic Sciences from 1972–2020 that used quantitative (green), qualitative (yellow), or both types of data (purple). The vertical dotted line represents 1993, when the Daubert decision was issued.

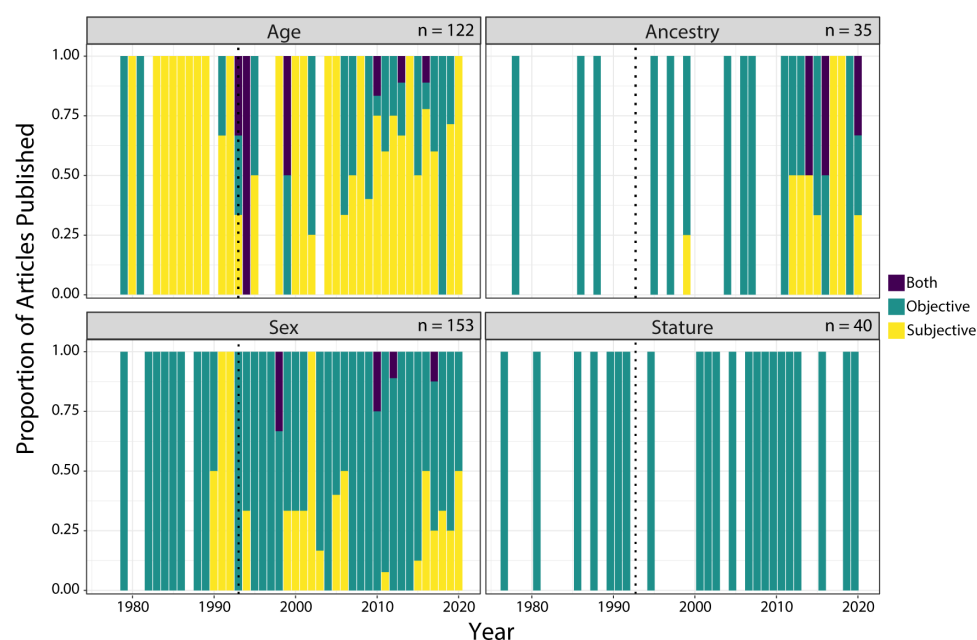


FIG. 5—Proportion of biological profile methods articles published in the Journal of Forensic Sciences from 1972–2020 that used objective (green), subjective (yellow), or both types of data (purple). The vertical dotted line represents 1993, when the Daubert decision was issued.

sex across the entire time span ($p < 0.001$). There was no significant change in the proportion of articles using quantitative vs. qualitative data for ancestry/population affinity or stature estimation articles; however, it is again noted that all of the stature estimation articles included in this data set used

quantitative measurement data. Similarly, chi-square tests of homogeneity showed a significant difference in the use of quantitative vs. qualitative data in age ($p < 0.001$) and sex ($p < 0.05$) estimation articles but showed no difference for ancestry/population affinity or stature estimation articles.

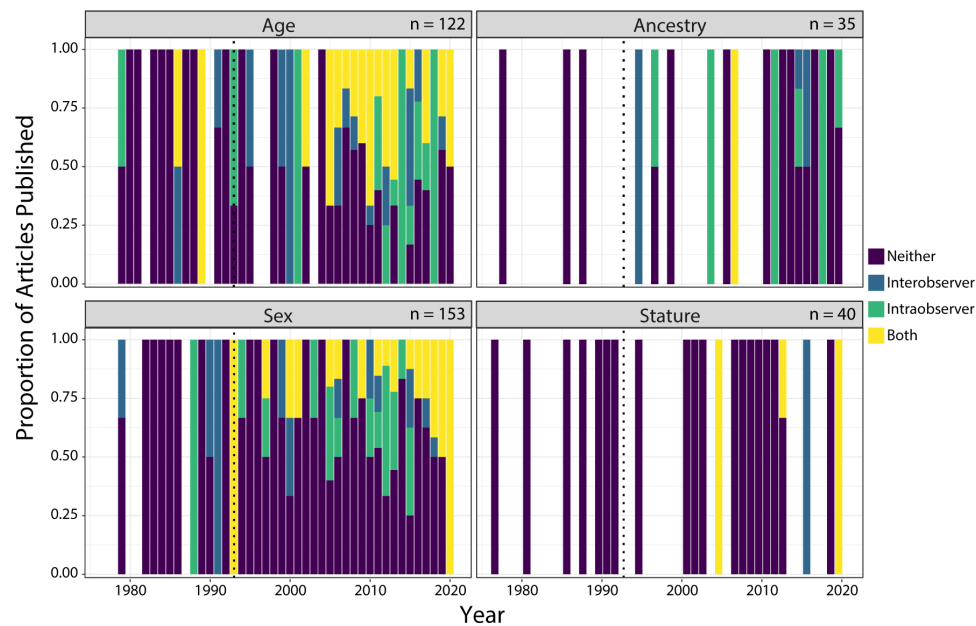


FIG. 6—Proportion of biological profile methods articles published in the Journal of Forensic Sciences from 1972–2020 that included an intraobserver error study (green), an interobserver error study (blue), both types of error studies (yellow), or neither type of error study (purple). The vertical dotted line represents 1993, when the Daubert decision was issued.

TABLE 5—Number of biological profile methods articles that provided data on intra- and/or interobserver error rates.

	Intraobserver	Interobserver	Both	Neither
Age	18	16	34	54
Sex	25	13	25	89
Ancestry/Population Affinity	8	3	1	23
Stature	0	1	3	36

When coding the same data set of biological profile “methods” articles as using either objective or subjective data, no subtopic showed a significant increase in the proportion of articles using objective data when examining the data set across the entire span of 1972–2020. To the contrary, articles focused on ancestry/population affinity estimation actually showed a significant increase in the use of subjective data ($p < 0.05$) across time. There were no significant differences in any biological profile subtopic when comparing the pre- and post-*Daubert* subsets for the use of objective vs. subjective data.

Finally, the data set was coded for whether the method presented or tested was subjected to at least one type of observer error study (Fig. 6; Table 5). For the chi-square test in the trend of proportions, biological profile method articles that tested either intraobserver error, interobserver error, or both types of error studies were grouped together in order to examine whether there had been any shift in how frequently publications quantified any type of observer error. There was a significant increase in the proportion of articles focused on

age ($p < 0.01$), sex ($p < 0.05$), and stature ($p < 0.05$) estimation that performed at least one type of observer error study across the entire data set. However, no significant differences were found when strictly comparing the pre- and post-*Daubert* subsets.

Discussion

Estimation of the biological profile is a core component of typical forensic anthropology casework. It is therefore not surprising that articles focusing on the biological profile have made up approximately one-third of all forensic anthropology articles published in *JFS* from 1972 to 2020. However, the rise and influence of *Daubert* on forensic anthropology as a field has been hypothesized to have contributed to a shift in how forensic anthropologists approach methodological research (Lesciotto 2015), including approaches to the development and validation of methods for estimating the biological profile. This hypothesis was tested using a bibliometric

analysis of articles published in *JFS* that focus on biological profile estimation methods.

Daubert has undoubtedly influenced how forensic anthropology research is presented in *JFS* publications. The frequency of articles that reference *Daubert* or other legal standards of evidentiary admissibility has risen significantly in recent years, often citing *Daubert* as a justification for performing the described research (Lesciotto 2022). This follows calls for a paradigm shift within forensic anthropology for methods to be updated to more explicitly comply with the *Daubert* factors and progress toward more objective and quantitative methods (e.g., Cameriere et al. 2005; Casado 2017; Christensen 2005; Cox et al. 2009; Dirkmaat et al. 2008; Maier et al. 2015; Ross & Kimmerle 2009). However, the issue of whether *Daubert* has influenced how forensic anthropology research is designed and conducted (e.g., actually caused a shift toward more objective methods) has not previously been assessed.

The results of this study show a significant shift in age and sex estimation research toward more quantitative methods, both when examining trends across the entire data set and when comparing pre- and post-*Daubert* subsets. Ancestry/population affinity estimation research actually shifted toward more subjective methods over the entire time span, although showed no significant difference between the pre- and post-*Daubert* subsets. However, the difficulty in creating a bright-line distinction between quantitative vs. qualitative and between objective vs. subjective types of data quickly became apparent during this research. While these terms are frequently used within forensic anthropology to describe types of data, discrete definitions typically only appear in publications focused on presenting a more theoretical framework (e.g., Winburn 2018; Winburn & Clemmons 2021). The terms “objective” and “quantitative” are often used as implicit synonyms, as are the terms “subjective” and “qualitative,” and these pairs of terms are frequently presented as opposing frameworks for research. However, as recognized by Winburn (2018), “the data collected by forensic anthropologists are frequently ambiguous” and often blur the (assumed) distinctions of objective vs. subjective and quantitative vs. qualitative. Similarly, Christensen and Crowder (2009) noted that “quantitative data is based upon qualitative judgments, and all qualitative data can be described and manipulated numerically.” While forensic anthropologists often take a “you know it when you see it” approach to classifying data as objective/subjective or quantitative/qualitative, the dividing lines between data types are fuzzy, at best.

Even assuming that data could be categorized, as was assumed for the purposes of this study, would a shift toward methods using solely empirical, measurement-based data actually represent a worthwhile goal for forensic anthropology? Historically, forensic anthropology has struggled to

achieve recognition as a reputable scientific field, due to methods being challenged as lacking scientific rigor (Boyd & Boyd 2018), in part based on the use of qualitative or observational approaches (e.g., Grivas & Komar 2008; Ross & Kimmerle 2009). Perhaps as a result of this history, objectivity remains as the “ideal” standard within forensic science (Winburn 2018; Winburn & Clemmons 2021). Scholars have also repeatedly cited the need for novel or improved objective methods that meet legal admissibility standards as justification for carrying out their research (Lesciotto 2022). Yet, if this is a common goal in the field, why hasn’t the predicted post-*Daubert* paradigm shift been fully realized? As the results of this study have shown, while there has been a shift toward the development of biological profile methods that rely on quantitative data, these data often fundamentally represent the numerical expression of subjective observations. This unexpected finding may be better understood by considering the results within the broader context of legal admissibility standards, as well as standards for how forensic anthropologists conduct their casework.

As discussed previously, the *Kumho Tire* decision clarified that *Daubert* is a flexible standard. While the Supreme Court listed several factors that judges could examine during the admissibility evaluation, *Kumho Tire* explicitly stated that “*Daubert* makes clear that the factors it mentions do *not* constitute a ‘definitive checklist or test’” (emphasis in original) (526 US at 150 (1999)). Instead, the admissibility evaluation and the factors that go into that evaluation will necessarily vary from case to case, as the evaluation must be tied to and reflect the facts of each individual case and the facts that are at issue. This flexibility is required because not everything in science can be reduced to an objective or quantitative measurement (see, e.g., Grivas & Komar 2008).

The NAS Report similarly emphasized the flexible nature of an admissibility inquiry under *Daubert* and notably lacks a recommendation calling for more objective or quantitative research. The authors of the report acknowledge the lack of scientific expertise among most judges and lawyers and conclude that improvements within the forensic science community will therefore not be the result of judges acting as the “gatekeepers” of admissible expert witness evidence (National Research Council 2009). Until continuing legal education requirements are updated, forensic science must act as its own gatekeeper and improve the research underlying forensic methods. However, while there is a push toward the development of quantified measures of reliability and accuracy (e.g., known error rates and validity), nowhere in the 13 recommendations listed in the NAS Report was there any call for methods that are based exclusively upon objective or quantitative data.

Additionally, while *Daubert* found that the *Frye* standard, which focused exclusively on “general acceptance,” was too rigid, the Court still held that “widespread acceptance can

be an important factor in ruling particular evidence admissible” (509 US at 594 (1993)). For forensic anthropology, standards of practice and professional or certifying associations could provide evidence of which methods have gained “widespread acceptance” in the field.

The Academy Standards Board (ASB), part of the American Academy of Forensic Sciences, has an active Anthropology Consensus Body that publishes guidelines for the standards of practice for forensic anthropologists involved in the recovery and analysis of human remains. As of 2022, only two standards have been published regarding estimation of the biological profile (<https://www.aafs.org/academy-standards-board>). While the “Standard for Sex Estimation in Forensic Anthropology” does not enumerate specific methods that have been approved or are recommended, the document does include metric variables and morphological traits as appropriate data for sex estimation methods (ANSI/ASB Standard 090 2019). The “Standards for Stature Estimation in Forensic Anthropology” document also declines to provide an exclusive list of recommended methods but does state that stature should be estimated using a method based on skeletal measurements (ANSI/ASB Standard 045 2019). This aligns with this study’s finding that *JFS* stature estimation method articles focused exclusively on objective, quantitative data.

The American Board of Forensic Anthropology (ABFA) is the certifying body for forensic anthropologists practicing within the United States. To prepare for the certifying examinations that are designed to assess competency in forensic anthropology, applicants are provided an extensive reading list that covers methods appropriate for use in forensic casework (<https://www.theabfa.org/applicants>). The publications included on this list cover a wide array of methods for estimating the biological profile, including methods based on skeletal measurements and morphological traits. Based on the types of biological profile estimation methods included in the ASB standards documents and the ABFA examination reading list, a strong argument could be made that methods relying on all types of data—objective, subjective, quantitative, and qualitative—are widely accepted within the field of forensic anthropology. The results of this study—that forensic anthropologists continue to use subjective and qualitative data, as well as objective and quantitative data, in developing methods for estimating the biological profile—are consistent with what would likely be considered to be “generally accepted” within the field of forensic anthropology.

While the ASB Standards documents do not discuss observer error in relation to methods for estimating sex or stature, the ABFA reading list includes multiple publications that provide quantification of both intra- and interobserver error in relation to the reliability of biological profile methods. A previous study by Ingvaldstad and Crowder (2009) found that only 30% of anthropological articles published in

JFS between 1980 and 2008 performed or presented observer error analyses. In this study, 42% of the biological profile methods articles performed at least one type of observer error study. While significant shifts toward performing more observer error studies have occurred since 1972, this does not appear to be directly correlated with the field’s preoccupation with *Daubert*. However, this apparent trend toward including more error studies in forensic anthropology publications is in alignment with the current accepted standards of the field.

Finally, it is important for forensic scientists, including anthropologists, to take a step back and acknowledge that *Daubert* governs judicial determinations of the admissibility of expert witness evidence—it does not govern scientific research. This assertion is not new. Christensen and Crowder (2009) eloquently stated that “*Daubert* does not and will not dictate science, but the ruling did lift the proverbial blinders from many forensic disciplines causing the realization that scientific rigor may be lacking.” Improvements in the scientific rigor of our discipline are currently being driven by the development of lab accreditation and quality assurance programs and increases in the professionalization and standardization of forensic anthropology, as previously discussed by the ASB Anthropology Consensus Body and the ABFA.

Conclusion

With a more thorough understanding of admissibility standards for expert witness evidence and a brief attempt at identifying sources that may assist in establishing the types of methods that are generally acceptable for forensic anthropology casework, it is clear that there is no tension between *Daubert* and the current framework for the research and development of methods for the estimation of the biological profile. Finding that biological profile methods have continued to use both subjective and qualitative data does not mean that forensic anthropology has failed to adjust to updated legal standards. To the contrary, nothing in *Daubert*, *General Electric*, *Kumho Tire*, the FRE, or the NAS Report mandates the sole use of objective or quantitative scientific methods. Most forensic anthropologists would find it difficult to imagine a toolkit for evaluating skeletal trauma or estimating the postmortem interval based only on methods developed from a pure quantitative comparison of experimental and control groups. While both trauma and taphonomy research have offered significant improvements in evidence-based assessments of skeletal biomechanics, fractography and fracture analysis, and decomposition, experimental work will likely never encompass the variation inherent in the human skeleton and potential scenarios of traumatic and taphonomic events.

Instead, forensic anthropologists have focused on producing research aimed at issues of accuracy, reliability, and validity, pursuant to Recommendation 3 of the NAS Report. Most biological profile articles published in *JFS* have focused on method development and validity, and this study found a significant increase in research articles that have assessed reliability through observer error studies. Any lingering concerns that forensic anthropology has not shifted further into objective or quantifiable methods to comply with *Daubert* are misplaced. Objective or quantitative methods are not inherently more valuable from either a forensic anthropological or legal admissibility viewpoint. Methods developed using subjective or qualitative data bear little risk of evidentiary exclusion, assuming of course that forensic anthropologists continue to adhere to the principles of good science. Forensic anthropologists have also focused on advancing the professionalization and standardization of the field, as evidenced by the work of the ASB's Anthropology Consensus Body and the ABFA. While we should continue to be aware of the legal landscape in which we operate, future method development should focus on scientific approaches guided by professional standards, rather than being restricted by perceived limitations of admissibility standards.

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