3D PRINTED STANDARDIZED GROSS ANATOMICAL MODEL OF THE THORAX OF SOUTHERN NIGERIAN MALE

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ABSTRACT

The study aims to print a standardized 3D gross anatomical model of the thorax of a southern Nigeria male. The study adopted a cross-sectional study design to collect anthropometric data for the design of 3D printed gross anatomical model. The anthropometric data were obtained via direct measurements and data was analyzed using IBM SPSS version 25. Using polylactic acid filament, CAD software, and a 3D printer, the study followed a three-step process: modeling the thorax digitally, slicing the model into printable instructions, and finally printing the model. The study focused on 3D printing a 20% scaled-down model of the human thorax, including the vertebral column. Challenges with accuracy and stability arose due to the model's irregular surfaces, requiring support-based printing. To address these issues, the thorax was divided into smaller segments for printing, then assembled with hot adhesives. The completed model, showcasing an S-shaped spinal column typical of mammals, was mounted on a wooden base for display and could be scaled up with larger printers. The utility of 3D anatomical models has increased among medical students and health programs for hands-on understanding of complex relationships in anatomy.

Keywords: 3D Model, 3D Printer, Anatomical Model, CAD Software, Human Thorax

INTRODUCTION

Anatomical models are three-dimensional representations of human or animal anatomy that have been used in various departments in the medical sciences and biological sciences [1]. Its importance has provided a tangible way to study complex human body structures, improving understanding by offering comprehensive and retentive information [2]. In medical training, these models are essential for practicing medical procedures including surgery, injections, spontaneous vagina delivery (svd) and so on [3].

The importance of the anatomical model cannot be overemphasized in medical training, research and development, and patient education. However, our medical sector lacks the availability of these models leading to difficulty in learning some complex body relationships. Even in few sectors, that have these models for their students used, also face some challenges of not having a regional defined anatomical model [4]. For appropriate medical training in specific regions, there is a need for regional anatomical models to clearly define the human morphology of the people [5, 6].

According to Asiwe et al., [7, 8], and Fawehinmi et al., [9] human morphology varies in ethnicity, race, and sex, leading to some contributing factors such as environmental, hormonal, genetic, diet and lifestyle. Southern Nigerian males are diverse, muscular [10], and often bilingual, with a focus on education, family, and community. They are proud to represent their culture and excel in various vocations, balancing tradition and modernity in an economically vibrant and culturally diverse region [11]. They are said to have different morphology due to the physical activities engage on a daily basis. Therefore, the need to resolve the regional variation has motivated the interest of this study to print a 3D standardized gross anatomical model of the thorax of southern Nigeria males. using the advanced technology.

MATERIALS AND METHOD

Research Design

In the quest to develop a 3D-printed standardized gross anatomical model of the thorax of southern Nigerian males. The study used a cross-sectional descriptive study design to generate the body dimensions of the southern Nigerian males. the study lasted twelve months; the first six months were anthropometric data collection of Indigenous southern males. the study used multi-stage sampling techniques to recruit the subjects without bias. the second phase of the research comprised the data recovery, analysis, printing of the 3D gross anatomical model, and the design of the manuscript.

Anthropometric dimensions

This study is a multi-disciplinary research, some anthropometric body dimensions were collected via a direct measurement using the non-stretchable tape and a meter rule, to measure the circumferential body dimensions and the vertebra height. The data obtained were analyzed using IBM SPSS version 25. For the design of 3D gross anatomical model.

Materials for the 3D printing

The study used polylactic acid filament (PLA), 3D designs software; computer-aided design (CAD), 3D Slicing software and a C-reality Ender 3D printer to generate the 3D gross anatomical model of the thorax for the southern Nigeria males.

Methods of 3D printing

The modelling, slicing and printing were carried out sequentially to produce the 3D model of the human thorax.

Modeling

This process involves obtaining the digital model of the thorax. The Modeling was done using a 3D modeling software (CAD software) to create the 3D model of the human thorax that can be printed on a 3D printer. The model file was downloaded and stored in a stereolithographic format for printing.

Slicing

This process involves using the slicing software to slice the model. The purpose of Slicing the model is to allow the 3D printer to calculate the route and the amount of filament required when printing the model. The Slicing software generates a G-Code file, which is essentially a long list of instructions, and then the 3D printer reads the G-Code instruction to build the model.

Printing

This is the next phase after slicing was completed, the sliced file was uploaded to the printer and the printer was calibrated to prepare it for printing. The extruders and the printing base were also calibrated, to improve the accuracy of printing during the printing process.

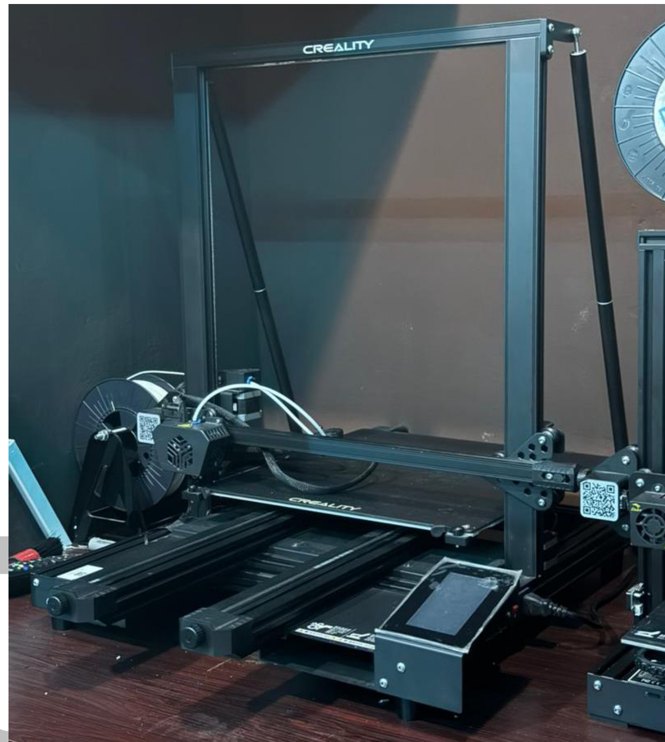

Figure 1: Creality 6 Max 3D printer

RESULTS AND DISCUSSION

This work centered on printing the human thorax. The thorax consisting of several bones that add up to make the vertebral column of mammals. The thorax model was scaled down to a value of 20% it's original size to enable easier fitting on the 3D printer bed. It would be worthy to note that the entire model contained irregular surfaces. As a result of the nature of the surfaces, support-based printing was used to support the model on the print bed surface, The total model of the thorax had a print time of 3 days, 8 hours and 44 minutes at 20% reduction scale, 20% infill density and support for all overhanging surfaces from a minimum of 10 degrees. This print setting however ideal presented itself to be cumbersome with many failure-prone points along the print process. There were also concern of accuracy of certain parts of the print due to their vaguely inaccessible positions by the extruder

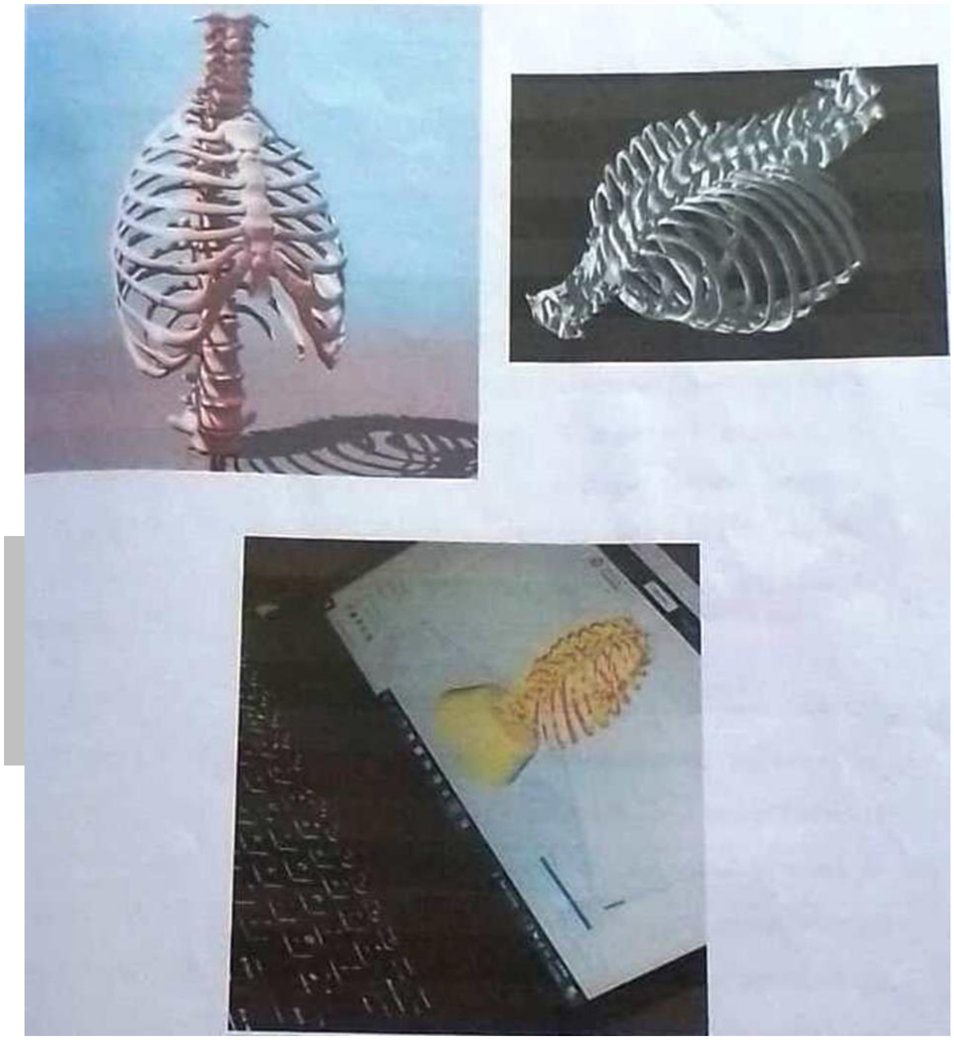

Figure 2: 3D CAD model of the thorax of a southern Nigerian male

This solution presented to these issues however was to separate the general thorax model into smaller individual parts which were able to be printed and reassembled. The model was separated into 4 segments namely; the lower vertebrae, which had a print time of 5 hours 33 minutes and consisted of about 3 sections of the bones found at the base of the model, the mid layer 1 which had a print time of 4 hours 18 minutes and consisted of the five bones above the lower vertebrae, the mid layer 2 which had a print time of 3 hours and 46 minutes and consisted of the 5 bones above the previous layer, the top vertebrae which had a print time of 2 hours and 5 minutes and similarly consisted of the bones above the previous stage. the rib support which had a print time of 9 hours and 11 minutes, the ribs which had a print time of 12 hours and 6 minutes. The reduction in print time for the bones belonging to the vertebrae column was a testament to the reduction in size of the bones of mammals with heavier bones being evolutionarily placed lower to support the body weight.

Figure 3: Standardized 3D printed human thorax of southern Nigerian male

At the end of printing all parts were ridded of their support and attached in other according to the model with hot adhesives. On assembling the thorax, a distinctive S-shaped spinal column was observed, which pointed to that of mammals which had a primary objective for supporting bipedal locomotion. The assembled thorax was fitted atop a small wooden base for balance and rigidity for observation and display. The model could easily be scaled up to any desire when presented with larger printers with an accommodating base plate area.

CONCLUSION

For years, medical students have relied on traditional cadaveric dissection to learn about human anatomy. But with the rise of new technologies, there's been a noticeable shift toward 3D anatomy models, both digital and physical. These 3D models are becoming more popular among students in medical, dental, and allied health programs because they offer a hands-on way to understand complex anatomical relationships. While 3D printing is a promising tool in medical education, its full potential in teaching anatomy is still being explored.

CONSENT

A written consent was issued to every subject to declare their consent to participate in this study as per University Standards.

ETHICAL APPROVAL

The study was approved by the ethical research committee of the University of Port-Harcourt, Port-Harcourt, Nigeria.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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