ORIGINAL ARTICLE

PROPOSAL OF A FUNCTIONAL MODEL, AND STUDENTS' PERSPECTIVE REGARDING ITS UTILIZATION IN BUILDING THE CONCEPT OF THE TRENDELENBURG TEST

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ABSTRACT

Objective: To propose a functional model from indigenous resources, and assess its effectiveness for explaining the difficult concept of Superior gluteal nerve injury and positive Trendelenburg test.

Study Design: Quasi Experimental Study

Place and Duration of Study: Department of Anatomy HITEC -Institute of Medical Sciences Taxila. Duration was 1 week.

Material and Methods: Hundred students of first year MBBS class were selected by purposive sampling technique, who were previously taught the concept, using conventional teaching methods, now learnt it again using the model. Feedback was taken from them via an online questionnaire. Google forms were used for collection of data and its analysis.

Results: Out of the 95 submitted responses, 13 (13.7%) students said that they did not understand the concept previously and now they understand it very well, while 78 (82.1%) students said that they understood the concept previously but now they understand it better. A total of 37 students (38.9%) said that it was very easy, and 41 students (43.2%) said that it was easy for them to understand the concept. Furthermore, 72 (94.7%) students said that they think more of such models should be made.

Conclusion: The model proved quite effective in explaining the difficult concept of Trendelenburg test, and construction of functional anatomical models from indigenous resources should be encouraged.

Key words: *Model, Skeleton, Superior gluteal nerve, Trendelenburg test*

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INTRODUCTION

Conceptualizing anatomy is of paramount importance for effective clinical practice; hence, Anatomy must be taught and learnt within a clinically relevant context with the help of interactive and engaging learning activities[1].As the reformed medical curricula are being introduced, the hours originally allocated to Anatomy teaching are reduced, calling for innovative approaches for an enjoyable and fruitful experience of teaching and learning Anatomy for students in the emerging context[2]. While learning Anatomy, the three-dimensional visualization of structures is of importance for concepts of structures as well as functions[3]. The Positive Trendelenburg test is one such concept and is used by medical practitioners internationally[4]. It demonstrates how an inability of the abductors of thigh at hip joint to perform their function on one side, leads to a drop in the pelvis and limb lengthening of the other side[5].

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The superior gluteal nerve innervates the gluteus medius and gluteus minimus muscle. These muscles abduct the thigh at hip joint, thus decrease the angle between thigh and trunk. During walking, one foot is fixed to the ground and the other is lifted. When the gluteus medius and minimus of the supported side contract, they reduce the angle between thigh and trunk by tilting the trunk towards the supported side, and as a result lifting the pelvis of the unsupported side up. This creates a small gap between the foot and ground on the unsupported side and helps in clearing the foot off the ground without dragging. The Superior gluteal nerve is vulnerable to injury by a wrongly placed intragluteal injection resulting in paralysis of the gluteus medius and minimus. As a result, the pelvis of opposite side will drop when the person lifts that foot off the ground[6]. This is called Positive Trendelenburg sign. Person showing it might develop certain compensatory gaits in order to clear the foot off ground, collectively known as Trendelenburg gait and include the gluteal gait, the steppage gait and the swing- out gait [7].

The concept explains how injury to muscles of one side of the thigh (abductors of thigh), leads to a drop in the pelvis, and limb lengthening of the opposite (healthy) side [8]. The complexity and seemingly contradictory nature of the concept makes it challenging for students to imagine. There is no mention in published literature regarding use of a functional model for explaining it. Hence, a need for exploring that possibility was felt.

The active learning is defined as "anything that involves students in doing things and thinking about the things they are doing"[9] while Felder and Brent defined it as "anything course-related that all students in a class session are called upon to do other than simply watching, listening and taking notes"[10]. The anatomy is not only about structure; its clinical and functional aspects are also important[1].The functional models can be used for this purpose and explaining difficult concepts like Trendelenburg sign, but there are little to few functional models available in Anatomy museums.

Indigenous resources can be used to make simple and cost-effective functional models to facilitate the students in understanding difficult concepts and their application in clinical context. the understanding of students. Some already available models can also be modified to create effective functioning models. A functional model to demonstrate the concept of "Injury to the superior gluteal nerve" was fashioned by modification of a dis-articulated skeleton, using indigenous resources with the objective to explore students' perceptions regarding its utilization in building the concept of the Trendelenburg test.

MATERIAL AND METHODS

It was a one week long quasi-experimental study, conducted at HITEC-Institute of Medical Sciences Anatomy Department after the approval of the institutional ethics committee. The purposive sampling technique was employed to select the participants.

A functional model explaining the concept of Trendelenburg test was fashioned from the indigenous resources. One hundred first year MBBS students of HITEC-IMS, that were taught the concept of Trendelenburg test already by the conventional lecture were engaged for the study after informed consent. Considering the online teaching due to COVID pandemic, a video was recorded showing the concept with the help of the functional model and a synchronous narration explaining the concept. The video was uploaded on the YouTube, and the student were provided the link https://youtu.be/zyyFOHX25Mo, where they accessed the video and tried to learn / clarify the concept of Trendelenburg test. They were then asked to fill the online feedback proforma (Figure 1), validated by five medical educationists, two of whom were anatomists as well. The feedback proforma assessed the effectiveness of the model in learning the Trendelenburg test in comparison to the conventional lecturing. Google forms were used for collection of data and its analysis. A total of 95 students participated and gave their feedback.

MAKING OF THE MODEL

This model has been fashioned by using artificial bones of lower part of body and cheap, locally acquired material.

The bones used included lower two lumber vertebrae, sacrum, right and left hip bones, femora, tibiae, fibulae, and patellae.

1. How has the model affected your understanding of the concept? *

- ◯ I did not understand the concept previously and now I understand it very well
- ◯ I understood the concept previously but now I understand it better
- ◯ My understanding is the same as before
- ◯ I did not understand it previously and nor do I now
- ◯ I undersood it previously but now I am confused

2. How easy was it for you to understand the concept through this model?*

- ◯ Very easy
- ◯ Easy
- ◯ Normal
- ◯ Difficult
- ◯ Very difficult

3. Which method of teaching do you prefer?*

- ◯ Books
- ◯ Books with model and video

4. Do you think more of such models be made?*

- ◯ Yes
- ◯ No
- ◯ May be

Any further feedback:

Your answer

Figure 1: The Feedback proforma.

Figure 2: The complete model hanging from the stand.

The bones were articulated together by the help of wires while allowing reasonable movement at movable joints (Figure 2).

The foot bones were not used in process. Instead, an artificial foot was created by using paper Mache and was articulated with the lower end of tibia and fibula by a thin metallic rod passing through and through the lower end of tibia and fibula, allowing dorsi and plantar flexion (Figure 3).

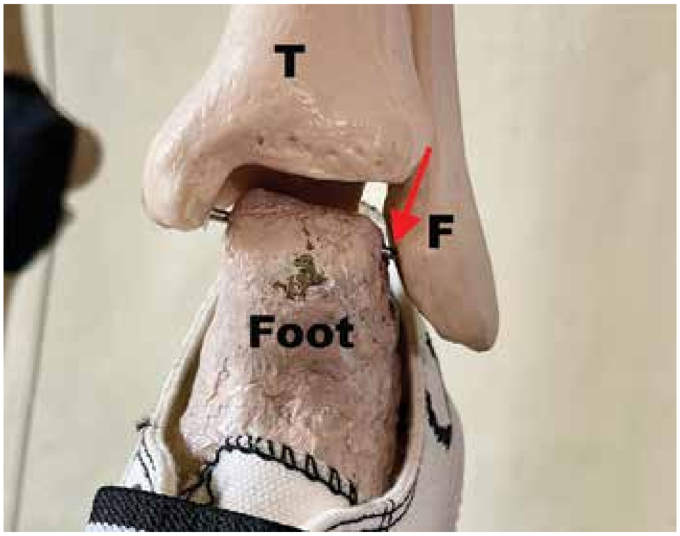

Figure 3: Showing the artificial articulation between lower ends of tibia (T), fibula (F) and artificial foot with the help of metallic rod indicated by red arrow.

For creating the knee joint, a metallic rod was passed horizontally through both condyles of lower end of femur, and the upper end of tibia was hung at this rod with the help of wires (Figure 4).

The knee joint was further stabilized by the help of rubber strips fixed both medially and laterally. The rubber strips used were cut from a tore type tube which can be acquired from basic tyre sellers. This stabilizing of the knee joints is an important step in ensuring the functionality of the model by giving it an upright position; essential for the demonstration of the Trendelenburg test (Figure 4). The patella was hung from the front of lower end of femur.

The gleno-femoral joint was fixed through a strong flexible wire passing through the head of the femur, and the acetabulum while allowing abduction and rotation of thigh at this joint.

The sacroiliac, interpubic, superior and inferior tibiofibular joints were fixed by wires.

Lower two lumbar vertebrae were articulated together and to the sacrum through a string passing through their centre, which was later used to hang the model (Figure 5). The model was hung from this string at a height which allowed the soles of shoes to touch the ground.

After the essential step of articulation of the skeleton was done, the muscles were cut from the same rubber tube used

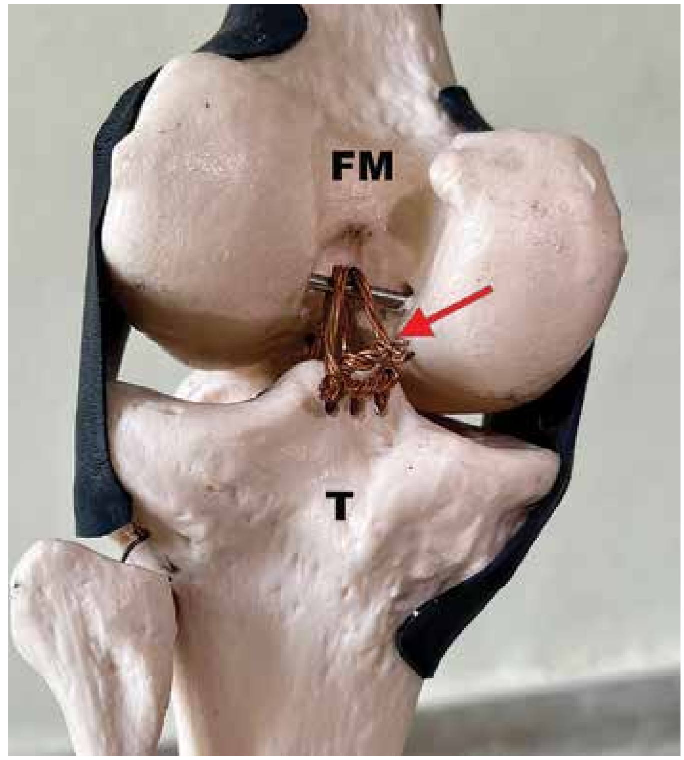

Figure 4: The posterior view of the knee joint. The upper end of tibia (T) can be seen hanging from lower end of femur (Fm) with the help of wires (Red arrow) The rubber straps holding the bones in place on both medial and lateral sides are also apparent.

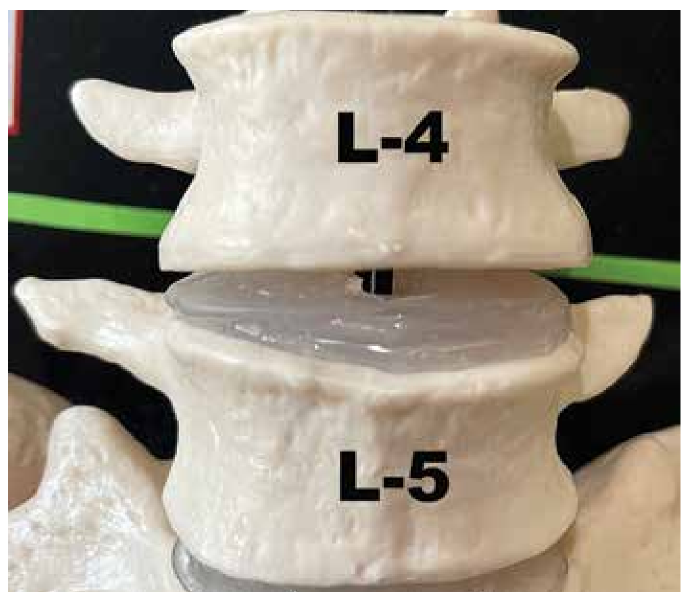

Figure 5: The articulation of lower two lumbar vertebrae (L-4 and L-5) by the string which was used to hang the model (red arrow).

previously, painted and attached with a strong adhesive glue at their origins on the hip bone. At the insertion strong snap buttons were used. One part of the button was attached on the muscle directly while the other part that is to be attached on the femur was attached to a strong cloth. The cloth along with the button was glued onto the femur at the respective insertion

Figure 6: The gluteus medius (G.Med) and minimus (G.min) fashioned from rubber sheets are fixed at insertion by bottons (red arrows) which can be unclasped to depict paralysis of muscles.

points. When installing the buttons, it was kept in mind that there should be some tension in the muscle when the button is closed. Opening the button represented muscle/nerve injury (Figure 6).

A thin straight metallic rod was positioned and set on top of the pelvis to make the 'pelvis tilt' visually easier to detect (Figure 7).

Strings were attached to back of the shoes and passed through a loop attached to the back of mid femur. Hooks were attached

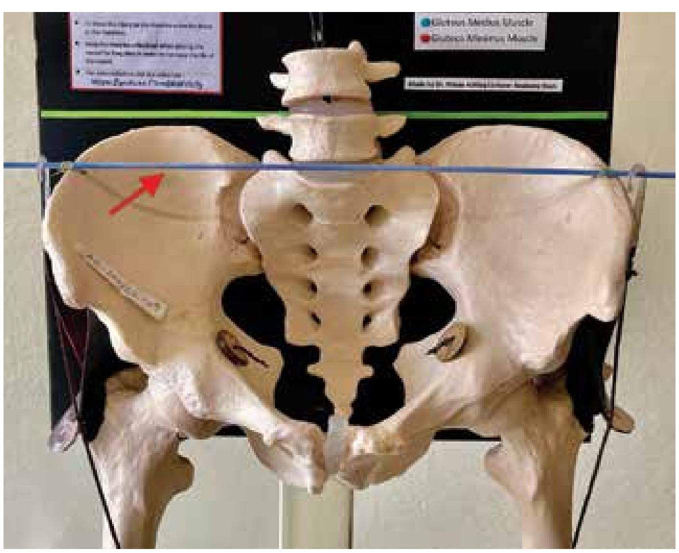

Figure 7: The red arrow indicates the metallic bar placed on pelvis to facilitate visualization of pelvis tilt.

Figure 8: The string (red arrow) attached to the shoe is passed through a loop on back of mid femur and is used to flex the knee and lift the foot off the ground.

to the end of the string for fixing in another loop at the back of the shoe, to keep the knee flexed when needed, in order to lift the foot off the ground (Figure 8).

A custom-built stand was made for the model according to its height. A support was provided at the back of the pelvis so that the pelvis does not rotate antro-posteriorly. Additionally, free space was ensured behind the legs so that there is space for the knees to flex (Figure 2).

The total expenditure on the model excluding the labour, the stand and the skeleton bones was under PKR 1000/-. The cost of the stand was PKR 4000/-.

Working of the model:

1. When the muscle fabric on both sides is buttoned or buckled, the model is at its default state. This is the structure of the skeleton when the muscle is healthy and undamaged. The pelvis remains straight as shown by the rod on top of it. This "undamaged muscle structure" is presented to the students before the beginning of the demonstration as the "controlled or reference environment".
2. To demonstrate injury to the muscles, one side of the pelvis

is unbuckled. A slight tilting of the pelvis is observed after this step. This is due to the change in tension between the two sides as the muscle on the other side is now more stretched.

3. At this point, it is to be observed that this slight tilt to the opposite side is not very significant as long as the feet are placed on the ground, i.e., the skeleton is standing. This tilt is even less significant in real patients because the weight of the torso on the pelvis balances out some of the imbalance. This weight can be demonstrated on the model by placing both palms on the top of the pelvis on each side and pushing down.
4. Now, with one side of the muscles unbuckled (representative of injury), the foot of the same side is lifted off the ground. The pelvis remains straight.
5. Then, the foot of the opposite side of the injury is lifted. This leads to a significant drop of the pelvis on the unsupported side.
6. Keeping this foot lifted, functional limb lengthening and compensatory gaits can also be demonstrated.

RESULTS

A total of 95 students saw the demonstration of model in the video uploaded on the youtube and gave the feedback. Out of which 61(64.2%) were female and 34 (35.8%) were male.

The question-1 inquired about the effectivity of model in understanding the concept in comparison to their previous understanding. Out of 95, 13 (13.7%) students said they did not understand the concept previously but now very well. According to 78 (82.1%) students, they understood the concept previously but now they understand it better. However, 4 (4.2%) students did not find any change in their understanding after watching the video. None of the students said that they did not understand it previously and nor do now. Similarly, none of the students said that they understood it previously but now they are confused (Figure 9).

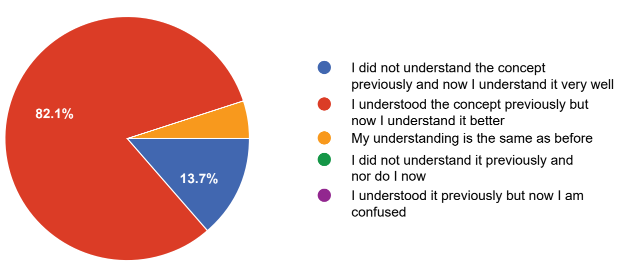

Figure 9: Pie chart depicting how the model has affected the students understanding of the concept.

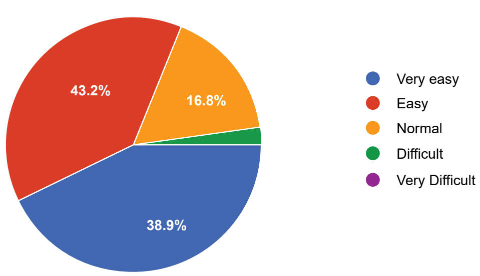

Figure 10: Pie chart showing students responses about how easy it was to understand the concept with model.

The second question was about the ease the model offered for understanding the concept. Out of 95, 37 students (38.9%) found it very easy, 41 students (43.2%) easy, while 16 student (16.8%) remained neutral. However, 1 student (1.1%) found it difficult, while no one opined it to be very difficult (Figure 10).

All students agreed that it was better to understand the concept with assistance of model and video along with the book, than from book alone.

On being asked about their opinion regarding more of such models to be made, out of 95, 76 students responded to this question. 72 (94.7%) students said 'yes', 1 (1.3%) student said 'no', 3 (3.9%) students said 'may be' (Figure 11).

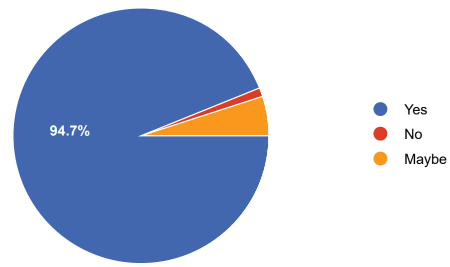

Figure 11: Pie chart showing students responses about need to make more of such models.

DISCUSSION

The purpose behind the making of this model was to facilitate the learning of the students attempting to understand the aforementioned concept. Popular discourse in pedagogy points towards the higher efficacy of practice and demonstration-based learning[11]. It has been long signified by research that student retention is significantly higher when they are learning concepts through practical hands-on laboratory exercises as compared to lectures[12]. The same is endorsed by the fact that the majority of students in our study reported positive effectivity of the model in clearing the difficult concept of Trendelenburg test.

Our study also highlights the ease reported by majority of students in understanding the concept with the help of model. This is in accordance with the reported fact that the topics which are usually considered "difficult" or "tricky" by students can often be explained more effectively through models, demonstrations, and simulations. Student comprehension and retention is shown to be at the level of 0.75 ± 0.25 with hands-on teaching methods as compared to traditional interactive lectures which were at 0.46 ± 0.37 [13]. Moreover, the studio learning – where students get to learn concepts through hands-on practical experiences instead of lectures – is increasingly entering the modern discourse as the 'ideal' method of teaching, it cannot be implemented universally without significant policy and budgetary reconstruction at the governmental level. However, as the model presented in this study aims to show, it can be implemented in a cost-effective way for targeted concepts[14]. This can be done by institutions and teachers wishing to enhance their students' conceptual understanding.

Most of the students engaged in this study felt the need for making of more functional models as an innovative method for learning Anatomy and difficult concepts therein. This needs for the such innovation in learning methods has become more important in the recent years due to globalization[15]. Globalization has significantly increased the competition modern medical students are up against. This increased global competition puts the students who have fewer resources at their disposal at a disadvantage. A good ratio of the medical colleges based in developing countries do not have the tangible and intangible resources to create studio-based learning environments for their students.

Research has shown that student performance increases significantly in both theoretical and demonstration assessments if their learning techniques involve a higher degree of hands-on activities[16].

CONCLUSION AND RECOMMENDATIONS

Some targeted difficult concepts in Anatomy and other fields of medicine can be explained effectively using specially designed functioning models. Locally available models can be modified into functioning models, and similarly functioning models can be made from scratch using locally available cost-effective resources. Moreover it is recommended that in the case of difficult concepts, further different teaching approaches should be tried and tested.

AUTHORS' CONTRIBUTION

Minaa Ashfaq: Conceived, model making, data analysis, manuscript writing.
Asma Hafeez: Conceived, final approval of manuscript and accountable for integrity of study.
Mariam Ashfaq: Model making, manuscript writing.
Maleeha zafar: Manuscript editing, bibliography, proof reading.

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