

**Review report on the doctoral thesis by  
Mgr. Barbora Suchá**

Topic of thesis: Sex classification using 3D skull modelling in multi-population sample

Author: Barbora Suchá

Reviewer: David Kachlík

Dissertation thesis written by Mgr. Barbora Suchá presents a bound manuscript of 110 pages of text in English and Czech.

It consists of a theoretical introduction (39 pages), aims and hypotheses of the dissertation (3 pages), an overview of materials and methods (7 pages), detailed results (21 pages), a briefer discussion (9 pages), perspectives and conclusions of the work (3 pages) including a list of used literature (22 pages, 294 items of national and international book and journal literature), figures (23) and tables (14), the author of which is the petitioner herself.

The current state of knowledge is far from complete, and determining sex from skeletal remains still continues to be a challenge and an integral part of scientific research. The aim of this thesis was to test a new method for sex estimation using the morphology of the external surface of the skull on a dataset that included an intentionally heterogeneous group of several contemporary populations from Central, Northern and Southern Europe and from North Africa, in order to provide a comprehensive assessment of the accuracy and reliability of the method across different populations. By including samples from diverse regions (Czech Republic, Slovakia, Denmark, France and Egypt) it aimed to assess the robustness of the sex estimation methodology in different demographic and geographical contexts.

The methodology included CT scans of 619 skulls from five different geographical groups of the current population, which were then computerized and statistically processed using a novel methodology. Petitioner was a member of a team that developed a robust classifier for sex determination based on visual anthropology. In the next step, they tested the reliability of the developed method for comparing data from two populations. Subsequently, they devoted themselves to determining the extent of sexual dimorphism in relation to age, using colour scale maps, skull aging and continued with the study of the relationship between sexual dimorphism and facial aging. Furthermore, the applicability of this methodology was verified on five different geographical groups using different statistical procedures and approaches.

The results, including the discussion, led to the confirmation of two out of the four hypotheses, namely that the new method for sex estimation using the morphology of the external surface of the skull is not only comparable, but competitive with established methods, and that sexual dimorphism on the skull clearly decreases with age. Furthermore, the work led to the support of the hypothesis that this new method for sex estimation shows high reliability and accuracy across near contemporary European populations. Finally, the work led to a partial support of the last hypothesis and showed a gradual decrease in reliability when comparing more diverse and geographically distant populations and the necessity of further improvement to achieve comparable quality even for more different populations.

Individual hypotheses and studies are not separate topics, but on the contrary, they follow the long-term focus of the workplace and the supervisor, and their methodological processing

is at a high level. The corresponding results significantly advance our knowledge and bring insights that can be used in further theoretical, but especially in applied research. In addition, the petitioner gained the necessary experience for the future continuation of her scientific work, so that she could independently not only carry out, but also manage research in the field of processing anthropological and anthropometric data aimed at estimating/determining sex and changes during aging.

The thesis is supported by four original result papers (the petitioner is twice the first author) and two conference contributions. All works were published in impact journals (Web of Science) with a cumulative impact factor of 11.488 (2x Q1; 2x Q2), which testifies both to the extensive independent work of the petitioner and also to her significant involvement in the excellently working team of her supervisor.

As a whole, the dissertation thesis provides instructions on how to compile, conduct and successfully publish such research. At the same time, it shows the directions in which to further develop the given topics. It is clear and comprehensible for the reader, thanks to the thorough documentation it leads the reader to the depth of knowledge of working with craniometric data and yet does not neglect to create a comprehensible impression as a whole. The metric, technical and statistical methods used are well chosen in view of the set goals, which are met.

In terms of formality, the work is written in a relatively high quality and carefully. As a reviewer, I have no major comment on the work.

- The referencing throughout the text should be used in a shorter form as it makes the text less fluently and more difficult for the reader. Also, the formatting should be uniform and should follow the Czech ISO norm. The References and Appendices are formatted differently.
- During formatting of text, the articles (the/a) as well as prepositions should not be left alone at the end of the line.
- The language should be either pure British or American English, mainly concerning spelling.

Specific remarks are listed below (page-paragraph-line):

- Utilisation of terms "subadult" and "juvenile" and "non-adult" should be aligned.
- Headings should not be terminated with a dot.
- The Aim of the research chapter contains some results which should not be incorporated here to let the reader follow the Aim through Methods to Results order.
- In the Section 5.1.1, I miss the number of the Ethics Committee Approval. Further, the proper names of the individual ethics committees, including the block letters, should be provided.

1-1-1: „plays a significant part“ should be „plays a significant role“.

3-2-3: “expertise of the forensic osteologist“ should be „expertise of a forensic osteologist“.

4-2-1: “and subsequently degenerative features“ should be „and subsequently degenerative features appear“.

4-3-4: “substantial number of methods published“ should be „substantial number of methods has been published“.

4-4-1: “pubic symphyses“ should be better „pubic symphysis“ as there is only one in the human body.

4-4-4: “sternal rib ends“ should be either „sternal (ventral) ends of ribs“ or „true rib ends“ based on what is the intention of the author.

Figure 1: „lambdoidal“ should be „lamboïd“ and „squamosal“ should be „squamous“ according to Terminologia Anatomica (TA); further it lacks legend for A-K abbreviations.

6-2-1: „plays significant role“ should be „plays a significant role“.

6-2-5: „such as osteoarthritis or changes in vertebral morphology“ – I would stress here „osteoarthritis“ as well as a prominent change visible on articular surfaces and its vicinity.

7-1-2: „the long bones of the hand“ – do you mean“ the long bones of the upper limb“ when further talking about humerus and radius?

7-1-3: „humeral head“ should be better „head of the humerus“.

7-1-7: „corpus of the C2–L5 vertebra“ should be „body of the C2–L5 vertebrae“.

7-1-9: „tibia without the spine“ – do you mean the „intercondylar eminence“?

7-1-10: „Stature estimates are accurate within 4.5 cm in 95% of individuals in our sample, without any directional bias“ – if this is the own result of the author, it should be placed in the Results or Discussion section.

7-1-12+18: „Zeman and Benus“ versus „Zeman and Beňuš“ should be unified according to the original reference.

7-2-3: „craniofacial region“ should be „craniofacial area“ as „regions“ of the human body are precisely defined by TA – also further throughout the text the term „region“ should be applied only to those units, unlike „area“ which can be used independently for any unit.

Figure 2: „odontoid process“ should be „dens of axis“.

9-4-4: „It refers to information about an individual's origin and their classification“ should be „It refers to information about an individual's origin and its classification“.

10-1-1: „dimorphism , mainly“ – redundant space before the comma.

10-3-8: „1 percent“ should be better „one percent“ as number 1-10 should be written full.

12-2-5: „it's advisable“ should be „it is advisable“ – also further throughout the text „it's“ should be „it is“ and so on.

13-1-12: „aDNA“ – unexplained uncommon abbreviation (when a list of abbreviations is at the end of the work, the abbreviations must be explained when first used in the text)

16-1-3: „Also, validation study by“ should be „Also, a validation study by“.

16-1-4: „rate of 83 %“ should be „rate of 83%“.

16-2-3: „Five regions“ should be „Five areas“.

16-3-3: „ventral pubis, dorsal pubis“ should be better „ventral portion of the pubis, dorsal portion of the pubis“ here and further.

19-2-9: „sphenoid, and ethmoid bones“ should be „sphenoidal, and ethmoidal bones“.

Figure 5: „mental eminence“ should be „mental protuberance“ (also 24-1-1) and „gonion angle“ should be „angle of mandible“ or „gonion“ (based on what the author precisely means).

21-1-5: „brow ridge“ should be „superciliary arch“. Or, if a synonym is used, it should be stated and explained when firstly used.

21-1-7: „Males typically featuring“ should be „Males typically feature“.

21-1-14: „The mastoids“ should be „The mastoid processes of the temporal bones“ here and further.

21-1-15: „nuchal crest“ – what does the author you mean – „some of the nuchal lines“ or the „external occipital crest“? (Also 23-2-11).

22-1-2: „a nasal spine with a wider nasal aperture“ – does the authors mean a „more prominent anterior nasal spine“?; and „nasal aperture“ should be „piriform aperture“ here and further.

23-2-1+2+6+7: „Acsadi and Nemeskeri“ versus „Acsádi & Nemeskéri“ should be unified according to the original reference.

23-2-6: „Acsádi & Nemeskéri, 1970).Two“ – missing space after comma.

23-2-12: „supraorbital ridge“ and „supraorbital margin“ are differently presented in the text and in Figure 7.

23-2-12: „supraorbital ridge“ should be “superciliary arch”. Or, if a synonym is used, it should be stated and explained when firstly used.

Table 4: „cranium or skull only“ – can the author explain what is the difference between the „cranium“ and the „skull“ in the table by Thomas et al. (2016)?

30-2-2: „occipital protuberance“ should be „external occipital protuberance“.

31-2-12: „metopion and vertex points, where females had a thicker frontal bone area“ – vertex is usually located at the sagittal suture between the parietal bones.

33-1-7: „jaw and cheekbones“ should be „mandible (or maxilla?) and zygomatic bones“.

33-2-1: „In study Ross et al. (1998)“ should be „In a study by Ross et la. (1998)“.

33-2-2: „was concluded“ should be „it was concluded“.

33-3-2: „density of spinal trabecular bones“ should be specified as „density of trabecular bones of the vertebral column“ (if really related to that).

34-1-7: „mastoid of the temporal bone“ should be „mastoid process of the temporal bone“.

37-3-3: „sample was transgender woman“ should be „sample was a transgender woman“.

37-3-7: „cheekbone reduction, orbital rim shaving“ should better be „zygomatic bone reduction, orbital margin shaving“.

40-1-1: „years of research“ is a very vague statement which should be specified.

40-2: “Introducing new method „ should be „Introducing a new method“.

40-2-3: “by study of Abdel Fatah et al. (2014)“ should be „by the study of Abdel Fatah et al. (2014)“.

40-3-1: “to only exocranial surface“ should be „to only the exocranial surface“.

40-3-2: “accessibility of method“ should be „accessibility of this method“.

40-4: ”Analysing the reliability of method“ should be „Analysing the reliability of the new method“.

40-4-1: “assess reliability of previously developed method“ should be „assess reliability of the previously developed method“.

40-5-1: “Method was successfully“ should be „The new method was successfully“.

40-6+57: „Observe and describe changes“ should be „Observing and describing changes“.

41-3: „Verify“ should be „Verifying“.

43-2-2: „central Europe“ should be „Central Europe“ and similarly for other geographical regions.

43-3-2: „age range of 28-90“ should be „age range of 28–90“ and similarly further throughout the text.

44-5: I miss here information on the ethics committee approval.

45-1-4: „spine“ should be „vertebral column“.

45-1-5: „the jaw and teeth“ – which jaw – lower? Or both?

Table 7: Although taken from the original work, the Latin terms should be replaced with English ones (or placed into the brackets, but then consistently throughout the text).

50: „Introducing new method“ should be „Introducing the new method“.

51-1-1: „Confusion matrices was used“ should be „Confusion matrices were used“.

53+53-1-1: “the reliability of method“ should be „the reliability of the new method“.

55-1-5: „did we observe“ should be „we did observe“.

55-2-5: “alveolar process“ should be „alveolar process of the maxilla“ here and further.

Figure 16: „elders“ should better be „elderly“ to be consistent.

58-1-7: „in regions such as the frontal, occipital, and zygomatic areas“ should be „in such as the frontal, occipital, and zygomatic regions“.

61-1-2: “in Material, section five subdatasets“ should be „in Material section, five subdatasets“.

61-1-3: “CZE - Czech population“ should be „CZE – Czech population“ and similarly further.

Table 10+11: Percent values should contain dot instead of comma and there should be no space between the value and %.

63-2-5: "There is significant overlap" should be „There is a significant overlap“.  
63-3-4: "There is also overlap here" should be „There is also an overlap here“.  
64-1-6: "Czech" is here and also further used as a noun for the country, but it should be either "Czech Republic" or "Czechia" in these cases.  
Figure 22-legend: The second sentence misses a verb.  
72-4-5: "the surface of the exocranium - „ should be „the surface of the exocranium – „,  
74-2-18: "accuracy rate of 87% - 90%" should be „accuracy rate of 87–90%“.  
77-3-3: "it is being criticized it" should be „it is being criticized“.  
77-3-4: "biological races - a concept" should be „biological races – a concept“.  
77-3-6: "the majority of researchers," – the comma should not be here.  
78-1-8: "in forensic," should be „in forensic anthropology“.  
81-1-2: "central6" should be „central“.  
82-1-2: "did not perform as well" should better be „did not perform so well“.  
83-2-1: "exokraniální povrch lebek" – sometimes it is better to use the Czech term – „vnější povrch lebek“ sounds better and means exactly the same.  
83-2-4: „konkurenceschopná se zavedenými metodami“ should be „konkurenceschopná zavedeným metodám“.  
83-3-5: „kraniálního tvaru“ should be „tvaru lebky“.  
83-4-1: „Čtvrtá hypotéza byla podpořena pouze částečně“ should be „Čtvrtá hypotéza byla potvrzena pouze částečně“.

These shortcomings do not in any way reduce the quality of the work, and these are only marginal issues, the correction of which would be appropriate to take into account during the possible preparation for book publication.

The author fulfilled the goals set at the beginning of the work, and her results can be applied to routine theoretical and applied practice.

The assessed work corresponds in its content, scope and processing to the requirements set for the dissertation, is arranged accordingly and brings original results. The author has demonstrated the ability to work independently in the field of scientific and research work.

Questions for the author:

1. After this experience, do you suppose that if also the endocranial features were used, would the results be more detailed and thus more reliable for sex estimation and still the approach would stay practical?
2. What do you think about testing a pure skull from collections of older Czech populations to get regional population data to compare as well as to test the method. Do you anticipate high accuracy still?

In accordance with the rules of the doctoral procedure, I recommend that the submitted work be defended and, in the case of a successful defence, to award Barbora Suchá with the title of Doctor of Philosophiae.

Prague, 18.7. 2024

A handwritten signature in blue ink that reads "David Kachlík". The signature is written in a cursive style with a distinct accent mark over the 'i' in "Kachlík".

Prof. MUDr. David Kachlík, PhD.

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