ORIGINAL ARTICLE

The Effects of an In-classroom Diagnostic Thinking Program on Medical Students: a quasi-experimental study

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Background: One of the expected competencies of physicians is clinical reasoning. Therefore, diagnostic thinking in medical students is important. The aim of this study was to investigate the effect of diagnostic thinking instructional program on medical students.

Method: The research was quasi-experimental. The target group was medical students who spent their internship in the internal department. The sample size for each group was 20 participants. 20 interns in the three-month rotation of autumn 2018 were considered as control and 20 interns entering the department in the winter rotation of the same year were considered as the intervention group. Students were evaluated using Diagnostic Thinking Questionnaire (DTI). Data analysis was done with descriptive and analytical statistics.

Results: The two groups did not differ in terms of the number of participants, age, grade point average and mean DTI score in the pre-test ($P>0.05$). The pre-test scores of two groups in the flexibility of thinking ($P=0.09$), memory structure ($P=0.68$), and the total score of diagnostic thinking ($P=0.4$) were not significantly different. The post-test scores of students in the sections of flexibility of thinking, memory structure, and the total score of diagnostic thinking of both groups did not change significantly compared to the pre-test scores ($P>0.05$). There was a significant relationship between only the two variables of grade point average and memory structure score in the post-test ($r=0.46$, $P=0.004$).

Conclusion: The in-class diagnostic thinking instructional program did not affect students' diagnostic thinking in the absence of patients which is probably due to the lack of patient encounters.

Keywords: Diagnostic thinking; Diagnostic reasoning; Clinical reasoning; Medical students; Medical education

أثر برنامج التفكير التشخيصي داخل الفصل الدراسي على طلاب الطب: دراسة شبه تجريبية

الخلفية: إحدى الكفاءات المتوقعة من الأطباء هي التفكير السريري. ولذلك، فإن التفكير التشخيصي لدى طلاب الطب مهم. هدفت هذه الدراسة إلى معرفة أثر برنامج تعليمي للتفكير التشخيصي على طلاب الطب.

الطريقة: كان البحث شبه تجريبي. وكانت المجموعة المستهدفة طلاب الطب الذين قضوا فترة تدريبهم في القسم الداخلي. وكان حجم العينة لكل مجموعة ٢٠ مشاركا. تم اعتبار ٢٠ متدربًا في دورة خريف ٢٠١٨ لمدة ثلاثة أشهر كمجموعة تحكم، وتم اعتبار ٢٠ متدربًا يدخلون القسم في الدورة الشتوية لنفس العام كمجموعة تدخل. تم تقييم الطلاب باستخدام استبيان التفكير التشخيصي (DTI). وتم تحليل البيانات باستخدام الإحصائيات الوصفية والتحليلية.

النتائج: لم تختلف المجموعتان من حيث عدد المشاركين والعمر ومتوسط الدرجات ومتوسط درجة DTI في الاختبار القبلي ($P> 0.05$). ولم تكن درجات الاختبار القبلي لمجموعتين في مرونة التفكير ($P = 0.09$)، وبنية الذاكرة ($P = 0.68$)، والدرجة الإجمالية للتفكير التشخيصي ($P = 0.4$) مختلفة بشكل كبير. ولم تتغير درجات الطلاب في الاختبار البعدي في أقسام مرونة التفكير وبنية الذاكرة والدرجة الكلية للتفكير التشخيصي لكلا المجموعتين مقارنة مع درجات الاختبار القبلي ($P>0.05$). كانت هناك علاقة ذات دلالة إحصائية بين متغيري متوسط الدرجة ودرجة بنية الذاكرة فقط في الاختبار البعدي ($r = 0.46$، $P = 0.004$).

الاستنتاج: لم يؤثر البرنامج التعليمي للتفكير التشخيصي داخل الفصل على التفكير التشخيصي للطلاب في غياب المرضى والذي ربما يرجع إلى قلة اللقاءات مع المرضى.

الكلمات المفتاحية: التفكير التشخيصي؛ المنطق التشخيصي سبب طبي؛ طلاب الطب؛ التعليم الطبي

تأثیر یک برنامه تفکر تشخیصی در کلاس بر دانشجویان پزشکی: یک مطالعه نیمه تجربی

زمینه و هدف: یکی از شایستگی های مورد انتظار پزشکان، استدلال بالینی است، لذا تفکر تشخیصی در دانشجویان پزشکی حائز اهمیت است. هدف این مطالعه بررسی تأثیر برنامه آموزشی تفکر تشخیصی بر توانایی دانشجویان پزشکی بود.

روش: پژوهش از نوع نیمه تجربی بود. گروه هدف دانشجویان پزشکی بودند که کاروزی خود را در بخش داخلی می‌گذراندند. حجم نمونه برای هر گروه ۲۰ نفر بود. به دلیل محدودیت تعداد دانشجویان ورودی به بخش، ۲۰ نفر از کاورزان در روتیشن سه ماهه پاییز ۱۳۹۸ به عنوان کنترل و ۲۰ نفر از کاورزان ورودی به بخش در روتیشن زمستان همان سال به عنوان گروه مداخله در نظر گرفته شدند. دانشجویان با پرسشنامه تفکر تشخیصی (DTI) ارزیابی شدند. تحلیل داده‌ها با آمار توصیفی و تحلیلی انجام شد.

یافته ها: گروه کنترل و مداخله از نظر تعداد شرکت‌کنندگان، سن، معدل و میانگین نمره DTI در پیش‌آزمون تفاوتی نداشتند ($P>0.05$) . نمرات پیش‌آزمون دانشجویان دو گروه در بخشهای انعطاف‌پذیری فکر ($P=0.09$)، ساختار حافظه ($P=0.68$) و در نمره کل تفکر تشخیصی ($P=0.4$) با یکدیگر تفاوت معناداری نداشتند. نمرات پس‌آزمون دانشجویان در بخشهای انعطاف‌پذیری تفکر، ساختار حافظه و نمره کل تفکر تشخیصی هر دو گروه نسبت به نمرات پیش‌آزمون تغییر معنی‌داری نداشت ($P>0.05$). نتایج آزمون همبستگی نشان دهنده آن بود که تنها بین دو متغیر معدل و نمره ساختار حافظه در پس آزمون، ارتباط معناداری وجود دارد ($r=0.46, P=0.004$).

نتیجه‌گیری: برنامه تفکر تشخیصی درون کلاسی بر توانایی تفکر تشخیصی دانشجویان در غیاب بیمار تأثیری ندارد که احتمالاً به دلیل نبود فرصت‌های کافی برای مواجهه با بیمار است.

واژه های کلیدی: تفکر تشخیصی؛ استدلال تشخیصی؛ استدلال بالینی؛ دانشجویان پزشکی؛ آموزش پزشکی

طبی طلباء پر کلاس روم میں تشخیصی سوچ کے پروگرام کے اثرات: ایک نیم تجرباتی مطالعہ

پس منظر: معالجین کی متوقع صلاحیتوں میں سے ایک طبی استدلال ہے۔ لہذا، طبی طلباء میں تشخیصی سوچ اہم ہے۔ اس مطالعے کا مقصد طبی طلباء پر تشخیصی سوچ کے تدریسی پروگرام کے اثرات کی تحقیقات کرنا تھا۔

طریقہ: تحقیق نیم تجرباتی تھی۔ ٹارگٹ گروپ میڈیکل کے طلباء تھے جنہوں نے اپنی انٹرن شپ اندرونی شعبہ میں گزاری۔ ہر گروپ کے نمونے کا سائز ۲۰ شرکاء تھا۔ خزاں ۲۰۱۸ کے تین ماہ کی گردش میں ۲۰ انٹرنز کو کنٹرول کے طور پر سمجھا گیا اور اسی سال کے موسم سرما کی گردش میں محکمہ میں داخل ہونے والے ۲۰ انٹرنز کو مداخلت گروپ کے طور پر سمجھا گیا۔ تشخیصی سوچ کے سوالنامے (DTI) کا استعمال کرتے ہوئے طلباء کا جائزہ لیا گیا۔ ڈیٹا کا تجزیہ وضاحتی اور تجزیاتی اعدادوشمار کے ساتھ کیا گیا تھا۔

نتائج: دونوں گروپوں میں حصہ لینے والوں کی تعداد، عمر، گریڈ پوائنٹ اوسط اور پری ٹیسٹ ($P>0.05$) میں ڈی ٹی آئی اسکور کے لحاظ سے کوئی فرق نہیں تھا۔ سوچ کی لچک میں دو گروپوں کے پہلے سے ٹیسٹ کے اسکور ($P = 0.09$)، میموری کی ساخت ($P = 0.68$)، اور تشخیصی سوچ کا کل اسکور ($P = 0.4$) نمایاں طور پر مختلف نہیں تھے۔ سوچ کی لچک، یادداشت کی ساخت، اور دونوں گروپوں کے تشخیصی سوچ کے کل سکور میں طلباء کے ٹیسٹ کے بعد کے اسکورز پری ٹیسٹ کے اسکور ($P>0.05$) کے مقابلے میں نمایاں طور پر تبدیل نہیں ہوئے۔ پوسٹ ٹیسٹ ($r = 0.46$، $P = 0.004$) میں گریڈ پوائنٹ اوسط اور میموری ڈھانچے کے اسکور کے صرف دو متغیروں کے درمیان ایک اہم تعلق تھا۔

نتیجہ: کلاس میں تشخیصی سوچ کے تدریسی پروگرام نے مریضوں کی غیر موجودگی میں طلباء کی تشخیصی سوچ کو متاثر نہیں کیا جس کی وجہ ممکنہ طور پر مریضوں سے ملاقاتوں کی کمی ہے۔

مطلوبہ الفاظ: تشخیصی سوچ؛ تشخیصی استدلال؛ طبی استدلال؛ میڈیکل طلباء؛ طبی تعلیم

INTRODUCTION

The problem-solving process used by physicians is generally recognized as clinical reasoning (1) which is the basis of clinical work (2). This ability is a multidimensional phenomenon (3) that help doctors to solve clinical problems. In clinical reasoning process, a person identifies and prioritizes relevant clinical data to make a hypothesis and a plan to confirm or reject that hypothesis (4–6) so that he can diagnose and treat the individual's disease. Studies showed that clinical reasoning was associated with diagnostic thinking (7). The process of diagnosting thinking involves arranging information in memory and developing strategies to retrieve it (8). Studies show that errors in diagnosis in medicine are the cause of 40,000 to 80,000 deaths per year (9), of which 10 to 20% are related to misdiagnosis, delayed diagnosis or no diagnosis (10) which are due to insufficient knowledge, incomplete data collection or incorrect confirmation (11) . It is estimated that 75% of diagnostic failures are related to failures in physician diagnostic thinking (12) which could be prevented (11). As a result, the development of cognitive processes, which is the basis of physicians' diagnostic thinking and begins in medical school, is an important issue in medical education.

The best strategy for reducing errors is to make students aware of biases and encourage them to rely more on diagnostic analytical thinking (13) to eliminate cognitive and diagnostic biases in the reasoning process (14) when encountering with complex or unfamiliar issues in future. Teaching this type of thinking, diagnostic errors, and the pitfalls that a doctor may fall into due to these errors while solving a clinical problem are among the important strategies that could help to promote analytical thinking (12). However, few studies have been conducted on teaching these strategies to promote diagnostic thinking in medical students. Therefore, this study was designed and implemented to investigate the effects of answer the question: Is a diagnostic reasoning instructional program effective for medical students?

METHODS

This study was a quasi-experimental study with a non-equivalent control group performed with medical students in the internal medicine department of Birjand University of Medical Sciences in 2021. Medical internship students at this university spend three months of their internship in the internal department. In this university, about 20 interns and 60 staff in each rotation enter this department and are divided into different rotations of the internal department, including general and subspecialty wards, clinic, internal emergency ward, as well as hematology and oncology. They become familiar with history taking and the diagnosis, and treatment of different cases in outpatient and inpatient parts of this ward. In addition, several classes are held during this course, where the topics of major internal diseases are taught. Morning report and inpatient rounds are also held in this section. Students are normally assessed with a written multiple choice and an essay test at the end of the rotation.

Assuming α is equal to 0.5, β is equal to 0.90, δ is equal to 3, the minimum significant difference between the case group and the control group is equal to 3 points, according to formula

$$n = \frac{(z_{1-\alpha/2} + z_{1-\beta})^2 * (\delta_1^{\ 2} + \delta_2^{\ 2})}{(\mu_1 - \mu_2)^2} = \frac{10 * 2 * 9}{9} = 20$$

, the required sample size in this study was 20 participants for each of the intervention and control group, which was selected with convenient sampling from the students who entered the internal medicine rotation. The inclusion criteria for this study were medical students studying at Birjand University of Medical Sciences who were undergoing an internship in the internal medicine department. Students who did not consent to participate in the study, or did not participate in the pre-test or post-test, or withdrew from the internship in the internal rotation, were excluded from the study.

Due to the limited number of students entering the ward and also to prevent contamination between the two groups, first the control group and then the intervention group entered the study so that the control group was trained in the first 3-month rotation and so did the intervention group in the next rotation. Training in the first 3-month rotation (control group) included routine training, i.e. daily morning report, clinical rounds, classroom lectures, and clinic. In the intervention group (second 3-month rotation), in addition to routine instruction, a diagnostic analytical thinking training course was held. Students who entered the internal ward were invited to participate in this study. Students had the right to choose to participate in the pre-test and post-test or diagnostic thinking training course. If the students were satisfied, they were included in the study. In case of not being satisfied to attend this course, a negative grade was not considered for the students. Both intervention and control groups, at the beginning of the course, were assessed with diagnostic thinking inventory (DTI) which was developed by Bourdieu et al. in France and has 41 questions on a 6-point Likert scale. DTI includes two main areas, namely memory structure and thinking flexibility. According to the 6-item scale and the total number of questions in the DTI, the minimum score in this questionnaire was 41 and the maximum score was 246. This questionnaire was translated by Dr. Monjemi in Persian and its validity and reliability were checked in a study by Dr. Soltani et al. (15). The students in the preset study were provided with the electronic DTI.

Charactristics of the Diagnostic Thinking Program

This program was held in classroom and in the form of lectures and case presentations. At the beginning of the course, the basics of clinical reasoning and the stages of analytical reasoning were provided to students. This basic content included the definition of clinical reasoning, analytical or hypothetico-deductive thinking, and non-analytical or intuitive thinking, which was scheduled in four sessions for the first two weeks of the course. Each session was held for 1.5 hours through case-based questions and answers. The following topics were taught in order:

Session 1: diagnostic framework and differential diagnosis, semantic qualifier and summary statement.

Session 2: illness script and problem list.
Session 3: Test selection and hypothesis refinement.
Session 4: Diagnostic errors and presentation of clinical scenarios with emphasis on identifying cognitive errors.
In all sessions, students practiced the topics with clinical cases.

Data Analysis

Data normality was determined using Shapirovilk test. Due to the normality of data distribution, paired t-test was used to compare scores within the group and independent t-test was used to compare scores between groups. ANCOVA was also used to eliminate the confounding effect of the pretest. Data analysis was done with SPSS software, version 21.

RESULTS

In this study, a total of 40 interns participated in both intervention and control groups. Of these, one intern in control group and three in intervention group were eliminated due to incomplete filling of questionnaire. Hence, data of 19 interns in control group and 17 interns in intervention group was analyzed (Table 1).

The results of Table 1 show that there was no significant difference between the intervention and control groups in case of age, gender, as well as GPA.

Table 2 shows the results of the comparison between the DTI scores in the pre-test and post-test scores in two groups. The results showed that at the beginning and end of the course, there was no significant difference between the control and intervention groups in terms of thinking flexibility, memory structure and total score. ($P>0.05$). Also, intra-group comparison of students' scores showed no significant change in post-test scores compared to pre-test in both study groups ($P>0.05$).

In this study, the results of the ANCOVA also showed that the diagnostic thinking training course had no effect on this ability of the students (Table 2).

The relationship of the variables age and GPA with thinking flexibility, memory structure, and total score of DTI before and after the instructional program is given in Table 3.

Among the investigated relationships between age/GPA and the components of the questionnaire, the only significant correlation was related to GPA and memory structure in the post-test (table 3).

Table 1. Frequency distribution of gender status of participating students

		Control	Intervention	P-Value*
		Number (Percent)	Number (Percent)	
Gender	**Female**	14 (73.7)	10 (58.8)	X^2:89 P:0.34
	Male	5 (26.3)	7 (41.2)	
	Total	19 (100)	17 (100)	
		Mean ± SD	Mean ± SD	P-Value*
Age		23.89 ± 0.73	24.7 ± 2.28	Sig: 0.12 F: 2.50
GPA		16.52 ± 1.09	15.72 ± 1.07	Sig: 0.81 F: 0.58

*independent t.test

Table 2. Comparison of the mean pre-test and post-test DTI score in two intervention and control groups

Variable	Group	Pre-test	Post-test	P-Value *	Ancova		
		Mean ± SD	Mean ± SD		F	P-Value	Eta square
Thinking flexibility	Control	74.74±8.12	72.73±9.15	0.5	0.049	0.826	0.001
	Intervention	70.29±7.2	71.7±7.26	0.52			
Sig**		0.09	0.71				
Memory structure	Control	73.89±5.69	75.47±8.49	0.56	3.45	0.072	0.095
	Intervention	74.82±8.04	73.41±4.98	0.6			
Sig**		0.68	0.38				
Total	Control	148.6±11.66	148.21±15.25	0.93	0.398	0.532	0.012
	Intervention	145.11±13.42	145.11±6.93	1			
P-Value **		0.4	0.448				

*Paired t-test
**Independent t-test

Table 3. The corerrelation of age/GPA with the DTI components

Variable		Pretest of thinking flexibility	Pretest of memory structure	Total pretest DTI	Posttest of thinking flexibility	Posttest memory structure	Total Posttest DTI
Age	Pearson correlation	-0.97	-0.53	-0.91	-0.251	-0.05	-0.20
	Sig	0.57	0.75	0.59	0.14	0.75	0.23
GPA	Pearson correlation	0.033	-0.56	-0.10	-0.63	0.46*	0.22
	Sig	0.84	0.74	0.95	0.71	0.004	0.18

* Correlation is significant at the 0.01 level

DISCUSSION

In this study, the level of diagnostic and clinical reasoning skills of medical intern students was investigated. The DTI tool was used as a standard tool in assessing students' diagnostic reasoning skills at the beginning and end of the internal disease internship in medical interns. The results of this study showed that there was no significant difference in the DTI post-test scores compared to the pre-test in any of the intervention and control groups. In addition, there was no significant difference between the two groups in the mean scores of the DTI post-test. These results show that the diagnostic analytical reasoning course could not have an effect on medical students' clinical reasoning skills in a short time of internal ward rotation.

In the present study, the average score of DTI in students before and after the course was in the range of 145-148 and there was no significant change after the instruction. In Bordage's study, who designed the DTI questionnaire, 270 people participated in nine groups, including medical students, residents, general practitioners, and specialists. In Bordage's study, the first- and third-year medical students scored 154 and 158, respectively, and with the increase in clinical experience, the scores of the DTI test also increased. In this way, the first and third-year students got the lowest score and were distinguished from the other seven groups. The first-year residents also got the lowest score among other seven groups and the specialists got the highest score, 180 (16). The results of Bordage's study showed that the average score of medical students is to an extent similar to the same average in the present study.

In another study in which DTI test was taken from 105 residents and 100 interns, the total score in interns and residents was 158 and 161, respectively that was not significant ($P = 0.56$). Also, the average score of thinking flexibility was 75 in interns and 76 in residents, and the average score of memory structure was 82 and 85 in interns and residents, respectively, none of which was significantly different ($P>0.05$) (15). It seemed that the DTI score in residents should be higher than that of interns. This result can be due to the fact that probably the interns were at the end of the internship period and the residents were in the first or second year of their residency, in a way that they were new to the field and the content was still not organized enough in their minds.

It seems that the structure of memory and the flexibility of thinking are two structures that need more time to improve, and this could be one of the reasons why the average DTI scores, in general and in each of its components, did not change significantly in a short-term course. Another reason that can be mentioned for the lack of effectiveness of the present program is the lack of observation of a sufficient number of patients during the rotation by the students. Therefore, students had no enough opportunities for reflective clinical practice and application of their learning on the bed, while reflective practice has been introduced as one of the important methods in promoting diagnostic thinking in doctors (13). Considering that the knowledge, experience, and learning environment which are the main elements in diagnostic reasoning (14,17), teaching diagnostic reasoning skills alone is not enough for improvement. As the study of Sobocan et al. also showed that medical students did not perform dramatically different in the DTI test when they were taught by using a virtual patient compared to the problem-solving method in internal medicine rotation. However, they improved in the flexibility of their thinking and structure of memory (18).

In addition, since in the present study, the educational sessions were conducted in classroom, the results could be indicated that in-classroon instruction, even though in a case-based manner, cannot replace case-based training at the patient's bedside. Although the present study showed the insignificant effect of the training program on diagnostic reasoning skills, there is no evidence for the effect of bedside teaching on this ability in medical students. Therefore, it is suggested the further research in bedside.

The present results showed that there was a significant correlation between GPA and memory structure score after the intervention, that could be an indicator that students with higher GPAs had more readiness to have structured memory after a preparedness program, even though it was a short-term program.

Our comprehensive review of the literature found limited studies in which the effects of an instructional course on diagnostic thinking would be investigated through a pretest-posttest analysis. For this reason, the available studies emphasize the amount of diagnostic thinking of students and assistants, and based on these results, it is not possible to conclude whether the instructional programs, especially if it is short-term, will be effective on this ability of students or not. This is also another critical area of inquiry.

The present study was accompanied with some limitations.

Since the number of students entering the internal rotation in each course was small, it was not possible to divide them into intervention and control groups in one rotation, and if possible, there was a possibility of information leakage between the two groups. For this reason, this study was a quasi-experimental. Two consecutive internship rotations of students were used as intervention and control groups, and it was probably associated with biases. Although the small exposure of students to multiple patients in the ward was another limitation of this study, given the fact that the experience of students is considered as a confounding factor in examining the effect of diagnostic reasoning training in the classroom, this limitation also would be considered as a strength for this study.

CONCLUSION

The results of this study demonstrated that holding diagnostic reasoning development workshops may have no effect on students' empowering in this ability. The review of similar studies showed that medical students in different studies had the same mean as the students participating in this study. Therefore, it seems that the variable of time is an important factor in developing these skills in students. In addition, the students in this study did not have enough opportunities for direct exposure at the patient's bedside, and this showed that classroom teaching, even on a case-based basis, would not replace bedside teaching for improvement of diagnostic skills. Therefore, it is suggested to conduct more studies. In addition, due to the existence of biases in quasi-experimental studies, conducting more studies in different contexts with stronger methodology is recommended.

Ethical considerations

Ethical issues including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc. have been completely observed by the authors. This study was performed after receiving approval from the ethics committee of Birjand University of Medical Sciences with the code IR.BUMS.REC.1399.473.

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