Teacher-made Three Dimensional Model of Pyramidal Motor System

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Abstract

Background: The study of the structure of nervous system, human neuroanatomy, is crucial to the medical and allied health students. The tracts in motor system and somato-sensory system are the most complicated portions which need simplification for better understanding. The pyramidal motor system consists of a group of fibres carrying messages for voluntary motor movement to the lower motor neurons in the brain stem and spinal cord. It controls all of our voluntary movements and understanding of its pathway is vital for medical students to be able to transfer this knowledge to real life clinical settings.

Aim & Objectives: To determine the effectiveness of teacher-made educational model in enhancing medical students’ learning of pyramidal motor system

Methods: An innovative attempt was made by the researchers to develop a model of pyramidal motor system using readily available materials. It was developed to illustrate the motor pathway in three dimensional model starting from the motor area in the cerebral cortex till to the skeletal muscle. A computer aided animation to demonstrate the cross sectional appearance of brain at different levels and the motor pathway was also created. The model was supported by the animation mimicking the conduction of nerve impulses along the motor pathway. A total of 87 Year 1 medical students in small groups were randomly exposed to two methods; (1) 44 students in this innovative method and (2) 43 in conventional small group teaching method. The difference in their assessment scores (both immediate and remote) was analyzed.

Results/Findings: The groups assisted by the innovative educational aid developed by the teachers for this purpose showed a significantly higher scores (p<0.05) indicating effectiveness of this innovative method.
Study Limitations: The study results only showed the immediate achievement of students in terms of paper & pencil test scores. The assessment scores would not reflect the students’ capability to apply this knowledge in the real patient situations.

Conclusion: The study provided a strong evidence that the three dimensional model created by the medical teachers enhanced the medical students’ learning of pyramidal motor system. Thus the medical schools should promote the innovation and utilization of teacher-made educational models to enhance their students’ learning of complex issues.

Key words: medical, learning, neuroanatomy, teacher-made model, pyramidal motor system

Background

A medical curriculum would not be complete without its Anatomical component. The medical and health practitioners of the new millennium are greatly indebted to the efforts made by the pioneers like Herophilus (Alexandria, Egypt), Alcmaeon (500 B.C. Italy) and Empedocles (490–430 B.C Sicily). The anatomical inferences in relation to diseases made by Hippocrates (the father of Medicine 460-377 B.C) and Aristotle (the great philosopher 384-322 B.C) were either supported or refuted by the works of Herophilus (the father of Anatomy 335-280 B.C) and Erasistratus (310-250 B.C). They conducted the first systematic dissections of the human body and Herophilus established the brain as the center of intelligence. The technological advances in the twentieth century have allowed scientists to look inside the human body without performing dissections or to conduct an antemortem study even without performing surgery. Along with this technological evolution in the study of Human Anatomy, progressive attempts had been made by the medical educators to teach Anatomy without the use of human cadavers.

The study of the structure of nervous system, the human neuroanatomy, is crucial to the medical students as well as to the students of all allied health professions. Even with the use of human cadavers, it is difficult for the students to visualize and comprehend the components and structural relations of the brain and spinal cord. In neuroanatomy teaching, the tracts in motor and somato-sensory systems are the most complicated areas which need simplification for better understanding and memorization. The illustrations of these motor and sensory tracts in most of the neuroanatomy textbooks would not allow students to get an imaginary 3D (three dimensional) view of the related structures without referring to the cadavers.

Patel and Moxham found that the order of preference for teaching methods (in descending order) was cadaveric dissection by students, prospection, living anatomy together with radiological anatomy, computer-aided learning (CAL), didactic lectures, and the use of models. With the advent of technology, there has been an explosion of computer-based anatomy materials which are made readily available. However, the application of those commercial materials in day-to-day teaching of Anatomy was rather limited due to the cost implications and the materials’ limited relevance to the intended learning outcomes.
The Medical School (SPU) of University Malaysia Sabah (UMS), is a training hub for students coming from all over Malaysia with a diversity of backgrounds and learning styles. The school is striving for excellence through innovative ways of imparting knowledge and experiences. The faculty thus tries to assist in students’ learning by attempting new approaches for presenting complex topics in a manner which will be easily understandable to students. A special study module in Anatomy focuses on student-creative models as they are said to be effective in aiding anatomy teaching among medical students. The faculty members also exert special efforts on creation of teacher made models for all relevant curricular activities. This project is an example of such an effort made by the faculty of School of Medicine, UMS.

**Theory background**

The **pyramidal motor system** controls all of body’s voluntary movements. The fibres of the **corticospinal (pyramidal) tracts**, which form the major descending tract, extend from the motor area of cerebral cortex down through the brainstem and occupy the anterior and the lateral aspects of the white matter of the spinal cord. The corticospinal tracts conduct motor impulses from the brain to the spinal cord where somatic motor neurons conduct impulses to various skeletal muscles effectors.  

The fibers of the corticospinal and corticobulbar tracts arise from the **sensorimotor cortex** around the central sulcus; about 55% originate in the frontal lobe (areas 4 and 6), and about 35% arise from areas 3, 1, and 2 of the postcentral gyrus of the parietal lobe. About 10% of the fibers originate in other **frontal or parietal areas**. The axons arising from the large pyramidal cells in layer V (Betz’s cells) of area 4 contribute only about 5% of the fibers of the corticospinal tract and its pyramidal portion.

They form part of the **posterior limb** of the internal capsule. The fibres descend in the crus cerebri of the midbrain. The corticospinal fibres get a little fragmented in the pons, and no longer visible as a nice tight bundle. In the medulla. The fibres come together again as the pyramids. At the **pyramids** in the inferior part of the medulla, 85% to 90% of cortico-spinal fibers decussate, or cross to the other side of the brain. The fibers that decussate are called the **lateral cortico-spinal tract** or the **lateral pyramidal tract**. The remaining 10% to 15% continue to descend ipsilaterally. They are referred as the **ventral pyramidal tract** or the **anterior cortico-spinal tract** since they travel down the ventral aspect of the spinal cord.

For the medical students, they need to understand and remember that the majority of fibres reach to the opposite side before reaching the spinal cord. The spinal nerves thus receive only the contralateral innervation from the cortico-spinal tract. This means that unilateral pyramidal tract lesions above the point of decussation in the pyramids will cause paralysis of the muscles served by the spinal nerves on the opposite side of the body. For example, a lesion on the left pyramidal tract above the point of decussation could cause paralysis on the right side of the body.
Rationale

The pyramidal motor system controls all of our voluntary movements that proper understanding of its pathway is vital for medical students to be able to transfer this knowledge to real life clinical settings. This project was part of an effort to improve the students’ understanding of the complex structure and pathways of the pyramidal motor system. The authors expect that better understanding of the subject would develop a pleasurable learning experience essential for further motivation towards learning.

Objectives

This project aimed at determining the effectiveness of teacher-made educational model (3D interactive model) together with computer aided animation in enhancing medical students’ learning of pyramidal motor system.

Material and Methods

A Post-Test Control Comparison design was used to compare the immediate learning outcomes among the “Test” and “Control” groups of year 1 medical students. An innovative educational aid (three dimensional model and a computer aided animation of pyramidal pathways) was developed and used as a teaching aid for students in “Test” group.

Innovation

Pyramidal corticospinal tract educational aid was designed to fulfill the above objectives with the use of three dimensional model and computer aided animation mimicking the conduction of nerve impulses along the motor pathway.

Educational aid 1: Three dimensional model

Plastic sheets were cut to conform to the shape and size of the cross sectional appearances at different levels of brain and spinal cord; i.e. (1) Cerebral cortex, (2) midbrain, (3) pons, (4) medulla and (5) spinal cord). The respective cross sectional appearances were drawn on the plastic sheets. The sheets were then arrayed vertically using a supporting pillar. The LED light bulbs in series of different colours were used to represent the pathways of the neurological tracts. One light bulb was placed in each plastic sheet to indicate the specific location of the tract. The switch of the bulbs is attached at the highest plastic sheet representing the cerebral hemisphere. If the switch was turned on, the bulbs would light up gradually in descending order. It gave an
example of the way neurological impulses were conveyed through the midbrain, pons and medulla. (Fig 1)

**Educational aid 2: Computer aided animation**

The same principle was applied to draw the cross sections of brain and spinal cord at different level in 3D mode. The pathways were drawn and the decussation was highlighted in different colours. Students mimicked the neurological impulses by mouse clicks. (Fig 2)

The Year 1 medical students in small groups were randomly exposed to two methods; (1) this innovative method and (2) conventional small group teaching method. The difference in their assessment scores (both immediate and remote) was analyzed with the help of SPSS statistical software.

**Results**

A total of 87 students took part in the study. They were given a conventional lecture on pyramidal motor system. At the end of the lecture, the students were given pre-test questions (MCQ of True False type covering 30 items) on pyramidal motor system. Then the students were randomly divided into (1) Test group and (2) Control group. Both groups were provided with trigger questions and reference materials as in routine SGDs (small group discussion). 43 students in the control group were to conduct SGD conventionally. However 44 students in test group were allowed to use the **Pyramidal corticospinal tract educational aid** (both the model and computer animation) during their small group discussion time. Both conventional & model aided SGDs were conducted simultaneously and at the end of SGD time, the students were again asked to answer the post-test questions. After one month, the students were to answer the post-test questions again so as to assess the level of remote memory retention. Three students from the test group and two from the control group did not take that repeat test. The results were as follows:

I. **Comparison of Pre-test Scores between the Test and Control Group**  
The mean pre-test scores for the test and control groups were (17.7± 3.5) and (18.2 ± 3.1) respectively. There was no significant difference between the pre-test scores of two groups although the test group got a slightly lower mean score. \([t=0.713 \text{ at df}=85, \ p <0.478]\)

II. **Comparison of Post-test Scores immediately after SGD**  
The test group showed a significantly greater score than the control group with the mean scores of (25.8 ±1.9) and (24.6± 2.8) respectively. \([ t=2.389 \text{ at df}=85, \ p <0.019]\)
III. Comparison of Repeat-test Scores after one month
There was no significant difference between the test scores repeated after one month. Test group obtained the mean score of (20.7 ±2.8) while the control group showed (19.4 ±3.4). [t=1.81 at df=80, p <0.074]

IV. Comparison of Differential Scores immediately after SGD
The increase in scores after SGD (Post test Scores minus Pre-test Scores) among the test group (8.1± 2.8) was significantly higher than that of the control group (6.4 ±3.2). [t=2.637 at df=85, p <0.01]

V. Comparison of Differential Scores after one month
The score difference between pre-test and repeat test after one month showed a significantly higher result with the test group (2.6 ±3.7) when compared with the control group (1.0 ±3.7). [t=1.96 at df=80, p <0.05]

Discussions
As shown by the results, this innovative learning aid developed by the teachers had made significant effect on medical students’ learning of pyramidal motor system. Since the earliest times of medical education, a variety of learning aids has been developed, tested and updated to enhance medical students’ learning. Though learning is individual, the learning aids help to stimulate student’s interest and extend the learners’ attention span. In addition the learning aids are useful to assist students in the comprehension and visualization of the complex structures and functions. E. Rathenberg has pointed out that teaching aids can make teaching interesting by reproducing reality in situations where the exposure to actual reality is not possible or still premature.9

Developing a model is the first step in simulating the whole real-world process.10 Physical simulation refers to simulation in which physical objects are substituted for the real thing.11 One can model a real world environment in a simplistic way so as to help a learner develop an understanding of the key concepts.10,11 Models also assist the student to grasp the nomenclature and to describe the physical findings. Different types of models are used in medical teaching to enhance students’ understanding and decision making. The most common used models are the static ones, which help the student to acquire spatial awareness and to understand the construction of the organ or the structure.

This model on pyramidal motor system was supported by the computer animation attempting to simulate the pathway of neuronal impulses. It was innovated at a minimal cost in collaboration with the IT unit of the School of Medicine and the School of Engineering, UMS. Findings of this study support the claim made by Trung Q Tran et al that teacher made models appeared to be an effective alternative to costly commercial models for medical students.12
Conclusion

The educational aids developed by the teachers had significantly increased the academic achievements, either immediate or remote. It helped the students to visualize how the nerve impulses were transmitted from motor area of the cerebral hemisphere to the skeletal muscles through the different levels of the brain and spinal cord. This study was done on Year 1 medical students who had little or no experience in clinical setting. In spite of that, the model and animation helped the students in explaining the potential consequences of a lesion severing the neural pathways at specific levels in the central nervous system. Thus the medical schools should promote the innovation and utilization of teacher-made educational models to enhance their students’ learning of complex issues.

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Conflict of Interest: None

References


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<td>25.82 ± 1.9</td>
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<td>24.60 ± 2.8</td>
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<td>REPEAT TEST</td>
<td>TEST GRP</td>
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<td>20.66 ± 2.8</td>
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Table 2: Comparison of Differential Scores between Test & Control Groups

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<td>CONTROL</td>
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<td>1.02 ± 3.7</td>
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Figure 1: Educational aid 1 - Three dimensional model
Figure 2: Educational aid 2 - Computer Animation