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Research Article

Do consecutive Patient Management Problem (PMP) and Modified Essay Question (MEQ) Examinations Improve Clinical Reasoning in Students?

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Abstract

Objectives: The purpose of this study was to evaluate the improvement of students' ability to answer consecutive patient management problem (PMP) and modified essay question (MEQ) exams, to assess its relationship with academic progress, and to determine whether consecutive PMP-MEQ exams can improve the students' clinical reasoning skills by improving the test scores. **Methods:** This descriptive, analytical, cross-sectional study consisted of 67 third-year nutrition students in three consecutive years, who were asked to prepare for a multiple-choice question (MCQ) test and consecutive PMP-MEQ exams. The students were required to answer PMP-MEQ exam, which comprised of two queries of five-choice question (PMP) and three short-answer questions (MEQ). Repeated measures ANOVA, independent *t*-test, paired *t*-test, and Pearson's correlation test were used for statistical analysis. **Results:** The mean difference in PMP scores was significant between the three periods (P = 0.0001). However, the difference in the mean score of PMP exam between students with grade point average (GPA) \geq 16 and GPA < 16 was not significant, except for PMP3 (P = 0.001). An increase was observed in the scores of students in both groups by continuous PMP examination. The significant mean difference in PMP3 exam showed that improvement of students with GPA \geq 16 was greater than that of students with GPA < 16 (P = 0.001). The difference in the mean scores of MCQ and PMP exams was significant, except for the third PMP exam in students with GPA \geq 16 (P = 0.143).

Conclusions: Use of PMP-MEQ exams in reasoning-based clinical education can be a suitable approach for clinical evaluation of undergraduate students. Also, continuous PMP-MEQ examination can improve the clinical reasoning of students, mainly those with GPA \geq 16.

Keywords: Clinical Reasoning, Continuous Assessment, Modified Essay Question, Patient Management Problem

1. Background

Effective clinical reasoning depends on the health professional's ability to collect and analyze the right cues or information to reach an accurate understanding of a patient problem or differential diagnosis, to plan and implement the right interventions, and finally to learn from the process (1, 2). Reasoning- and competency-based medical education requires a robust and multi-dimensional assessment system (3). It relies on continuous, inclusive, and elaborate assessment and feedback systems, which facilitate the development of reasoning and competence (4).

On the other hand, in most countries, a multiple choice question (MCQ) is the most common assessment method of medical knowledge, followed by modified essay question (MEQ) (5). MCQ does not focus on the evaluation of cognitive skills, and many MCQs assess small sections of textbooks. With the introduction of problem-based learning for the evaluation of clinical reasoning and competence in medical and health professional courses, besides the shift from a traditional lecture-based curriculum to a student-centered one, many schools are currently reviewing their assessment tools and introducing new strategies for evaluating the student (6).

In a study, two popular formats of tests, i.e., MCQ and MEQ, were compared. Based on their findings, although MCQ and MEQ may assess different skills, there is a very strong relationship between their content scores (7). In another study, the results of MEQ and MCQ were strongly and positively correlated, and the overall examination showed good reliability and validity. In their study, MEQ included more questions on recall of knowledge, which were more

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structurally flawed, compared to MCQ. The MEQ exam failed to achieve its primary goal, that is to assess higherorder cognitive skills (8). In fact, some researchers believe that a well-constructed MCQ is superior to MEQ in assessing the higher-order cognitive skills of undergraduate medical students in a problem-based learning setup.

Development of MEQ for the assessment of students' cognitive skills is not a simple task and is frequently associated with item-writing flaws (9). Knox described that with careful preparation, MEQ can provide a measure of abilities (including attitudes), which cannot be easily assessed by other means. MEQ can also provide an active learning experience in small groups or in a large plenary session (10). In another study, the patient management problem (PMP) method was applied to assess whether an increase in clinical experience can influence the nutrition care planning process. The findings revealed that basic nutrition care planning skills are attained during dietetic internships, while advanced skills, such as information processing and/or confidence in clinical decision-making, are acquired through clinical experience (11).

2. Objectives

The effectiveness of continuous PMP-MEQ examination in clinical reasoning training for nutrition students with different levels of academic progress has not been studied yet. Therefore, the purpose of this study was to evaluate the improvement of students' ability in consecutive PMP-MEQ exams and to determine its relationship with different levels of academic progress. This study also aimed to determine whether consecutive PMP-MEQ exams can improve different aspects of clinical reasoning skills by increasing the exam scores.

3. Methods

3.1. Study Sample

This descriptive, analytical, cross-sectional study was conducted at Kerman University of Medical Sciences among 67 third-year undergraduate nutrition students, who were enrolled in the study between 2015 and 2017 in three consecutive years.

3.2. Study Design

At the end of the routine teaching module on the topic of "food-borne diseases", the students were asked to prepare for MCQ and PMP-MEQ exams. The assessment method was described for all students. Ten MCQs were presented, with five discriminators for each question. The students were told that one of the discriminators would be

the correct response to MCQ. In the first phase of the examination, after MCQ, the students were asked to complete the PMP-MEQ exam, which comprised of two queries of fivechoice question (PMP) and three short-answer questions (MEQ). In the second and third phases, the students participated in the second and third PMP-MEQ examinations; each exam took place one week after the other.

Generally, the instructor must be familiar with the design and development of PMP-MEQ exams. Arrangement and preparation of PMP-MEQ was based on the modified four-step instructions published by Harden (12). In this exam, no test-retest was performed. In the first stage, the instructor planned and designed a clinical case and provided information about an individual patient, who was referred to the emergency ward with a set of signs associated with the ingestion of an unknown contaminated food (based on the subjective report). Next, students, based on their etiological knowledge of the disease transmitted by microorganisms, described the incubation period, as well as signs and symptoms of the clinical case.

The students were required to answer two questions (PMP exam) about the type of microorganism and the food causing intoxication. In the final stage, the students were required to answer three short questions to explain the reason for their diagnosis and suggest appropriate treatments for patient and preventive methods to prevent the prevalence of the disease in the community. PMPs simulate reality and reproduce the decisions of a medical student for investigating and managing a patient. Also, the students were required to be involved actively in the problem (12).

According to Bloom's taxonomy, there are four levels of cognitive learning, including understanding, applying, analyzing, and evaluating. Various dimensions of clinical reasoning, such as awareness of clinical cues, confirmation of clinical problems, determination and implementation of actions, and evaluation and reflection, were incorporated in the PMP-MEQ exam in this study.

3.3. Statistical Analysis

Statistical analysis was performed in SPSS version 22.0, and P < 0.05 was considered statistically significant. General linear models (repeated measures ANOVA) were used to compare the mean differences in PMP and MEQ scores, based on the grade point average (GPA) of the semester and the total GPA of five semesters. GPA generally represents the average value of the accumulated final grades earned in courses over time. The results of analyses are presented in Tables 1 and 2.

The non-significance of Box's test of equality indicates the equality of covariance matrices for dependent variables in the groups. Also, non-significance of Mauchly's

fable 1. Results of One-Way Repeated Measures ANOVA of PMP-MEQ Scores Based on the Students' GPA in the Fifth Semester ^a						
Scores	Total (N = 67)	$\text{GPA} \geq 16(\text{N}\!=\!26)$	GPA < 16 (N = 41)	Sig.		
PMP-MEQ1	4.79 ± 4.68	4.85 ± 4.89	4.76 ± 4.60	0.939		
PMP-MEQ2	9.93 ± 6.90	10.65 ± 7.12	9.46 ± 6.81	0.496		
PMP-MEQ3	14.10 ± 4.54	16.31 ± 3.80	12.71 ± 4.44	0.001		
Sig.	0.0001	0.0001	0.0001			

^aValues are expressed as mean \pm SD.

Table 2. Results of One-Way Repeated Measures ANOVA of PMP-MEQ Scores Based on the Students' Total GPA During Five Semesters^a

Scores	Total (N = 67)	Total GPA \geq 16 (N = 37)	Total GPA < 16 (N = 30)	Sig.
PMP-MEQ1	4.79 ± 4.68	4.65 ± 4.91	4.97 ± 4.45	0.784
PMP-MEQ2	9.93 ± 6.90	11.41 ± 6.98	8.10 ± 6.46	0.051
PMP-MEQ3	14.10 ± 4.54	15.49 ± 4.25	12.40 ± 4.35	0.005
Sig.	0.0001	0.0001	0.0001	

^aValues are expressed as mean \pm SD.

test of sphericity meets the assumption of compound symmetry, and Levene's test indicates that the variance in three periods (PMP1, PMP2 and PMP3) is equivalent for the measures. Independent t-test was used for the comparison of mean differences between PMP-MEQ and MCQ exams. Also, paired *t*-test was performed for the comparison of mean differences in PMP-MEQ scores between students with GPA \geq 16 and GPA < 16. Moreover, Pearson's correlation test was used to determine the relationship between the exam scores and academic progress variables, such as GPA and total GPA.

4. Results

Male students comprised 29.9% of the total study population. The results of repeated measures ANOVA showed that the mean difference in PMP scores was significant in three examination periods (P = 0.0001). However, the difference in the mean score of each PMP exam between students with GPA \geq 16 and GPA < 16 was not significant, except for PMP3 (P = 0.001). Therefore, the scores differed significantly in the three examination periods. We found that the students' scores increased by continuous PMP examination in both groups. The significant mean difference in PMP3 scores showed that the progress of students with GPA \geq 16 was greater than that of students with GPA < 16 (P = 0.001) (Table 1). Therefore, continuous PMP assessment contributes to the improvement of students' clinical reasoning, mainly in students with GPA \geq 16.

The results of repeated measures ANOVA indicated no significant difference between the total GPA of five

semesters and GPA of the fifth semester. The mean difference in PMP scores was significant between the examination periods (P = 0.0001); in other words, the scores differed significantly in these periods. We found an increase in the students' scores with continuous PMP examination in both groups. However, the difference in the mean score of third PMP exam was significant between students with total GPA \geq 16 and total GPA < 16 (P = 0.005); the difference was also close to significant in the second PMP exam (P = 0.051). The significance of mean differences in PMP3 scores indicate that the progress of students with total GPA \geq 16 was greater than that of students with GPA < 16 (P = 0.005) (Table 2). The interpretation of results presented in Table 1 is as the same as the results presented in Table 2.

Additionally, the results of paired *t*-test in Table 3 confirm the results presented in Tables 1 and 2 regarding academic progress variables. The results of independent *t*-test regarding the mean scores of MCQ exam and each PMP exam were significant, except for the mean difference of MCQ score with the third PMP score in students with GPA \geq 16 (P = 0.143) (Table 3). The increase in the scores of students with continuous PMP examination, particularly in students with GPA \geq 16, revealed that improvement of clinical reasoning was prominent in this group.

Table 4 presents the results of Pearson's correlation coefficient (r), as a common method for analyzing the relationship between two variables. The results showed that the third PMP exam score was significantly related to academic progress variables, such as GPA and total GPA (P < 0.01). The MCQ score was also significantly related to academic progress variables (P < 0.01) (Table 4). These significant relationships indicate that the students' MCQ scores

table 3. Significant Differences Between MCQ and PMP-MEQ Scores Based on the Students' GPA of the Fifth Semester and Total GPA of Five Semesters"							
Scores	MCQ	PMP-MEQ1	Sig.	PMP-MEQ2	Sig.	PMP-MEQ3	Sig.
Total	16.49 ± 2.57	4.79 ± 4.68	0.0001	9.93 ± 6.90	0.0001	14.10 ± 4.54	0.0001
$\text{GPA} \geq 16(\text{N}\!=\!26)$	17.38 ± 1.86	4.85 ± 4.89	0.0001	10.65 ± 7.12	0.0001	16.31 ± 3.80	0.143
GPA < 16 (N = 41)	15.93 ± 2.81	4.76 ± 4.60	0.0001	9.46 ± 6.81	0.0001	12.71 ± 4.45	0.0001
Sig.	0.023	0.939		0.496		0.001	
Total GPA \geq 16 (N = 37)	17.27 ± 2.09	4.65 ± 4.91	0.0001	11.41 ± 6.98	0.0001	15.49 ± 4.25	0.015
Total GPA < 16 (N = 30)	15.53 ± 2.81	4.97 ± 4.45	0.0001	8.10 ± 6.46	0.0001	12.40 ± 4.35	0.001
Sig.	0.005	0.784		0.051		0.005	

Table 3. Significant Differences Between MCQ and PMP-MEQ Scores Based on the Students' GPA of the Fifth Semester and Total GPA of Five Semesters'

^aValues are expressed as mean \pm SD.

were similar to the third PMP scores. Therefore, improvement of students' clinical reasoning through continuous PMP examination was confirmed.

5. Discussion

This study aimed to provide applicable evidence for medical and paramedical school instructors in clinical departments, who are responsible for evaluating the clinical reasoning of undergraduate students. Schmidt and Mamede claimed that different approaches can be implemented in clinical reasoning education in different phases of training. In their review, they discussed the most common approach, i.e., serial-cue approach, perhaps because of its simulation of diagnostic activities (13). In Germany, development and implementation of a clinical reasoning course in the final year of undergraduate medical training was a major objective of medical education, which could lead to an improvement in the target skills. Overall, it seems advantageous to integrate a longitudinal course in the medical curriculum in order to present better strategies for improving clinical reasoning (14).

In this regard, a previous study provided a successful example of a small-group brainstorming course for enhancing the diagnostic and clinical reasoning skills of new medical clerks. The positive results obtained during the "clinical excellence program" encouraged the formal implementation of this course as part of the clerkship curriculum (15). Therefore, the small group teaching-learning approach is one of the effective approaches, which can improve clinical reasoning skills.

In the current study, by continuing problem-based learning as PMP-MEQ examination, we aimed to improve the clinical experience and clinical reasoning of students. It should be noted that integration of basic sciences knowledge in clinical reasoning is an essential component of health professional education. Generally, effective clinical reasoning involves several sequential domains, including awareness of clinical cues and collection of cues and information, confirmation of clinical problems, determination and implementation of actions, and evaluation and reflection. It involves remembrance and memory, understanding and recognition, interpretation and organization, integration and analysis, and deduction to solve a clinical case in different situations (e.g., classroom and patient's bed).

Knowledge of basic sciences supports the acquisition of new clinical knowledge, which improves diagnostic reasoning. Successful teaching strategies involve establishing connections between basic and clinical sciences, use of reasonable analogies, and study of multiple clinical problems in multiple settings (16). Conversely, inadequate clinical knowledge is the most common problem, resulting in poor clinical reasoning, as obviously reported in the present study. In the current study, improvement of clinical reasoning in students with poor academic progress was lower than that of students with appropriate academic progress. One of the main concerns in medical education is integration of clinical reasoning into the medical curriculum (without clinical reasoning being consistently defined, taught, or assessed within or between educational programs in the curriculum), which may result in major variations in clinical reasoning education. These findings support the need for the development of optimal educational practices for clinical reasoning curricula and learning assessment (17).

In another study, different attitudes to teaching and learning clinical reasoning were identified, which reflect the Western and Asian cultures of learning. The potential effect of cultural differences in planning optimal programs for teaching and learning clinical reasoning is important in the changing global context of medical education, especially when the Western medical education is implemented in Asian settings (18).

Generally, assessment follows the teaching-learning process. The assessment method of important examinations strongly influences student learning and may shape

able 4. Correlation Coefficients Between MCQ Score, PMP-MEQ Score, and Academic Progress Variables							
Variables	MCQ	PMP-MEQ1	PMP-MEQ2	PMP-MEQ3	GPA of Fifth Semester	Total GPA	
MCQ	1	0.162	0.238	0.315	0.424 ^a	0.452 ^a	
PMP-MEQ1		1	0.295 ^b	-0.160	-0.002	-0.079	
PMP-MEQ2			1	0.080	0.163	0.282 ^b	
PMP-MEQ3				1	0.373 ^a	0.425 ^a	
GPA of fifth semester					1	0.878 ^a	
Total GPA						1	
^a Correlation is significant at 0.0	01.						

^bCorrelation is significant at 0.05.

and improve the student's learning approaches (19). In a study, the modified problem-based learning (PBL) method, with short-answer questions, was the preferred method in 39% of students, followed by PBL with the modified essay question (36%) and lectures (25%). Therefore, the modified PBL is a reasonable option for schools that cannot meet the staff and space requirements of PBL curriculum (20). Accordingly, in some universities, where the clinical environment for teaching and learning clinical reasoning is not available, implementation of some exams, such as PMP-MEQ, in a clinical format is preferable.

Palmer and Devitt revealed that MEQs are often preferable to other forms of assessment, such as MCQs, for the evaluation of higher-order cognitive skills. MEQs often form a vital component of end-of-course assessments in higher education. In a study, effectiveness of MEQ in the measurement of higher-order cognitive skills was examined in an undergraduate institution. The modified essay question failed to consistently assess higher-order cognitive skills, whereas MCQ examined more than merely recall of knowledge. The researchers concluded that construction of MEQs for the assessment of higher-order cognitive skills cannot be assumed to be a simple task (21).

Moreover, a study investigated the effect of practice exam on the scores of a test, comprising of both MCQ and PMP. It was found that the effect of practice exam on the PMP score was greater than its effect on the MCQ score (22). In another study, correlations between objective structured clinical examination (OSCE) and written tests, such as script concordance testing and clinical reasoning problems, were insignificant. The results showed that written tests of clinical reasoning could provide additional applicable information for the evaluation of students' capabilities during a course of family medicine clerkship (23).

5.1. Conclusions

Integration of PMP-MEQ in reasoning-based clinical education can be an effective approach to the clinical eval-

uation of undergraduate students. Continuous PMP examination can improve the students' clinical reasoning, mainly among students with GPA > 16.

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Footnotes

Authors' Contribution: Mohammad Reza Mahmoodi contributed to the conception of the original idea, conducting in the study design, analysis and interpretation of the data, drafting and revising the draft, and approval of the final version of the manuscript.

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