Original Article

The effect of drug dosage calculation training program on math anxiety and nursing students' skills: A non-randomized trial study

Leila Sayadi[1], Alireza Nikbakht Nasrabadi[2], Amin Hosseini[2]*

[1]Nursing and Midwifery Care Research Center, School of Nursing and Midwifery, Tehran University of Medical Sciences, Tehran, Iran
[2]School of Nursing and Midwifery, Tehran University of Medical Sciences, Tehran, Iran

ARTICLE INFO

*Corresponding Author:
Amin Hosseini, School of Nursing and Midwifery, Tehran University of Medical Sciences, Tehran, Iran.
E-mail: aminhosseini835@gmail.com

ABSTRACT

Background & Aim: Drug dosage calculation is one of the main skills in the drug administration process that requires sufficient knowledge about mathematical calculations and drug dosage; besides, lack of math anxiety is required for drug dosage calculation. This study aimed to determine the effect of mathematical calculation and drug dosage training programs on math anxiety and nursing students' drug dosage calculation skills.

Methods & Materials: The present research was a non-randomized trial study. As a result of convenience sampling, 80 nursing students (40 in the control group and 40 in the intervention group) participated in the study. The study intervention included a mathematical and drug dosage training program including lecture, workshop, and practicing mathematical and drug calculations at the patient's bedside. The data were collected using a demographic, Betz' math anxiety, and drug dosage calculation skills questionnaires. Finally, descriptive and analytical statistics were used to analyze the data.

Results: The two groups were homogeneous in terms of demographic variables, math anxiety, and drug calculation scores in the baseline. Two-way analysis of variance with repeated measures indicated the significant effect of the group on math anxiety (P=0.024). Given the interaction between group effect and time for the drug dosage calculations, comparing the differences between the second- and third-time scores of the baseline scores showed a statistically significant difference between the two groups in terms of drug dosage calculations (P <0.001).

Conclusion: Implementation of a drug dosage calculation training program for nursing students can lead to the reduction of math anxiety and improvement of the drug dosage calculations; this can ultimately help improve patient safety.

Introduction

Patient safety is one of the main healthcare priorities worldwide, which means avoiding any harm or injury to the patient while providing care (1). Medication errors are among the most prevalent medical errors that threaten the patients' safety (2). In the United Kingdom (UK), 201142 medical errors and accidents were recorded between 2016 and 2017 (3). The rate of medication errors was 15.2%-88.6% in South Asian countries (4) and 53% in Iran, particularly in nurses (5). In addition to imposing costs (6), these errors, in many cases, lead to patient mortality (3).

Drug dosage calculation errors are among the most important types of medication errors (7), the rate of which has been reported 20 to 40.9% in some studies (8, 9). Although physicians and nurses can make such mistakes, drug dosage calculations are considered the nurses' fundamental skills for drug administration (10); therefore, nursing plays a vital role in these calculations' safety (11). This issue is of special importance among nursing students, as future nurses usually provide drugs to the patients several times a day (10). However, studies have shown that nursing students' knowledge of drug dosage calculation is limited (10, 12), and they perceive that there were insufficient training programs in this area. Therefore, they may be prone to medication errors, and

there is a need to conduct interventions to increase students' drug dosage calculation power (13).

On the other hand, drug dosage calculation requires the use of mathematical and arithmetic rules. These calculations are difficult to perform (10), which can lead to students' math anxiety. Math anxiety is a psychological condition that occurs when people are confronted with mathematical content, whether in teaching and learning or in resolving mathematical problems or mathematical exams (14). This condition has been observed among nursing students. In Norway, for example, 44.3% of nursing students reported high levels of math anxiety before taking the drug dosage test (15). This type of anxiety leads to tension and reduced self-esteem among students; it can also decrease the students' ability to do mathematical and drug dosage calculations (16, 17). Therefore, it is necessary to consider this issue in the studies of drug dosage calculations.

Despite the relationship between math anxiety and drug dosage calculations (18), most of the previous studies only focused on improving the nursing students' calculation skills. For example, different studies were conducted to determine the effectiveness of the drug dosage calculation training programs in the form of a workshop, the use of actual clinical scenarios, the practice of such skills in the clinical environment (19); online education (7), and e-learning classes based on face-to-face lectures (20) on nursing students' mathematical and medication skills. In another study, the researchers investigated the effect of experimental education strategy on reducing the drug dosage calculation error among nursing students (21). In the context of Iran, most studies have been conducted to determine the effect of lecture, small groups, and multimedia software (22, 23) on the improvement of students' skills in the calculation of drug dosage; the results of all of these studies indicate the positive effect of such interventions. Nevertheless, it should be noted that the subject of drug dosage

calculations should be included in the clinical pharmacology course. Hence, the respective students can be familiar with administering drugs in the proper dose (10). However, nursing students might receive dispersed training on drug dosage calculation within the course of fundamentals of nursing as well as in internships in Iran; this procedure does not contain all the items and standards of drug dosage calculation, and therefore the drug dosage calculation training programs should be included in clinical pharmacology courses.

Math anxiety is considered as important as drug dosage calculations. However, only limited studies have been performed on interventions that aim to reduce math anxiety. A study in New Zealand investigated the effectiveness of voluntary supplementary math tutorials on math anxiety and skills as well as nursing students' drug dosage calculation test scores; the results showed that this training helped reduce math anxiety, improve mathematical skills, and nursing students' drug dosage calculations (16). On the contrary, the results of another study in Alaska indicated that basic math tutorials did not lead to a significant change in the reduction of math anxiety among the students (24). The inconsistency between these results can be due to the effect of different factors such as cultural background, genetics, as well as personal and educational factors on math anxiety (25); In contrast, math anxiety has not been examined in Iran, and therefore, there are no interventions on the reduction of math anxiety among nursing students. Hence, if students receive mathematical and drug dosage calculation instructions and are provided with repeated related practices at the bedside, one can expect a decrease in students' math anxiety and an increase in their drug dosage calculation skills. Therefore, the present study was conducted so as to determine the effect of drug dosage calculation training programs on math anxiety and calculation skills among nursing students.

Methods

This non-randomized trial study was based on pre-and post-intervention conducted from October 12, 2019, to February 20, 2020.

Setting and Participants

The present study was conducted in the School of Nursing and Midwifery of Tehran University of Medical Sciences (TUMS), which registers nursing students at all education levels, including bachelor's, master's, and Ph.D. degrees. The bachelor's degree in nursing lasts 4 years, including a clinical pharmacology internship course. The students pass the clinical pharmacology course under a clinical instructor's supervision in 10 days in hospitals. 80 senior nursing students who were passing clinical pharmacology internships course participated in this study. Both the control group and the intervention group contained 40 students. The following inclusion criteria were considered for the present study: studying as a nursing student in the School of Nursing and Midwifery of TUMS, passing the clinical pharmacology internship course, and not participating in any drug dosage calculation courses outside the school. Reluctance to participate in the study, not participating in any workshops on drug dosage calculation, and unauthorized absence in the internship course were considered the exclusion criteria in the present study.

Intervention

The intervention of the present study included training programs for drug dosage calculation. This program was planned to perform during ten days of pharmacology internship. On the first day of the training program using lectures, the decimal numbers, percentages, and basic mathematical skills were explained. Also, how to use the calculator was explained to the participants. Moreover, different measurement units and methods of converting these measures to each other,

drug dosage calculation based on weight, and calculation of oral and injectable drugs were discussed. Different formulas were presented regarding drug dosage calculation, including drug forms, how to calculate different drug forms (injectable and non-injectable). Practical training on drug dosage calculation and calculation methods were also proposed. They were also taught how to adjust the calculated drug dosage in the syringe pump and infusion pump; besides, there was also an attempt to solve students' problems. A booklet on drug dosage calculation was delivered to students. This booklet's content included mathematical and drug dosage calculations, which were prepared from other books related to drug dosage calculations.

The second day of the internship was dedicated to practical work. At first, various scenarios were presented, including a brief history of the patients along with the respective prescriptions. The students were then clustered in groups of three and calculated the appropriate drug dosage based on the physician's prescription. The designed scenarios included oral and injectable drugs, vaginal or rectal suppositories, ointments, or topical creams. According to the designed scenarios, different types of injectable drugs were also provided to the students in order to create conditions similar to clinical conditions. These drugs include potassium chloride vials, magnesium sulfate, sodium bicarbonate, heparin, dopamine, dobutamine, epinephrine, and atropine ampoules. After completing the practice exercises, all the students were informed of the method of calculating the drug dosage for each scenario.

The designed scenarios were developed based on the literature review and were approved by the authors and professors of clinical pharmacology. For instance, "A patient undergoes open-heart surgery due to coronary artery occlusion and the physician prescribed 0.7 µg/kg/min Milrinone. If each 10 ml ampoule contains 10 mg milrinone, how would you set the infusion rate (ml/h) in case the injection of the drugs is provided

with a pump syringe of 50 ml?". From the third to the tenth day of the internship, the students entered the clinical field and practiced the instructions while undergoing a clinical pharmacology internship.

Clinical pharmacology internship was held routinely in the control group where the students entered the hospital from the beginning and prepared the drugs daily. Moreover, one of the students would explain the mechanism and nursing care of the drugs prescribed in the wards. The instructor would supervise such presentations and provide additional tips. The instructor would also provide explanations if there was a question about the ward drugs and their calculation methods. It should be noted that the routine conditions were also implemented for the intervention group.

Outcomes

Math anxiety and drug dosage calculation skills were considered as the outcomes of the present study. Math anxiety was measured using Betz Math Anxiety Questionnaire. Drug dosage calculation skills were also measured using a researcher-made questionnaire.

Data collection

The demographic questionnaire included items such as age, sex, the time gap from graduation from high school, and working experience in the hospital as a practical nurse. The Betz Math Anxiety Questionnaire consisted of ten questions (five positive and five negative questions) based on a five-point Likert scale from strongly disagree (1) to strongly agree (5). The reverse order was applied to positive questions. Anxiety was then measured, and higher scores were considered indicative of higher anxiety. The scores of this questionnaire ranged from 10 to 50 (16). Drug dosage calculation skills questionnaire was developed based on the literature review and the questionnaires used in previous studies (10, 26). This questionnaire included 32 questions about unit conversion, fractional and decimal numbers of the drugs, calculation of drug

units, calculation of oral and injectable drugs, calculation of drug injection using a serum, micro-set, syringe pump, and infusion pump (where correct answers equal 1 and wrong answers equal 0). Therefore, the total score ranges from 0 to 32. The participants in both control and intervention groups completed the questionnaires at three intervals: before the intervention (baseline or first time), the tenth day of the internship (second time), and one month after the end of the internship (third time).

The Maths Anxiety Questionnaire was translated using the Forward and Backward translation method. At first, the English version of the instrument was translated into Persian by two translators who were fluent in Persian and English. After screening by the researchers (authors of the article) and approving the translated questionnaire, it was translated back into English by another translator. The re-translated version was compared to the original version in terms of preserving the original concepts. The validity of the Math Anxiety Questionnaire and the Drug Dosage Calculation Skills Questionnaire were determined by ten faculty members of the School of Nursing and Midwifery, and its reliability was evaluated after confirmation of the face validity and content validity. In a study conducted in the UK to evaluate math anxiety, self-esteem, and ability in nursing students, the reliability of this questionnaire was reported to be 0.86 to 0.90 (18). The test-retest method was used to evaluate the questionnaire's reliability, where 20 students completed the questionnaires twice within a ten-day interval. The ICC (95% CI) was reported 0.863 (0.448-0.966) for the Anxiety Questionnaire and 0.937 (0.747-0.984) for the Drug Dosage Calculation Questionnaire. It should be noted that these participants and the completed questionnaires were not considered as the research samples.

Sample size

According to the formula and the effect size of 0.55, the minimum sample size would include 35 participants. Moreover,

given the 15% possibility of sample drop, the ultimate sample size was 40 for each group.

The clinical pharmacology internship students' lists were obtained from the School of Nursing and Midwifery educational board to conduct the study. Initially, the internship groups were assigned to the control group based on convenience and continuity. The researchers continued this procedure until they assigned 40 individuals to the control group. Consequently, sampling for the intervention group was also done based on convenience and continuity; the same procedure was applied for the intervention group.

Blinding

It was not possible to apply to blind to the researcher and the participants; however, blinding was performed for data analysis.

Ethical considerations

This study is the result of a registered research project (*98-02-99-43061*); it was also approved by the Ethics Committee of the school of nursing and midwifery & rehabilitation- TUMS (*IR.TUMS.FNM.REC.1398.113*) on July 14, 2019, and from the Registration Clinical trial Center (no. IRCT20190727044341N1) on September 5, 2019. Besides, all the students were informed that the scores obtained from these questionnaires would never affect their Grade Point Average (GPA).

Data analysis

Data analysis was performed using SPSS software version 16, where the qualitative variables were summarized and reported with frequency (percentage) and the quantitative variables with a mean (standard deviation). The normality of quantitative variables was evaluated and confirmed using the Kolmogorov-Smirnov test. Two-way Analysis of Variance with Repeated Measures was also used to evaluate the effect of time and the group simultaneously. In this analysis, the interaction effects of assessment times with study groups (intervention and control) and their main effect were investigated. Then, for intra-group comparison, the assessments were used separately for each group to compare the changes in math anxiety scores as well as mathematical and drug dosage calculations in the three-time intervals of: before the intervention, the end of ten days of internship, and one month after the end of internship based on Bonferroni post hoc test.

Results

84 students had taken pharmacology internship courses from October 12, 2019, to February 20, 2020. Consequently, 40 students were assigned to the control group and 40 students to the intervention group. However, 4 students were not included in the study due to unauthorized absence in the internship course (Figure 1). Besides, all the students completed the proposed questionnaires.

Baseline data

Based on the results of the study, there was no statistically significant difference between the two groups of control and intervention in terms of age, duration of diploma courses (month), high school field of study, high school math score, interest in mathematics, employment, working experience in hospital, and personality type. Based on the findings, the intervention group had a significantly higher GPA compared to the control group (Table 1).
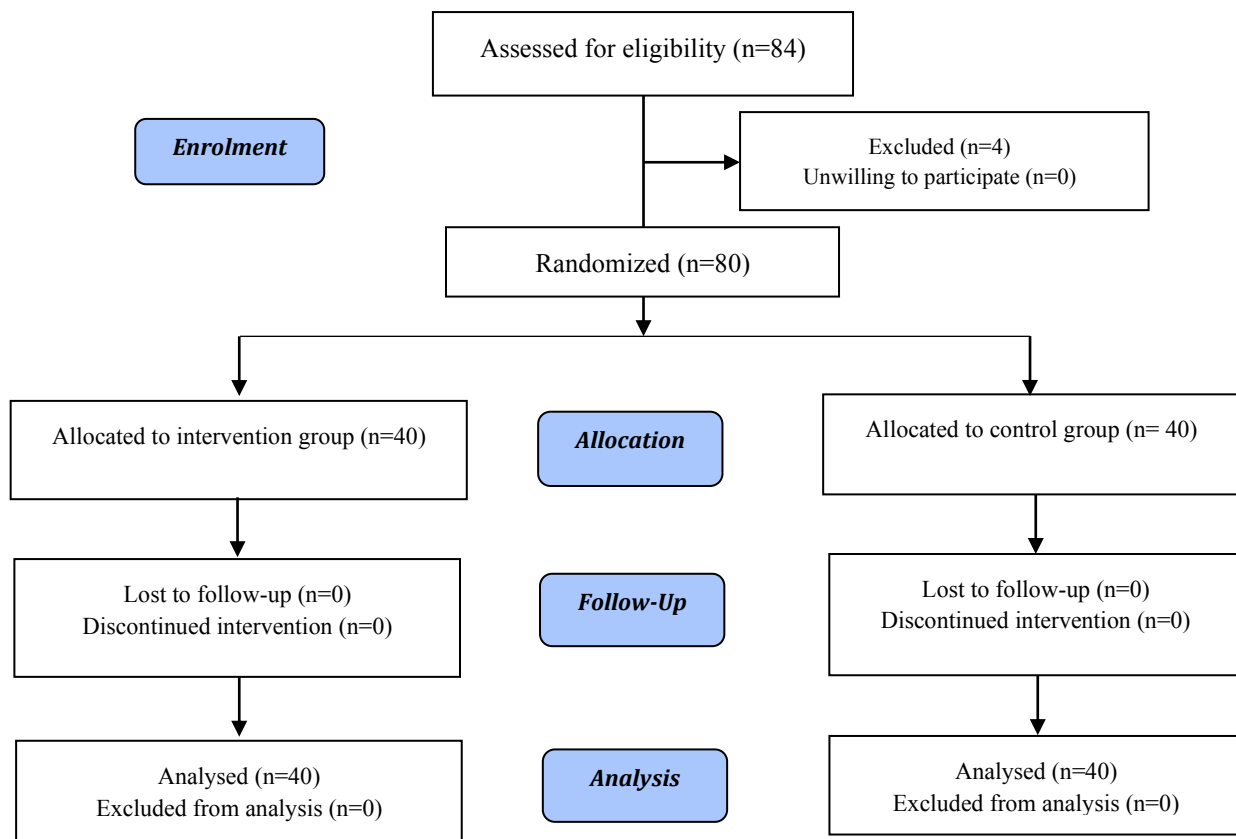
Figure 1. Consort flow diagram of the study

Table 1. Characteristics of the study population stratified by intervention status (N=40 in each group)

		Intervention N (%) Mean ± SD	Control N (%) Mean ± SD	P
Age (Year)/Mean (SD)		22.25 ±3.45	24.33 ±5.95	0.060
Gender	Male	15 (37.5%)	21 (52.5)	0.178
	Female	25 (62.5)	19 (47.5)	
Duration of diploma courses (month)		48.98 ±53.53	64.55 ±70.41	0.269
High school math score	Poor	0 (0)	6 (15)	0.085
	Average	14 (35)	13 (32.5)	
	Good	12 (30)	9 (22.5)	
	Excellent	14 (35)	12 (30)	
Interest in mathematics	Reluctant–low	3 (7.5)	6 (15)	0.568
	Average	21 (52.5)	19 (47.5)	
	High	16 (40)	15 (37.5)	
Employment	Yes	2 (5)	6 (15)	0.481
	No	38 (95)	34 (85)	
Working experience in hospital (month)		18.5 ±0.7 N= 3	15.04 ±12.07 N=6	0.714
Personality type	A	12 (30)	12 (30)	1
	B	28 (70)	28 (70)	
Math anxiety		24.78 (8.21)	26.73 (8.19)	0.291
Drug dosage calculation		15.70 ±3.48	14.70 ±4.98	0.303

Outcomes

Two-way analysis of variance with repeated measures for math anxiety showed no significant relationship between the intervention times and the groups ($F_{(2, 234)} = 0.046$, P= 0.955). In other words, there was a similar trend between the measured time changes in the intervention and control groups (Figure 2). There were no significant differences between the first, second, and third measures in both intervention and control groups regarding math anxiety (P=0.999). The analysis of the main effect of the group indicated a significant effect (P=0.024) (Table 2). In addition, the results of the independent t-test showed that there was a significant difference between the intervention and control groups in terms of math anxiety in the second time (P<0.001)

and the third time compared to the baseline (P <0.001). Therefore, the math anxiety scores showed a significant decrease in the intervention group compared to the control group (Table 4).

Two-way analysis of variance with repeated measures for drug dosage calculations showed a significant relationship between the intervention times and the groups (P<0.001). In other words, there was a dissimilar trend between the measured time changes in the intervention and control groups, where no time changes were observed in the control group. However, the drug dosage calculation score was significantly higher in the second and third times compared to the first time in the intervention group (Figure 3).

Table 2. Comparing math anxiety between control & intervention in different times

	Intervention Mean ± SD	Control Mean ± SD	Time effect*	Intervention effect*	Interaction effect*
First time/baseline	24.78 ±8.21	26.73 ±8.19	$F_{(2, 234)} = 0.001$ P=0.999	$F_{(1, 234)} = 5.160$ P=0.024	$F_{(2, 234)} = 0.046$ P=0.955
Second time	24.40 ±8.03	27.10 ±8.12			
Third time	24.48 ±8.05	26.98 ±8.16			

*Two-way Analysis of Variance with Repeated Measures utilizing Greenhouse-Geiser adjustment for the interaction effect of the group by measures interaction and the main effects
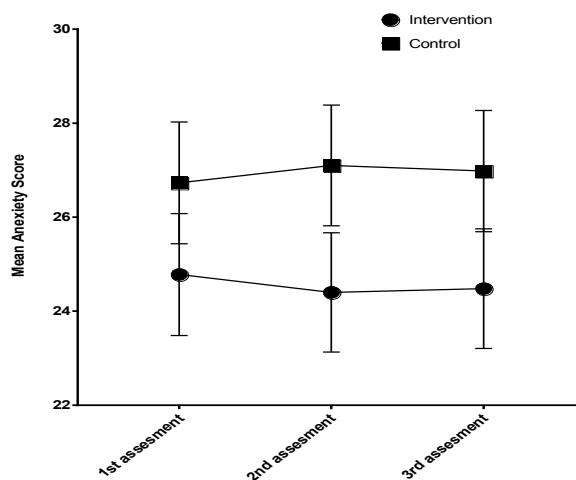
Figure 2. Comparing the Anxiety score across assessment times in intervention and control groups. Two-way Analysis of Variance with Repeated Measures utilizing Greenhouse-Geiser adjustment for the interaction effect of the group by measures interaction and the main effects

Given the significance of the interactions between the results of the comparisons of each two times, Bonferroni correction was performed separately in each group. The results indicated that no significant difference was observed between the first and the second times (P=0.991), between the first and the third times (P=0.949), and also between the second and the third times (P=0.982) in the control group. On the other hand, after the Bonferroni correction, there was a significant difference observed between the first and the second times (P<0.001) and also between the first and the third times (P<0.001) in the intervention group. Nonetheless, no significant difference was observed between the second and the third times (P=0.977). In other words, the drug dosage calculations score remained unchanged in the control group, but it significantly increased after the intervention in the intervention group.

Besides, the drug dosage calculations score remained unchanged at the third time compared to the second time in the intervention group (Table 3). The results of the independent t-test showed that there was a significant difference between the intervention and control groups in terms of drug dosage calculations in the second time (P<0.001) and the third time (P<0.001) compared to the first time (Table 4).

In order to determine the effect of anxiety on the score of drug dosage calculations, initially, the changes in anxiety and drug dosage calculation scores were calculated for the second and third times compared to the baseline. Then, Pearson correlation was calculated separately for the intervention and control groups where the results indicated no significant correlation. In other words, anxiety did not affect drug dosage calculation scores (Table 5).

Table 3. Comparing drug dosage calculation score between control and intervention in different times

	Intervention Mean ± SD	Control Mean ± SD	Time effect*	Intervention effect*	Interaction effect*
First time	15.70 ±3.48	14.70 ±4.98	$F_{(2, 234)} = 43.86$	$F_{(1, 234)} = 10.8$	$F_{(2, 234)} = 40.62$
Second time	26.75 ±3.54	14.82 ±5.10	P<0.0001	P<0.0001	P<0.0001
Third time	26.50 ±3.50	15.00 ±5.05			

*Two-way Analysis of Variance with Repeated Measures utilizing Greenhouse-Geiser adjustment for the interaction effect of the group by measures interaction and the main effects
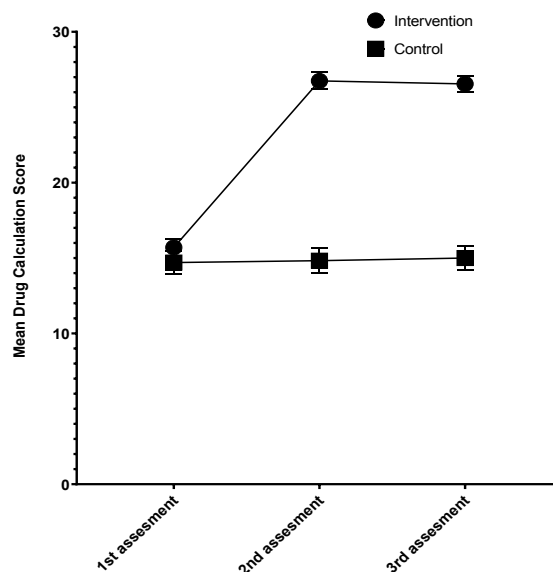
Figure 3. Comparing the drug calculation score across assessment times in intervention and control groups. Two-way Analysis of Variance with Repeated Measures utilizing Greenhouse-Geiser adjustment for the interaction effect of the group by measures interaction and the main effects

Table 4. Comparison of differences from baseline for math anxiety and drug dose calculation between intervention and control groups

	Group	Mean	Std. Deviation	P-Value
Anxiety change 2_1	Control	.3750	.70484	<0.001
	Intervention	-.3750	.80662	
Anxiety change 3_1	Control	.2500	.49355	<0.001
	Intervention	-.3000	.72324	
Drug change 2_1	Control	.1250	.82236	<0.001
	Intervention	11.0500	2.67898	
Drug change 3_1	Control	.3000	.93918	<0.001
	Intervention	10.8500	2.67515	

P-values were calculated using independent t-tests on changes of measures from baselines

Table 5. Correlation between changes in anxiety and drug dosage calculation

Correlation	Group	Correlation	P-value
Anxiety with the drug dosage calculation for the second time	Intervention	-0.145	0.371
	Control	0.049	0.760
Anxiety with the drug dosage calculation for the third time	Intervention	-0.037	0.820
	Control	0.277	0.084

Discussion

The study results regarding math anxiety showed that the same trend was observed in the measured time changes in both the intervention and control groups, which indicates no statistically significant difference. Nonetheless, the comparison between the two groups showed a significant decrease in math anxiety scores among the students in the intervention group. Unlike the control group, the intervention group's results indicated that the mean score of drug dosage calculations was significantly higher in the second and third times compared to the first time. Moreover, a comparison of the two groups showed a significant increase in the score of drug dosage calculations in the intervention group compared to the control group. The findings also showed no significant relationship between anxiety and the score of drug dosage calculations.

The results showed that although the math anxiety score was not statistically significant within the three-time intervals in each of the control and intervention groups, the math anxiety score was generally lower in the intervention group. In other words, the intervention could lead to the reduction of students' math anxiety. In New Zealand,

voluntary supplementary math tutorials have reportedly reduced nursing students' math anxiety (16). Meanwhile, a study in Alaska showed that basic math tutorials did not affect students' math anxiety (24). Differences or similarities between the present study and other studies can be due to any individual or genetic factors or even individual backgrounds. Thus, cultural backgrounds and individual and genetic factors are influential in math anxiety (25).

Regarding the scores of drug dosage calculations, the results showed a significant increase in the score of drug dosage calculations in the second and the third time in the intervention group compared to the first time. There was a significant increase in the drug dosage calculation scores in the intervention group compared to the control group. The findings of a study in Italy showed that the clinical skills workshop led to an increase in the mean score of students' drug dosage calculations (19). Besides, mathematical concepts and drug dosage calculation skills were taught through feedback and problem-solving approaches in the United States. The results of the study over three weeks indicated higher scores in the intervention group (27). In Turkey, web-based teaching, including the audio form of a lecture, content PDF files, exercise, and problem-solving approach, positively affected arithmetic and drug dosage calculation skills (7). Another study conducted in Belgium in 2016, attempted to evaluate the effectiveness of an e-learning course compared with a face-to-face lecture on medication calculation. The intervention group participants received e-learning instructions, and the participants in the control group received a face-to-face lecture. This study showed that although both medication calculation courses improved medication calculation skills, the effect was much higher in the face-to-face lecture than in the e-learning course (20). Studies have shown that anxiety affects drug dosage calculation scores. For example, A study was conducted in the UK to investigate the effect of math anxiety on nursing students' drug dosage calculation

skills. The researchers reported that the students who failed the drug dosage calculation exams were more anxious than those who passed the test (18). A review study attempted to examine the effects of math anxiety on medical students' ability to perform correct drug dosage calculations, and the results showed that math anxiety could have negative effects on drug dosage calculations (28). However, the results of the present study showed that there was no significant relationship between anxiety and the drug dosage calculation scores. It should be noted that training, practice, and repetition of drug dosage calculations provided in the present study could contribute to an increase in drug dosage calculation skills.

This study's findings highlight the need to pay attention to math anxiety, drug dosage calculations and adopt strategies to increase the nursing students' skills. The present study interventions have reduced math anxiety and an increase in the drug dosage calculation scores. It is claimed that applying strategies such as those provided in the present study where drug dosage calculation training program was conducted during a clinical pharmacology internship course using lectures and workshops can help reduce students' math anxiety and improve nursing students' drug dosage calculation skills.

The present study was conducted by holding lectures and educational workshops followed by further education in the clinical setting.

Limitations

Randomization and random assignment were not performed in this study. Moreover, the researchers investigated the two outcomes of math anxiety and drug dosage calculation; other outcomes such as students' satisfaction with the proposed programs were not taken into account in the present study. Besides, the students' GPA was obtained through self-report.

Conclusion

The results highlighted the effect of drug dosage calculation training programs on reducing math anxiety and increasing the nursing students' drug dose calculation score. The introduction of such educational programs in nursing schools can help increase students' skills in calculating drug dosage. This can ultimately contribute to the reduction of medication errors due to incorrect drug dosage calculation.

Acknowledgments

Conflict of interest

There is no conflict of interest.

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