ORIGINAL ARTICLE

NEURO-MUSCULAR PHYSIOLOGY EXPERIMENTS: COMPUTER ASSISTED LEARNING VERSUS TRADITIONAL LECTURE DEMONSTRATIONS

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Background: We describe an evaluation of the effectiveness of a computer assisted learning (CAL) program, which simulates a series of experiments of neuromuscular (NM) physiology on frog's gastrocnemius-sciatic nerve preparation, compared with a traditional laboratory. **Methods:** Both CAL program and simple laboratory demonstrations were used to teach experimental neuro-muscular physiology to 100 first year undergraduate medical students. One group of 50 students (Group 1) was taught using traditional demonstrations and the other group of 50 students (Group 2) was taught using a CAL program. After completion of the experiments, both groups of students were tested for the knowledge gained during the experiments. Student attitudes were surveyed by a questionnaire consisting of 16 close ended and one open ended question. **Results:** The test scores of Group 2 were better than Group 1 and there were statistically significant differences (unpaired *t*-test) in the marks obtained. Feedback questionnaire revealed that for most students the dissection and use of animals was not essential to demonstrate known facts or principles. Student feedback on ease of use of CAL program and level of interaction was very positive. The computer simulation demonstrations were highly recommended by students but most of them also felt that CAL should be used in conjunction with interactive demonstration by a skilled instructor. **Conclusion:** The CAL programs can actively involve students even in large classes and are designed to cover the major objectives of the NM physiology experiments. CAL programs appear to provide an effective alternative to animal demonstrations in teaching experimental neuromuscular physiology, better in some aspects and not in others.

Keywords: Computer Assisted Learning (CAL), Traditional methods, Neuro-muscular experiments, Feedback questionnaire

INTRODUCTION

Physiology courses continue to rely on laboratory observations to provide students with practical information to correlate with their developing base of conceptual knowledge.[1] Traditionally, laboratory exercises in physiology have associated use of animals such as frog, rat, guinea pig, dog etc. as tools to learn first-hand aspects of the subject. In the past either very few or no ethical concerns were raised or there were no better alternative teaching methods available. With increasing awareness and ethical concerns there have been continuous objections to using animals in teaching. Killing of animals for laboratory use has become controversial especially after the intervention of animal rights activists and opponents of animal experimentation. Computer simulations, which are now widely available at relatively low cost, can provide a dry lab experience that may fulfil some, but not all, of the objectives of the animal labs. These alternatives may be particularly appropriate where the animal lab is costly to run or requires a high level of technical expertise.[2,3] The availability of alternatives, through innovative technologies have resulted in paradigm shift in the use of animals in the laboratory. Most of the evidence suggests that where computer simulations are used as alternatives they can fulfill many of the learning objectives of the vet lab, although not too effective in teaching animal handling, dissection and laboratory skills.[4] The results of a study seem to support more widespread adoption of alternative teaching methods in biomedical education.[5] Computer models play an important role in the non-animal alternative testing.

A computer model, a computer simulation or a computational model is a computer program, or network of computers, that attempts to simulate an abstract model of a particular system.[6] A recent study was conducted by Dewhurst and Kojic in Eastern European universities, to explore the use of animals in teaching and implementation of innovative technology based teaching. They found that there was little current use of technology-based teaching and learning resources, but there was considerable enthusiasm to modernise teaching and to introduce innovative learning and teaching methods.[7]

In this background the situation in India has changed little. The curriculum for the medical undergraduate physiology course, prescribes the use of animals for laboratory exercises, though Medical Council of India (MCI) has also advocated use of computer-aided simulation models for animal experiments in recent amendements. Hence the onus to

bring the change lies on us as teachers. The debatable issue of whether we should use animals for repetitive work to gain skills, makes it obligatory to change along with the global trend, to the use of computer assisted alternatives. Many of the medical institutes have shifted their teaching pattern of physiology experiments from using live frog tissues by individual or small group of students to single demonstartions by skilled faculty members. This minimised the sacrifice of animals. This holds true, since a lot many animals were sacrificed to reiterate known physiological concepts. With increasing awareness and ethical concerns the scenario has further changed and many institutes have shifted to taking Lecture demonstrations and discussion of graphs of the various experiments.

This study details two separate approaches to laboratory teaching of neuro-muscular physiology to 1st year medical students. One is traditional neuro-muscular physiology experiments by a skilled faculty member using lecture demonstartions, showing of the experimental graph and discussions on it, whereas the second involves the use of computer software simulation. This paper reports the comparison of the competency of the knowledge gained by students by using different methods of teaching frog neuro-muscular experiments as well as student perception of the CAL program.

MATERIAL AND METHODS

Approval was taken from the research and ethical committee of the institute. The class of 100 first year medical students is usually divided into two practical groups of 50 students each. The design of the study was explained to the students before the start of the study. The main objective of both the sessions was to reinforce concepts presented to students in traditional lectures. Both were designed to illustrate the neuro-muscular experiments on the frog's gastrocnemius muscle and sciatic nerve preparation. One batch of the students (Group 1) attended lecture demonstartions first, while the other batch of the students (Group 2) attended the computer demonstrations first.

Both practical sessions were designed to illustrate the following experiments:

1. Recording a single muscle twitch.
2. Effect of two successive stimuli on skeletal muscle contraction.
3. Effect of increasing frequency of stimuli on skeletal muscles (Genesis of tetanus).
4. Genesis of fatigue on skeletal muscles.
5. Determination of conduction velocity of the sciatic nerve.
6. Written test (25 questions in all).

The learning experience in each case was used as a focus of analysis and discussion to reinforce basic physiological principles and their integration in response to each intervention.

The Lecture Demonstrations

Group 1 followed the traditional approach, which had been developed by the academic staff in the department after the instructions from the institute ethical committee on the minimal use of frogs for experimental purposes. An introductory lecture (2.5 hours) covered the theoretical background and introduced students to methods to be used. Each demonstration was led by a faculty member assisted by another instructor and a skilled technologist. The demonstrations were carried out in a manner to involve the students directly through question and answer interactions.

Another lecture demonstration was on the equipment used earlier for animal demonstrations. Students were asked to study the apparatus and make relevant connections.

On the third experimental day, detailed demonstration was undertaken on the procedure of dissection of frog gastrocnemius-sciatic nerve preparation. Subsequently the various lecture demonstrations for different experiments to be studied were undertaken as stated above. Each experiment took one full practical class of 2.5 hours duration. Except for the first three demonstrations which took the whole of the practical time, the rest of the demonstrations took 1 hour of the practical time. The students were asked to use the extra practical hours to study and discuss the experiment and complete their workbooks.

The Computer Laboratory Demonstrations

A computer assisted learning (CAL) program was used specifically to offer an alternative, student centred approach to teaching the module. The CAL program is an easy-to-use laboratory simulation software and lab manual that consists of exercises containing a number of physiology lab activities that can be used to supplement or substitute wet labs. The CAL program allows us to repeat labs as often as we like, perform experiments without harming live animals, and conduct experiments that are difficult to perform in a wet lab environment because of time, cost, or safety concerns. Pre-lab and Post-lab Quizzes for each activity and Stop & Think and Predict Questions within the steps of each experiment help students make the connection between the activities and the physiological concepts they demonstrate.

The CAL group also had a 2.5 hour introductory lecture. The lecture also included a brief introduction to describing the computer simulation. Another detailed demonstration was undertaken on the procedure of dissection of frog gastrocnemius-tibial nerve preparation

Except the introductory lectures, demonstration of equipment to be used; all experiments conducted on CAL program took 1hour of practical time. The students were asked to utilise the extra time, by working on the CAL program independently on the personal computer.

They were asked to organize their work schedule and use the computer facility in the department, during their free time and at their own pace. Computer simulations also allowed greater flexibility of learning. Students were more able to work at their own pace and could repeat experiments where necessary, to aid understanding.

All students were given a written test after completion of the nerve-muscle (N-M) physiology practicals. This comprised 25 multiple choice questions (MCQs). Questions were designed to reinforce basic physiological principles and their integration in response to each intervention. Some MCQs were based on data manipulation, calculation and interpretation.

Subsequently Group 1 students were given a demonstration of the CAL program. Group 2 students had performed most of the N-M experiments using CAL program, while Group1 students had attended traditional lecture demonstrations and were just exposed to CAL program. Then both Group 1 and Group 2 students' attitude to the CAL program was surveyed by a questionnaire consisting of 17 questions. There were 16 close ended questions and 1 open ended question. Question 17 was an open ended question asking for comments on the pedagogical approach followed, i.e., using the CAL program or attending the lecture demonstration sessions.

After completion of the test and after the feedback obtained through survey questionnaire, two practical sessions based on the CAL program were designed for Group 1 students. This was done keeping in mind that half of the students using tradition lecture formats earlier should not be bereft of the experience of studying and working on the CAL program, being made available to Group 2 students.

RESULTS

Out of the 100 students at the start of the practical experiments, 38 students got migrated to other medical colleges of the state and same number of students joined the institute from other medical collages and some were new admissions. Of the 62 students participating in the study, only 50 students voluntarily participated in the test. Twenty students from group 1 and 30 students from group 2 attempted the test. The test results (converted to % scores), mean, standard deviation and *p*-value are given in Table-1. The test scores of group 2 were better than group 1 students and there was statistically significant difference ($p<0.05$) in the marks obtained by both the groups of students.

An anonymous feedback questionnaire form was distributed to both the group students after the completion of the demonstrations and the results were analysed. Students' attitude to the feedback questionnaire is given in Table-2. The questions were phrased both as positive and negative statements to check for inconsistencies in the way they were answered. Of the 50 questionnaire forms distributed (30 in group 2 and 20 in group 1), 45 were returned (28 from group 2 and 17 from group 1). Results show that there was statistically significant difference between the mean knowledge gained by the groups.

Table-1: Comparison of marks obtained in the test by the two groups (Max Marks: 25)

Groups	Students	Marks (Mean±SD)	*p*
Group 1 (Lecture-Demo)	20	16.90±3.144	0.037
Group 2 (CAL group)	30	19.2±4.055	

Table-2: Results of Feedback Questionnaire on 5 point Likert scale (% of total)

Questions	SD		D		N		A		SA	
	Gp 2	Gp 1	Gp 2	Gp 1	Gp 2	Gp 1	Gp 2	Gp1	Gp 2	Gp1
1. CAL programs of animal experiments are difficult to use.	46.4	5.8	46.4	64.7	7.1	11.7	0	5.8	0	11.7
2. Practical lab experiments using frog's live tissue are the only successful method available to reinforce theory.	25	11.7	46.4	35.2	7.1	0	14.2	41.1	7.1	11.7
3. Practical lab experiments by Lecture-demonstration are better than CAL	18	35.7	35.7	17.6	28.5	47.1	17.8	11.7	0	17.6
4. The use of frog's N-M preparation to demonstrate known facts poses no moral dilemma.	21.4	0	28.5	35.2	28.5	52.9	21.4	11.7	0	0
5. CAL programs cannot adequately replace animal practical experiments while teaching physiology	7.14	5.8	32.1	29.4	17.8	11.7	35.7	41.1	7.1	11.7
6 . CAL will enable the teacher to spend more time with students	3.5	5.8	17.8	11.7	10.7	5.8	46.4	47.1	21.4	29.4
7. Lecture-demonstration method cannot adequately replace animal experiments	0	0	14.2	0	21.4	17.6	53.5	58.8	10.7	23.5
8. Hands-on experience with live animals/tissues is essential for all students	0	5.8	0	23.5	21.4	11.7	53.5	23.5	17.8	35.2
9. CAL program offers students control to their own pace of learning.	3.5	17.6	0	5.8	14.2	5.8	71.4	64.7	10.7	5.8
10. During lab experiments too much time is spent learning how to use equipment	10.7	17.6	32.1	17.6	14.2	11.7	32.1	47.1	10.7	5.8
11. All undergraduate animal experiments should stop	28.5	35.2	25	23.5	28.5	23.5	7.14	11.7	10.7	5.8
12. CAL can replace animal experiments as they meet most of learning objectives.	7.1	23.5	17.8	11.7	14.2	35.2	46.4	23.5	14.2	5.8
13. CAL programs provide a suitable alternative to animal based practicals	0	11.7	0	5.8	25	29.4	57.1	35.2	17.8	17.6
14. CAL can lead to acquisition of lab skills.	7.14	11.7	25	17.6	39.2	41.1	25	23.5	3.5	5.8
15. Using CAL program can significantly reduce the no. of animals used in teaching	0	5.8	7.1	5.8	3.5	17.6	60.7	47.1	28.5	23.5
16. CAL are better alternatives to Lecture Demonstration methods	0	11.7	10.7	11.7	14.2	35.2	50	29.4	25	11.7

SD=Strongly Disagree, D=Disagree, N=neutral, A=Agree, SA=Strongly Agree.
Feedback is from 28 students out of total 30 in group 2 and 17 students out of 20 in group 1.

To the open ended question "If given another chance you would like to attend which practical (CAL or lab-demonstration)? And WHY? What can be improved?" From group 2, 81% students preferred practicals using CAL program, 10.7% students preferred to attend simply lab-demonstrations and same percentage preferred to attend both programs. From group 1, 53% students preferred to attend Lab demonstrations, 29% preferred to attend CAL program and 17.6% students preferred to attend both CAL program as well as lab-demonstrations.

Most of the students were of the opinion that both should be used in future for better understanding of the experiments as both had inherent advantages and disadvantages. Students suggested including a video of the dissection of the N-M preparation and mounting, or at least introducing animation model of the dissection.

DISCUSSION

The CAL programs and alternatives have grown in number over the years, so have studies examining the efficacy of these studies in experimental setting. A number of studies have compared traditional animal dissection with various alternatives. Balcome in 2000 summarised 20 studies presenting other applications of alternatives in experimental learning. In a number of studies carried on earlier, measurable student performance was equivalent between the compared learning methods.[1,9] In a few other studies students performed better using alternatives.[10–12] In one study CAL study was found to provide inferior learning to dissection.[13] The design of this study was deemed too rudimentary for a college-level class by Balcome in his letter to the editor.[14] A conclusion based on these studies is that CAL or alternative methods are pedagogically equivalent to animal dissections. In the present study, CAL program group of students (Group 1) got more marks then the Lecture demonstration group of students (Group 2) and the results were statistically significant.

Both the groups were taught considerable material in a short period of time and the CAL program was based on software designed for individual use rather than group presentation. Evaluation of the program was therefore limited to subjective review by the students involved.

The analysis of the responses from each individual showed that the CAL group found it easier to use the CAL program than the lab group (Q1). Majority of group 2 students were of the opinion that practical lab experiments were not the only successful method to reinforce the theory (Q2).

Most of the group 2 students felt that lab demonstrations were not superior to CAL program, while most of the group 1 students were either neutral or were for the lab demonstrations (Q3). Majority of the CAL group believed that there was a place for non-animal based teaching in physiology and that using animal tissue did pose a moral dilemma, while majority of the lab group either agreed to it or were neutral on this topic (Q4). Though most of the students in both groups disagreed that the animal experiments should be stopped (Q11). Earlier study by Balcome on survey of student's feelings and attitudes towards animal consumptive learning methods show that concerns and reservations about such are commonplace ranging from 30% to 70%.[15] Students from both the groups felt that CAL or lab demonstrations cannot completely replace the practical experience of working on frog's tissue and therefore a hands-on experience with live animal/tissues is essential for all students (Q5–8). Possible reason might be that CAL does not convey a sense of reality that the students need to develop essential laboratory skills (Q8). Both groups appreciated that the use of CAL program offers them to control their own pace of learning (Q9), while there was no consensus on the question of spending too much time on learning to use the equipment in labs gave varied results (Q10). Study by Nosek *et al* revealed that CAL offers self-paced learning that puts students in control of their learning resources.[16] Majority of students in both groups felt that CAL cannot replace animal demonstrations on live tissue (Q12), but the data on whether CAL can provide acquisition of lab skills was inconclusive, most students were neutral to the idea (Q14). The response to Q13, Q16 was interesting as both groups agreed that CAL was a suitable alternative to animal experiments as well to simple laboratory demonstrations of the experiments, but many of the students from group 1 were also neutral to this idea. Probably they could not form a conclusive thought process after being exposed to the CAL program for a very short period of time. Majority of students in both groups believed that the use of CAL program will significantly reduce the number of animals used in teaching (Q15). An earlier study by Dewhurst and Jenkins revealed that British biomedical students saved teaching and staff time and money, proved an effective and enjoyable mode of student learning and significantly reduced animal use.[17]

The response to the open ended question was interesting. While 22/28 students in group 2 wanted to attend only CAL program in the future, only 5/17 students in group 1 preferred attending only CAL program in future. However both groups felt strongly that a combination of CAL and lab demonstrations was effective as replacement for animal demonstrations, but CAL programs do have an important role in undergraduate studies. Some students felt that CAL was quicker and easier way, more grasping. Many felt it was interesting, provided better understanding, helped to visualise everything and less time consuming.

CONCLUSION & RECOMMENDATION

Lecture/demonstrations and computer assisted learning programs both can fill the need for understanding of fundamental concepts of N-M physiology experiments and are regarded as highly effective teaching tools. The CAL program was highly interactive and was designed to cover the major objectives of the N-M physiology practicals. The students easily gain learning objectives and achieve better scores. Alternatives need to replace dissections; they also being ethically preferable make the case all the more clear.

The curriculum of N-M physiology experiments on frog should be modified and updated. It seems sooner than later, we all need to use computer simulation models for animal experiments.

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