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Research Article

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An Effective and Feasible Teaching Curriculum to Improve and Evaluate Medical Undergraduate Teaching Skills for Electromyography Teaching

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Abstract

Objective: *We aimed to explore impact of the presentation-assimilation-discussion (PAD) on the standardized training of medical undergraduate and to provide suggestions for hospital managers, trainers, and trainees.*

Methods: *Forty-two medical undergraduate students in the Department of Neurology of the First Affiliated Hospital of Chongqing Medical University and the Second Affiliated Hospital of Chongqing Medical University after passing Clinical theoretical knowledge learning programs, were randomly divided into two groups, and the learning effect was observed using a PAD class and traditional teaching.*

Results: *The students in the PAD class group showed significantly better theoretical knowledge and electromyography (EMG) report accuracy than those in traditional teaching group. Those in the PAD class performed better on a general questionnaire than those in the traditional teaching class.*

Conclusion: *The PAD class can be used to teach EMG, which can deepen the interest of medical undergraduate in learning EMG, improve their critical thinking ability, and comprehensively improve their ability to synthesize knowledge.*

Keywords: *Educational impact; Medical education ; Medical undergraduate ; PAD class; Electromyography.*

1. Introduction

Electromyography（EMG） is a test that records the electrical activity of a nerve or muscle to understand its functional status[1] and includes needle electrode electromyography, nerve conduction detection and F wave, various reflexes, repeated electrical nerve stimulation, motor unit counting, and single fiber electromyography[2,3]. EMG examination is an extension of nervous system examination and has been included in the routine training of neurology undergraduate. Its purpose is to enable clinical undergraduate to conduct EMG examinations and issue reports under the guidance of superior physicians. However, electromyography is highly technical and practical and requires comprehensive judgment based on the clinical manifestations of patients and operators to have knowledge of neuroanatomy and electrophysiology. Therefore, teaching electromyography has been characterized by its esoteric and abstract nature, and it is difficult to master.

The presentation-assimilation-discussion (PAD) class is a novel teaching method that half the class time is allocated for the instructor's presentation and the other half for student's assimilation and discussion[4]. To enable students to better master electromyography, to make the technology a necessary skill for students and to improve the clinical value of the results of electromyography, PAD Class teaching has been applied to the clinical teaching of electromyography.

We hypothesize that PAD class can better achieve efficient and high-quality learning objectives compared with traditional classroom teaching methods. Thus, our study aim is to evaluate the effectiveness and acceptability of the PAD Class teaching method by implementing these two methods in EMG teaching for the medical undergraduate training.

2. Methods

2.1. Subjects

This was a prospective, randomized, controlled study. A total of 42 students in the Department of Neurology of the First Affiliated Hospital of Chongqing Medical University and the Second Affiliated Hospital of Chongqing Medical University after passing Clinical theoretical knowledge learning programs were selected. The results of their clinical theoretical knowledge learning are all excellent and they will be graduated from the clinical medicine specialty in six months. They were randomly divided into a PAD teaching group and a traditional teaching group, with 21 students in each group. PAD classroom teaching was carried out for the PAD teaching group, and a traditional teaching method combining observation and operation was carried out for the traditional teaching group. The learning time of both groups was 3 months and the teachers and raters were the same for students in both groups.

Inclusion criteria: standardized training for clinical undergraduate; age 20 to 28 years. Exclusion criteria: individuals who did not reach the excellent level of clinical theoretical knowledge learning; individuals who do not agree to participate in this study; and pregnant women. The reporting of this study conforms to the DoCTRINE Guidelines: Defined Criteria to Report INnovationsin Education[5].

We obtained verbal informed consent from all participants to use their scores in this study. In addition, we removed all the personal information from all data used in the retrospective analysis.

2.2. Course program

2.2.1. PAD classroom

2.2.1.1. Presentation

Teachers teach by slide show. The main purpose of the lecture is to sort out the knowledge framework and clarify the key points and difficulties to enable students to preliminarily understand what they have learned and prepare for the completion of homework. After the lecture, the trainee enters the assimilation process.

2.2.1.2 Assimilation

According to the teacher's instruction, students independently study the textbooks and materials provided by the teacher one week after class and complete the following personal assignments. First, students are asked to write down the biggest gains in the learning process, 3 for each person. Second, students are asked to pose question that they know the answer to but others may not. Third, students are asked to list at least one question they do not know the answer to and ask other students to answer it during the discussion. Individual assignments are submitted to a WeChat group before discussion, and every student is required to evaluate the work of the other students. Through independent learning and thinking, students can realize the understanding and internalization of what they have learned, establish their own knowledge system, and pave the way for class discussion.

2.2.1.3 Discussion

According to the content of the above individual work, students first discuss and ask other students to condense the problem. Through the discussion between students to solve basic low-level problems, high-level problems are condensed. Then, in the interactive discussion between teachers and students, the teacher answers the students' questions, solves the high-level problems condensed by the students, evaluates the discussion atmosphere and students' participation, and finally summarizes the course.

Subjects in this group and those in the traditional teaching group received routine EMG operation and daily learning. That is, the instructor provides a thorough explanation of theoretical knowledge within the official framework.

2.2.2 The traditional teaching

Traditional teaching involves students following physicians on duty carrying out EMG operations, daily learning and regular theoretical lectures. In other words, the instructor provides a thorough explanation of theoretical knowledge within the official framework, rather than discussing the cases in a group. That is, teacher-centered instruction is the primary method[6].

2.3 Teaching effect evaluation

In the PAD classroom group and the traditional teaching group, the teaching results were evaluated through theoretical examination, practical examination and questionnaire survey. The theoretical examination included the relevant knowledge and clinical application of electromyography (score: 100). The practical assessment method was as follows: after 3 months of study, the two groups of students performed electromyography for common diseases of real patients in neurology. The subjects decided the detection method by themselves, completed the electromyography independently and wrote the test report. The above practices were scored by experts engaged in electromyography (with a maximum score of 100, detailed scoring criteria can be found in Table 1).

Table 1: Practical examination scoring basis.

Assessment content	score	Grading basis
Ask for medical history	10	Including the main symptoms, onset time, onset mode, disease evolution and family history. Two points for each.
Physical examination	10	Including muscle volume, movement, sensation, physiological reflex and pathological reflex. Two points for each.
Electromyographic manipulation	40	Operating proficiency（20 points）: Proficiency 20 points; Relatively unfamiliar, but can accurately operate 10 points; 0 for being rusty. Check completeness（20 points）: complete 20 points; 10 points for being able to complete most tests; Can only complete a small part of the examination or cannot complete 0 score independently.
Report on electromyography	40	Totally correct 40 points; Incomplete or partial errors in description 20 points; 0 points for error.
Note: Score by experienced senior EMG physicians.		

Two groups of students were surveyed by questionnaires to understand the feedback results of different teaching modes. A six-item online questionnaire was answered anonymously by the two groups. The students' responses to each item were assessed using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) [4], and the number of responses for each option was counted separately. The raters are the same in both groups and blinded to group assignment.

2.4 Statistical analysis

All values are expressed as the means±standard deviations (SD). The t test was used to compare two groups of ordinal variables. Graphs were created using GraphPad Prism 9 software. The $\chi 2$ test was used to compare age, gender, education level, and physician category differences between the PAD classroom group and the traditional teaching group. $P < 0.05$ was considered statistically significant.

3. Results

3.1 Demographic characteristics

A total of 42 standardized training for medical undergraduate participated in the study. Twenty-one participants were assigned to the PAD classroom group, while the other 21 participants were assigned to the traditional teaching group. The average age of participants was 22.52±1.11 years-old in PAD group and 23.50±1.54 years-old in traditional teaching group. The results show that there were no significant differences between the two groups in terms of age and sex.

3.2 Comparison of theoretical assessment results between the two groups

The statistical results showed that after 3 months of learning, the PAD group had significantly better theoretical knowledge assessment results than the traditional teaching group (P<0.01) (Figure 1).

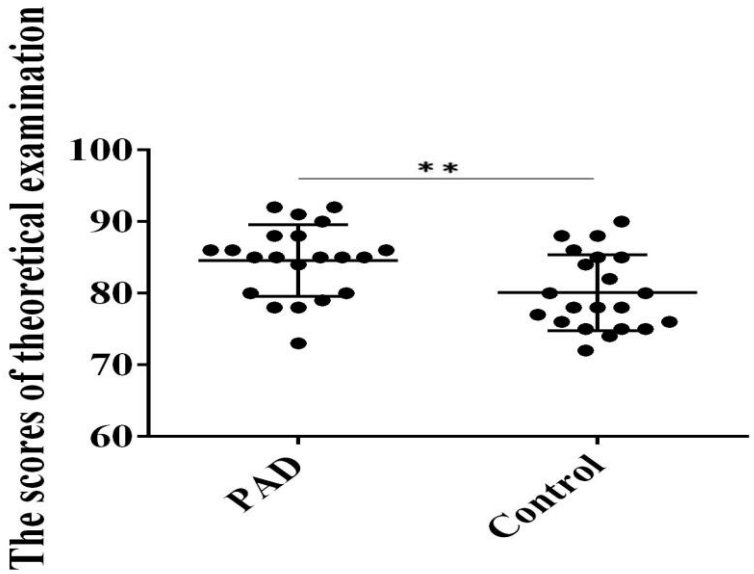

Figure 1: Comparison of theoretical test results between the PAD group and the traditional teaching group. **p<0.01.

3.3 Comparison of practice assessment results between the two groups

There was no significant difference between the two groups in the overall practice assessment results (P>0.05) (Table 2). However, in terms of the accuracy of the EMG report, the PAD class group was significantly better than the traditional teaching group (P<0.05) (Table 2).

Table 2: Results of Practical Examination.

Assessment content	PAD group (Mean±SD)	Traditional teaching group (Mean±SD)	*P value*
Asking for medical history (10 points)	7.76±0.10	7.33±1.06	0.195
Physical examination (10 points)	6.90±1.26	6.95±1.02	0.969
Electromyography operation (40 points)	37.43±1.40	36.67±1.28	0.082
Electromyography Report (40 points)	35.90±1.22	34.67±2.48	0.048
Total score (100 points)	86.90±1.95	85.48±3.01	0.096
Note: The PAD classroom group was significantly better than the control group in terms of the accuracy of the EMG report.			

3.4 Questionnaire survey results

At the end of the study, the students' subjective feelings about the teaching outcome were assessed. The results showed that the PAD class group scored significantly higher than the traditional teaching group in "improving interest in EMG learning", "improving learning initiative and enthusiasm", "improving critical thinking ability", "improving the ability to analyze and solve problems" and "improving the ability to comprehensively use knowledge" (Table 3).

Table 3: Comparison of questionnaire survey results between PDA group and control group.

Response on the Likert Scale	Groups	Number of students (percentage)					*P*-Value
		5	4	3	2	1	
Improve the electromyography study interest	PAD	9 (42.86%)	5 (23.81%)	4 (19.05%)	3 (14.29%)	0 (00.00%)	0.034
	Control	5 (23.81%)	3 (14.29%)	4 (19.05%)	5 (23.81%)	4 (19.05%)	
Improve learning initiative and enthusiasm	PAD	10 (47.62%)	4 (19.05%)	4 (19.05%)	3 (14.29%)	0 (00.00%)	0.029
	Control	4 (19.05%)	5 (23.81%)	4 (19.05%)	5 (23.81%)	3 (14.29%)	
Improve critical thinking skills	PAD	8 (38.10%)	6 (28.57%)	4 (19.05%)	2 (9.52%)	1 (4.76%)	0.036
	Control	4 (19.05%)	3 (14.29%)	6 (28.57%)	5 (23.81%)	3 (14.29%)	
Improve innovation capability	PAD	5 (23.81%)	4 (19.05%)	5 (23.81%)	4 (19.05%)	3 (14.29%)	0.728
	Control	5 (23.81%)	6 (28.57%)	4 (19.05%)	3 (14.29%)	3 (14.29%)	
Improve the ability to analyze and solve problems	PAD	11 (52.38%)	5 (23.81%)	4 (19.05%)	1 (4.76%)	0 (00.00%)	0.025
	Control	6 (28.57%)	4 (19.05%)	3 (14.29%)	6 (28.57%)	2 (9.52%)	
Improve the ability to use knowledge comprehensively	PAD	12 (57.14%)	5 (23.81%)	2 (9.52%)	2 (9.52%)	0 (00.00%)	0.009
	Control	5 (23.81%)	4 (19.05%)	5 (23.81%)	5 (23.81%)	2 (9.52%)	

Note: Student responses to each item were assessed using a 5-point Likert scale: 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree). Non-parametric Mann-Whitney U test was used to compare the score distribution.

4. Discussion

At present, the skill levels of EMG practitioners in many hospitals vary greatly, and most neurologists do not have a deep understanding of EMG, resulting in a lack of clinical connection with EMG; this situation prevents EMG results from being used effectively in clinical practice[7,8] . Traditional EMG teaching focuses on only operation methods. In this way, students are trained to operate mechanically, lack interest in electromyography and initiative and enthusiasm in learning, and cannot conduct proper examination according to the needs of the disease, nor can they conduct in-depth analysis of the patient's disease according to the test results[8]. In recent years, many colleges and universities have actively promoted classroom teaching reform and introduced student-centered teaching models such as flipped classrooms, case teaching and PBL teaching into neurology classroom teaching[9-16]. However, in the practical application of these teaching modes, due to the lack of teachers' preschool guidance, insufficient teaching, and substantial requirements on students' self-learning ability, solving traditional teaching problems can appear unsatisfactory in the traditional cultural background of Chinese students, which advocates cautious words and actions. After the PAD classroom was promoted, it was widely recognized as the only emerging classroom teaching model with Chinese originality [4]. Based on the principles of creative learning and progressive autonomy in psychology, this model reconstructs the classroom teaching process into three processes of progressive teaching, presentation, assimilation and discussion, which may provide a new path for innovative education. This teaching mode fully arouses students' enthusiasm and initiative, creates a lively and rigorous learning atmosphere for students, and enhances their learning interest and critical thinking ability[17]. In this study, the PAD classroom is applied to electromyography teaching, and a good teaching effect is achieved. Compared with traditional teaching, the PAD classroom students' theoretical assessment results and the accuracy of the EMG report are better.

The main teaching principles of the PAD class are elaboration and white space [4]. In the PAD class, teachers provide only guided and framed lectures, explaining learning objectives and the logical structure of learning content. In the teaching process, white space, an important technique of expression in traditional Chinese art, is used. It can also be compared to teachers drawing branches of a tree and asking students to add leaves, leaving them space for active exploration and asking students to "fill in the blanks" with tasks. Reducing the classroom teaching time controlled by teachers allows teacher to release the power they should not have, redefining the power of teachers. It not only guarantees the realization of students' autonomy in learning but also relieves the responsibility of teachers so that teachers are no longer solely responsible for students' learning results. With the PAD classroom teaching mode, teachers can return to their rightful position and become guides, facilitators, organizers and supporters to maximize the realization of students' learning autonomy and realize their value of "teacher for teacher", which also shows great respect for teachers.

At the same time, as in our study, the PAD classroom greatly increased students' interests, enthusiasm and initiative in learning. In the PAD class, there is a time interval between teaching and discussion so that students can arrange learning independently, internalize and absorb. The main tasks of after-class study are reading review, independent thinking and completing homework tasks. Homework tasks are the core link between teaching and discussion and the key to the success of the examination[18]. Homework does not require students to give a standard answer, advocating the use of homework to express their thoughts, with behavior to show the thought. Assignments must have a certain degree of openness, provide students with sufficient divergence and imagination space, and encourage students to carry out personalized construction in a novel and unique way as much as possible.

The starting point of the PAD class is to change "immediate discussion" to "delayed discussion". The class discusses the content of the previous class. Students use the time between classes to complete tasks, learn independently, internalize, absorb, discuss their own opinions in this class, share with each other, and explore the origin of opinions[4]. In the discussion, students form collective wisdom, without standard answers, and emphasize the use of collective power to construct new achievements at a higher level. The discussion results indicate that students' innovative learning is likely to progress to a higher stage autonomously. During the discussion, all members share their homework. Since different students have different homework, it is necessary to explore common things to form

collective wisdom. In practice, the guidance proposed by the author is as follows: try to find a clue to connect the thoughts of each member and integrate them; either find a theme that incorporates the personalities of each member or have each group construct its own higher-level approach and results. Combined with the results that compared with the traditional lecture-based teaching, the PAD class stimulated a passion for learning among students and results in improved outcomes in the oral pathology teaching[4], our study shows that PAD teaching not only improves students' interests, enthusiasm and initiative, create a lively and rigorous learning atmosphere for students, but also enhance their cognitive abilities such as critical thinking and solving complex problems.

There are many methods applied to the teaching of electromyography, they need to be further explored to produce the optimal effect for students who participate in the standardized training of neurology. This study may lead to further discussion in neurology circles and allow them to provide experience to one another to make the teaching of electromyography more reasonable and scientific, realize the harmonious combination of professional theoretical knowledge and clinical practice, establish the unique clinical thinking of neurology, and make contributions to the training of excellent neurologists.

5. Conclusion

The PAD class can be used to teach electromyography, which can deepen the interest of medical undergraduate in learning electromyography, improve their critical thinking ability, and comprehensively improve their ability to synthesize knowledge.

Abbreviations

PAD: Presentation-assimilation-discussion
EMG: Electromyography

Ethics approval and consent to participate

Ethics Committee exemption was conducted by the First Affiliated Hospital of Chongqing Medical University. The study was approved by all the participants.

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Authors' contributions

HZ wrote the original draft, XX, WK, JL, YH, and YF reviewed and advised on the original draft. All authors approved the final manuscript and were responsible for the decision to submit for publication.

Competing interests

The authors declare no competing interests.

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