

# Recent Trend and Perspectives in Forensic Anthropology: A Bibliometric Analysis

Emanuela Gualdi-Russo<sup>1,2</sup> and Giulia Fonti<sup>1,2</sup>

<sup>1</sup> University of Ferrara, Department of Biomedical and Specialty Surgical Sciences, Ferrara, Italy

<sup>2</sup> FORENlab, Forensic Sciences Technology Center, Consorzio Ferrara Ricerche, Ferrara, Italy

## ABSTRACT

*This paper evaluates research in Forensic Anthropology (FA) in order to report on the state of this field of science. In particular, we carried out a review of all PubMed-listed scientific studies in the past decades using »forensic anthropology« as the keyword. In our »meta-analysis«, we observed variation in the number of publications per 2-year interval throughout the study period. In total, 1589 studies were found in the database and 1292 of them were published in the period 2000–2009. There was a significant positive correlation between the number of published articles and time (subdivided into 2-year intervals). The rate of increase was lower in the last decade. Based on the observed trend, we expect that the phenomenon will continue in the near future, reaching a number close to 400 FA publications in PubMed in the biennium 2012–13. We also carried out a specific content analysis of all FA papers published in the journal *Forensic Science International* in the last decade. During this period, the majority of FA papers concerned skeletal biology, although there was a positive shift toward virtual anthropological studies.*

**Key words:** forensic anthropology, bibliometrics, content analysis, research trend

## Introduction

It is very difficult to give a non-reductive definition of Forensic Anthropology (FA) and, at the same time, to achieve unanimous consensus since its characteristics, methods and goals are rapidly changing. FA has been defined from time to time as either a sub-discipline of physical anthropology dealing with scientific and technical applications to forensic contexts or a »full-grown scientific discipline«<sup>1</sup>. Its diffusion and development in the world are very different: in addition to the evident differences between Europe and the United States, there is considerable variation in the current FA situation among different European countries. The roots of FA can be recognized in Europe starting from the 18<sup>th</sup> century, through research mainly by physical anthropologists and anatomists on the determination of body proportions, stature and sex from human skeletal remains<sup>2</sup>. However, its development, albeit similar, has been much slower than in the U.S., where FA research and practice are well documented since the 1970s<sup>3,4</sup>.

FA research was initially focused on human skeletal remains for definition of the victim's biological profile (sex, age, stature)<sup>5</sup>, with important extensions of the

analysis to new methodologies for the study of skeletal biology and for the reconstruction of the events (cranio-facial reconstruction, forensic taphonomy, estimates of post-mortem interval)<sup>1,6,7</sup>. Subsequently there was a progressive extension to the diagnostics of living persons (at least in Europe), with reference both to new diagnostic features and to the identification of individuals from images taken by video surveillance systems and movies<sup>8–10</sup>. As recently suggested<sup>11</sup>, forensic visualization and simulation may also be fundamental for presentation in courtrooms but especially to properly address the study of dynamic events in crime scene reconstruction. In this respect, FA can contribute to the creation of virtual anthropomorphic models to be as representative as possible of the size, shape and proportions of individuals present at the crime scene<sup>12</sup>. The described trends are a logical consequence of the potentialities of traditional physical anthropology, which deals not only with skeletal biology but also with morphometric characteristics of living populations in relation to age, sex and environmental factors. In addition to medical experts,<sup>13,14</sup> the expertise of anthropologists in these biological fields can provide significant contributions to identification in forensics.

In addition to the above-mentioned aspects, the development of FA seems to have accelerated in recent times. Therefore, it is interesting to evaluate the progress of scientific research in this area and to formulate a hypothesis about its prospects for future development. A review of the international literature may help to evaluate the state-of-the-art in a particular field of research via the so-called meta-analytical approach. Therefore, we analyzed the general scientific impact of FA, expressed as the number of published papers according to the PubMed Central database, the free digital archive of biomedical and life science journals. Furthermore, we carried out a specific content analysis of all FA papers published in *Forensic Science International (Forensic Sci Int)* during the last decade. *Forensic Sci Int* was chosen because it is one of the two most widely acclaimed European journals specializing in forensic science<sup>15</sup> and because this journal often welcomes papers that present research results in FA.

In summary, this paper provides information on the scientific impact and tendencies of FA in biomedical research, analyzing both the general scientific productivity according to PubMed and the partial productivity during the last decade according to a specific forensic journal. In addition, the future prospects of FA are discussed on the basis of recent trends.

## Materials and Methods

Our study included both the analysis of FA trends, via the PubMed database starting from the first publications, and the analysis of main FA topics dealt with in the last decade by an important forensic journal. For the first analysis, we examined all papers listed in the PubMed electronic database (<http://www.ncbi.nlm.nih.gov>) using the keyword »forensic anthropology« (last access: September 1<sup>st</sup>, 2010). All the data were then divided into 2-year intervals from 1970–71 to 2008–09. The 2-year intervals were replaced in the statistical analysis with numbers from 1 to 20 for easier computation.

Correlation and simple regression analyses were carried out to assess temporal trends during the whole period (40 years), the last 20 years and the last decade, as well as to hypothesize future prospects in the development of FA.

For the second analysis, all FA papers published in *Forensic Science International (Forensic Sci Int)* from January 1<sup>st</sup> 2000 to December 31<sup>st</sup> 2009 were investigated. The articles, identified in the journal by the keyword »forensic anthropology«, were divided into original research articles and review articles according to the journal indications (when reported). The articles were then categorized into skeletal biology and non-skeletal biology (anthropological studies on living or cadaver) and further divided by topic into the following seven subjects: 1 – FA in general (global or local development of FA, field of interest, etc.); 2 – Age, sex, stature and ethnic affinity (methods to diagnose the age at death and the sex from the skeleton; methods for estimating height from bones or from images of living persons taken from video surveillance cameras; ethnicity); 3 – identification (fingerprints, footprints and other identification methodologies that do not fall into the above categories); 4 – virtual anthropology (facial anthropology, 3D methodologies, facial reconstruction, soft tissue thicknesses, etc.); 5 – taphonomy (burned bones, post-mortem interval, etc.); 6 – case-studies; 7 – others (morpho-metric studies/topics that do not fall into the above categories, biomolecular anthropology, trauma, etc.). Two observers conducted the search and classification independently according to clear guidelines involving attribution to one of the seven subjects starting from the first one listed and taking account of the specific description reported for each one. When clarification was required, the relevant papers were read. Reports from scientific meetings, surveys, book reviews, etc. were not considered in this analysis. The statistical analysis was carried out for 2-year intervals as described above.

A p-value less than 0.05 was considered significant. The statistical analysis was performed using STATISTICA software (Statsoft 5.0, Vigonza, Padua, Italy 2000).

**TABLE 1**  
FREQUENCY OF FORENSIC ANTHROPOLOGICAL ARTICLES LISTED IN PUBMED FROM 1970 TO 2009 BY 2-YEAR INTERVALS

Interval	N	%	Interval	N	%
1. 1970–71	3	0.19	11. 1990–91	7	0.44
2. 1972–73	0	0.00	12. 1992–93	8	0.50
3. 1974–75	0	0.00	13. 1994–95	59	3.72
4. 1976–77	2	0.13	14. 1996–97	94	5.92
5. 1978–79	3	0.19	15. 1998–99	101	6.36
6. 1980–81	2	0.13	16. 2000–01	219	13.79
7. 1982–83	2	0.13	17. 2002–03	205	12.91
8. 1984–85	8	0.50	18. 2004–05	246	15.49
9. 1986–87	0	0.00	19. 2006–07	250	15.74
10. 1988–89	7	0.44	20. 2008–09	372	23.43
Total				1588	100.00

## Results

The PubMed search with the keyword »forensic anthropology« yielded a total of 1589 papers up to the end of 2009. Of them, 1292 were listed from 2000 to 2009 and the remaining 297 papers from 1970 to 1999 (except for a single paper published prior to 1970)<sup>16</sup>. The percentage was computed on the total number of papers cited for the last 40-year period (N=1588). The frequency of these papers is reported in Table 1. Despite a doubling from the first 2-year interval to the last, the frequency of FA papers in the first 20 years is inconsistent. The publications increase more than 14 times from 1990–91 to 1998–99 and more than 53 times from 1990–91 to 2008–09. Therefore, FA papers show a progressively increasing impact, especially in the last 20/10 years.

Figure 1 shows the trends observed in the entire 40-year period, in the last 20 years and in the last decade by means of three regression lines (A, for the period 1970–71/2008–09:  $y = -92.55 + 16.38 x$ ; B, for 1990–91/2008–09:  $y = -441.82 + 38.58 x$ ; C, for 2000–01/2008–09:  $y = -373.4 + 35.1 x$ ). Linear relationships between the number of papers dealing with FA (dependent variable Y) and the publication biennium (independent variable X) show a mean increase of about 16 papers per 2-year interval (as indicated by coefficient b) over the whole period. The mean increase is about 38 papers in the last two decades and 35 papers in the last decade. The linearity index increases from regression line A ( $r^2=0.719$ ) to B ( $r^2=0.942$ ) and decreases slightly in C ( $r^2=0.703$ ). The r-coefficients denote a positive correlation between variables (A:  $r=0.848$ ; B:  $r=0.971$ ; C:  $r=0.838$ ). Correlations are significant for A ( $p=0.000002$ ) and B ( $p=0.000003$ ), but slightly above the chosen p value for C ( $p=0.0762$ ). Assuming that the trend observed over the past decade (regression line C) continues in the near future, we expect that the number of FA papers will almost double (N=398.8) in the next four years ( $x=22$ ) with respect to the papers cited for the first 2-year interval of the last decade (2000–01). We consider it imprudent to make predictions over a more extended period of time on the basis of the observed trend.

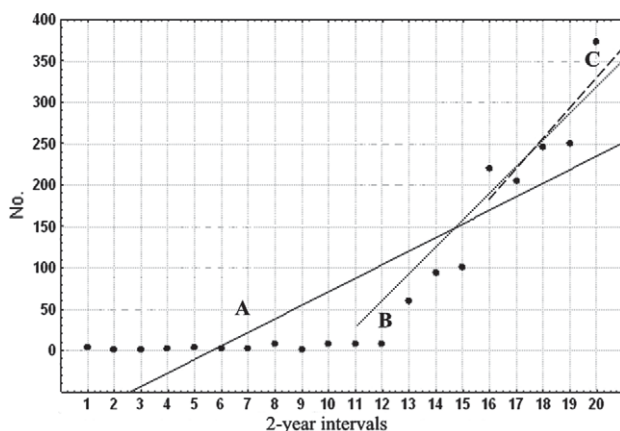


Fig. 1. Trends in FA publications: regression lines for the period 1970-71/2008-09 (A), for the period 1990-91/2008-09 (B) and for the period 2000-01/2008-09 (C).

**TABLE 2**  
FREQUENCY OF SKELETAL VS. NONSKELETAL BIOLOGY  
ARTICLES PUBLISHED IN THE FORENSIC SCI INT BY 2-YEAR  
INTERVALS

Interval	Skeletal		NonSkeletal		Total N
	N	%	N	%	
2000–01	6*	7.3	3	6.7	9
2002–03	6	7.3	4	8.9	10
2004–05	15	18.3	6	13.3	21
2006–07	20	24.4	8	17.8	28
2008–09	35	42.7	24	53.3	59
Total	82	100.0	45	100.0	127

\*one of them was both on skeleton and living

Since more than 80% of the 1588 papers reported in PubMed were published in the last decade and our main interest was to focus on more recent research tendencies, our content analysis only included papers published in Forensic Sci Int in the period 2000–2009. In this period, Forensic Sci Int published a total of 151 FA papers, with an increase of about 46% from the first to the last 2-year interval: from 11 papers in 2000–01 to 69 papers in 2008–09. There were only 11 »review articles«, the other 140 being »original research articles«. Of them, only 127 were assigned to one particular category based on the prevailing subject matter of the article (Table 2). This was not an easy task and it was influenced by a certain subjectivity. However, it is evident from this subdivision that skeletal biology dominated the field of FA in the last 10 years of Forensic Sci Int. This tendency was common with anthropological research in general, as shown by analyses of papers published in American Journal of Physical Anthropology<sup>17</sup>, confirming that skeletal biology is one of the largest sub-fields of physical anthropology and a strategic area of anthropological expertise in forensic applications.

The frequencies of articles in the above-mentioned seven categories are presented in Table 3. Papers discussing age and sex determination, stature and ethnic affinity are prevalent (with a mean of 46.4% of total FA papers), followed by FA in general and virtual anthropology. Moreover, they show an increase over the decade within their category (+57.1% from first to last 2-year interval). Papers on case-studies are less frequent among FA papers, probably in accordance with specific editorial choices. Virtual anthropology increases by about 29% over the last decade within the category. Interestingly, papers on taphonomy, although represented by a low number, exhibit an evident increase during the decade within their category (+75%). The number of papers dealing with identification methods tends to remain constant over the period, with small fluctuations.

## Discussion and Conclusions

The meta-analysis is a widely used method for evidence-based scientific studies. Although the term »meta-

**TABLE 3**  
 FREQUENCY OF FA ARTICLES PUBLISHED IN THE FORENSIC SCI INT BY SUBJECT MATTER AND 2-YEAR INTERVALS

Matter	2000-01		2002-03		2004-05		2006-07		2008-09		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
FA, in general	3	27.3	2	18.2	8	29.6	7	21.2	2	2.9	22	14.6
Age, sex, stature, ethnic affinity	2	18.2	5	45.5	10	37.0	11	33.3	42	60.9	70	46.4
Identification	2	18.2	0	0	1	3.7	5	15.2	2	2.9	10	6.6
Virtual Anthropol.	2	18.2	1	9.1	2	7.4	8	24.2	8	11.6	21	13.9
Taphonomy	1	9.1	0	0	1	3.7	0	0	10	14.5	12	7.9
Case studies	1	9.1	2	18.2	3	11.1	2	6.1	0	0	8	5.3
Others	0	0	1	9.1	2	7.4	0	0	5	7.2	8	5.3
Total	11	100	11	100	27	100	33	100	69	100	151	100

-analysis« applies only partially to the present work, we used a »meta-analytical« approach in maintaining the specific quality criteria, selecting only studies on a well-specified subject listed in PubMed.

The main limitations of this study are the following: i- only papers listed in PubMed were chosen; ii- only one keyword was used to select papers; iii- only studies published in the last decade were considered in the detailed analysis of a specific journal. In future, other databases may be analyzed, with additional keywords (e.g., »forensic taphonomy«, »forensic osteology«, etc.) and extension of the content analysis to other journals (in particular, Journal of Forensic Science and International Journal of Legal Medicine) and time spans.

The analysis revealed the following main points:

- a. there has been a significant increase in forensic anthropological studies over time (according to the PubMed database);
- b. the acceleration in FA publications has slowly diminished in the last decade (PubMed);
- c. papers published in the last decade in Forensic Sci Int show a general trend to an increase in FA articles and a prevailing interest in research on skeletal biology (particularly sex and age diagnoses);
- d. virtual anthropology is a newly emerging FA topic in recent publications in Forensic Sci Int.

In summary, our study attempts to provide accurate information on the impact of forensic anthropological studies in bio-medicine through the analysis of a database including only studies with quality standards.

We expect that, after the recent explosion of anthropological contributions to forensic research, a natural

threshold will be reached because of the limited number of anthropologists engaged in academic activity and the variety of their scientific interests, as indicated by the slowdown of the phenomenon. Consistently with the redefinition by Dirkmaat et al.<sup>1</sup>, we hope that FA will become a stand-alone discipline, as its field of research is spreading and broadening from context analysis to virtual reconstruction of the event and crime scene. Nevertheless, it is difficult to predict where and when this iter will be completed.

Although the content analysis of Forensic Sci Int over the past decade indicated the prevailing role of skeletal biology (about two-thirds of the published FA articles), we observed a clear tendency to the emergence of new areas of anthropological interest and experience, documented by the increased number of publications on virtual anthropology.

In conclusion, the progressive increase in FA publications during the last 40 years is a clear indication of the increasing interest of biological anthropologists in FA research. They may enhance the potential of the forensic sciences by developing new approaches to a wide range of topics. While skeletal biology will remain the main area of investigation by forensic anthropologists, major new contributions will come from research on living individuals, with particular emphasis on identification conducted directly on the subject (i.e., biological profile and, in particular, age determination) and indirectly on images from video-surveillance systems. Moreover, the identification of a specific biological profile may be crucial to build the virtual models needed to analyze the case in a virtual reconstructed crime scene.

**REFERENCES**

1. DIRKMAAT DC, CABO LL, OUSLEY SD, SYMES SA, Yearbk Phys Anthropol, 51 (2008) 33. DOI: 10.1002/ajpa.20948. — 2. UBELAKER DH, Introduction to Forensic Anthropology. In: SCHMITT A, CUNHA E, PINHEIRO J (Eds) Forensic Anthropology and Medicine. (Humana Press, Totowa, 2006). DOI: 10.1002/oa.920. — 3. BRICKLEY MB, FERL-

LINI R, Forensic Anthropology: developments in two continents. In: BRICKLEY MB, FERLLINI R (Eds) Forensic Anthropology. Case study from Europe. (C.C. Thomas Publisher LTD, Springfield, 2007). — 4. KRANIOTI EF, PAINE RR. J Anthropol Sci, 89 (2011) 71. DOI: 10.4436/jass.89002. — 5. ISCAN MY, Yearbk Phys Anthropol, 31 (1988) 203. DOI: 10.

- 1002/ajpa.1330310510. — 6. HAGLUND WD, SORG MH, Forensic taphonomy. (CRC Press, Boca Raton, 1997). — 7. DUDAY H, Lezioni di Archeo-tanatology. Archeologia funeraria e antropologia di campo. (Soprintendenza Archeologica di Roma, Roma, 2006). — 8. MEIJERMAN L, NAGELKERKE NJ, VAN BASTEN P, VAN DER LUGT C, DE CONTI F, DRUSINI AG, GIACON M, SHOLL S, VANEZIS P, MAAT G J, Med Sci Law, 46 (2006) 141. DOI: 10.1258/rsmmsl.46.2.141. — 9. CATTANEO C, Forensic Sci Int, 165 (2007) 185. DOI:10.1016/j.forsciint.2006.05.018. — 10. BRINKMANN B, Int. J. Legal Med, 121 (2007) 431. DOI: 10.1007/s00414-007-0194-2. — 11. MA M, ZHENG H, LALLIE H, J Forensic Sci, 55 (2010) 1227. DOI: 10.1111/j.1556-4029.2010.01453. — 12. GUALDI E, MEZZARO P, Antropologia forense e modellazione virtuale. In: RUSSO P, GUALDI E (Eds) Corso di base in Balistica Forense. (I Quaderni di FORENlab, Ed. »Il Ponte Vecchio«, Cesena, 2010). — 13. CUCULIC D, BRALIC M, BOSNAR A, STEMBERGA V, Coll antropol, 36 (2012) 681. — 14. MARINOVIC D, COKLO M, NJIRIC S, MUZIC V, Coll antropol, 35 Suppl 2 (2011) 347. — 15. JONES AW, Forensic Sci Int, 165 (2007) 115. DOI: 10.1016/j.forsciint.2006.05.013. — 16. SCHWIDETZKY I, Hum Biol, 26 (1954) 21. — 17. HENS SM, GODDE K, Am J Phys Anthropol, 137 (2008) 234. DOI: 10.1002/ajpa.20871.

*E. Gualdi-Russo*

*University of Ferrara, Department of Biomedical and Specialty Surgical Sciences, Corso Ercole I D'Este 32, 44121 Ferrara, Italy*  
*e-mail: emanuela.gualdi@unife.it*

## **RECENTNI TRENDOVI I PERSPEKTIVE U FORENZIČKOJ ANTROPOLOGIJI: BIBLIOMETRIJSKA ANALIZA**

### **SAŽETAK**

Članak se bavi procjenom istraživanja u forenzičkoj antropologiji (FA) kako bi stekao uvid u stanje ovog znanstvenog polja. Obavili smo pregled svih publikacija indeksiranih u PubMedu proteklih desetljeća rabeći »forensic anthropology« kao ključnu riječ. U našoj »metanalizi« promatrali smo varijaciju u publikacijama u dvogodišnjem intervalu kroz istraživani period. Ukupno je u bazi podataka nađeno 1589 istraživanja od kojih je 1292 bilo objavljeno u periodu od 2000–2009. Postoji značajna pozitivna korelacija između broja objavljenih članaka i vremena. Porast je bio nešto niži u zadnjoj dekadi. Temeljem uočenog trenda očekujemo da će se fenomen nastaviti u bliskoj budućnosti te da će doseći broj od 400 FA publikacija u PubMed u periodu od 2012–2013. Proveli smo također analizu sadržaja svih FA članaka objavljenih u časopisu Forensic Science International u protekloj dekadi. U tom periodu većina FA članaka bavila se biologijom skeleta iako postoji pozitivan pomak prema virtualnima antropološkim istraživanjima.