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The effect of small group simulation-based interprofessional education on non-technical skills of anesthesia providers: A randomized controlled trial

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Abstract

Background: Most serious adverse events in health care are related to non-technical skills failures. Anesthesiology profession, due to its vital, risky and decisive nature, is more focused on technical, physiological and medicinal aspects compared with other professions, and anesthesia experts and researchers have not paid serious attention to non-technical aspects of their work.

Objectives: This study examined the effect of simulation-based interprofessional education (SBIPE) in small groups on non-technical skills of anesthesiologists and nurse anesthetists.

Methods: This single-blind randomized controlled trial was conducted during April and May 2023 on anesthesiologists and nurse anesthetists in the operating room of Imam Khomeini Hospital, Ahvaz, Iran. Participants included 64 anesthesiologists and nurse anesthetists who were randomly assigned into an intervention group (n=32) and a control group (n=32). The intervention group was divided into small groups to receive three hours of SBIPE. The Anesthetists' Non-Technical Skills (ANTS) scale which encompasses four components of task management, team working, situation awareness, and decision-making was used to collect data. To analyze the data, independent and paired t-tests were used.

Results: In the intervention group, the mean scores of task management, team working, situation awareness and decision-making were 9.32±2.29, 7.96±2.05, 7.84±1.91 and 6.00±1.61 at baseline and increased to 12.36±2.18, 12.28±2.31, 12.28±2.19 and 10.04±1.62, respectively (P<0.001). In the control group, however, changes were significant only in the task management component (9.20±2.27 to 10.76±1.59) (P=0.004).

Conclusion: Compared with simulation-based uniprofessional education, SBIPE was more effective in improving non-technical skills of anesthesia providers. Therefore, similar interprofessional education programs can be used to improve non-technical skills of anesthesiologists and nurse anesthetists.

Keywords: Interprofessional education, Patient Simulation, Social learning, Nurses, Anesthesia.

Introduction

Training efficient professionals requires capabilities that go beyond technical skills and knowledge. Therefore, to improve patient health and safety, studies are looking for strategies to improve the efficiency, awareness, and sense of responsibility of healthcare workers in fulfilling their professional duties.[1] Improving the clinical staff's non-technical skills in parallel with their cognitive and technical skills can promote patient safety and quality of care.[2] A study showed that the lack of non-technical skills was responsible for 80% of errors in high-risk activities of undergraduate medical students.[3] Another study also highlighted the important role of non-technical skills in improving technical skills and achieving therapeutic and care purposes.[2] Non-technical skills are cognitive, social, and personal skills that complement the technical skills of clinical staff and influence their safe and efficient performance. There are different non-technical skills in different professions. These skills are well established in the field of anesthesiology and mainly include situation awareness, decision-making, teamwork, leadership, and stress and fatigue management.[4] Many errors in

healthcare occur in stressful work environments, such as operating rooms.[1] In one study, poor non-technical skills were found to have a greater impact on the occurrence of errors in anesthesia than technical skills.[5] Another study has also shown that adverse health and patient safety conditions, such as embolism, anesthetic side effects, drug reactions, and infections, are more likely to be related to poor non-technical skills.[6]

The education of anesthesiologists and nurse anesthetists is a complex process, and interprofessional practices within the anesthesia team plays a critical role in optimizing patient outcomes and reducing anesthesia complications.[7] Nonetheless, the lack of interprofessional training can lead to poor coordination between anesthesia team members and reduce the quality of patient care.[7] Simulation is an effective strategy that goes beyond routine anesthesia training and addresses the anesthesia team's performance during critical events.[8] Simulation-based interprofessional education (SBIPE) in small groups is a contemporary method based on educational theories[9] and can be used by healthcare professionals to improve their communication and collaboration.[10] Some studies have shown that SBIPE in small groups can increase the efficiency of healthcare professionals' technical and non-technical skills.[7,10,11] However, there are conflicting results in this area. A study reported that SBIPE in small groups could enhance attitude and teamwork of anesthesiology residents and nurse anesthesia students.[7] Another study also showed that an SBIPE course could improve medical students and anesthesia technician trainees' attitude towards interprofessional collaboration and learning.[12] However, in a recent study, the same method failed to significantly improve medical and nursing anesthesia students' scores in readiness for interprofessional learning.[13] Furthermore, most studies in this area have been conducted with students, and the impact of this educational method on healthcare workers has been less investigated. Therefore, questions arise about the impact of small group SBIPE on the non-technical skills of anesthesiologists and nurse anesthetists.

Objectives

This study examined the effect of small group SBIPE on non-technical skills of anesthesiologists and nurse anesthetists.

Methods

Study design and participants

This single-blind randomized controlled trial was conducted from April to May 2023. The research population included all anesthesiologists and nurse anesthetists working in the operating room of Imam Khomeini Hospital, Ahvaz, Iran. The sample size was calculated based on a similar study, where the effectiveness of SBIPE for nursing students could change their mean interprofessional collaborative competency from 4.48±0.49 to 4.78±0.33.[14] Then, using the formula for comparing two means, and considering $\mu1=4.48$, $\mu2=4.78$, $S1=0.49$, $S2=0.33$, $\alpha=0.05$, and $\beta=0.2$, a sample size of 31 was calculated for each group. However, we selected 32 participants in each group for more confidence. There were 16 eligible anesthesiologists and all of them were selected by census method however, nurse anesthetists were recruited by convenience method from those who met the inclusion criteria. Participants were eligible to participate in the study if they had work experience in the general operating room for 2 or more years as a direct anesthesia provider, had constant presence in the desired operating room as a permanent staff, and were willing to participate in the study. The exclusion criteria were previous participation in SBIPE programs, participation in a parallel workshop, and inadequate questionnaire completion.

First, we randomly assigned the participants into two control and intervention groups, according to gender and expertise. In this way, each group included 8 anesthesiologists and 24 nurse anesthetists. Then, each group was divided into small groups. Groups of 6-8 people are often considered as small groups for learning purposes.[15] The intervention group was divided into four interprofessional small groups of eight people each (including two anesthesiologists and six nurse anesthetists). The control group, on the other hand, was divided into small, uniprofessional groups of eight people. One of these subgroups included eight anesthesiologists and each of the other three subgroups consisted of eight nurse anesthetists [Figure 1].

Data collection instruments

The Anesthetists' Non-Technical Skills (ANTS) scale was used to evaluate the non-technical skills of the anesthesia team members. The ANTS was developed in Scotland (2010) and specifically evaluates the behavioral indicators affecting the non-technical skills of anesthesia providers. It assesses 15 elements of anesthetists' non-technical skills in four components of task management, team working, situation awareness, and decision-making. The items in ANTS are rated on a Likert scale ranging from 5 to 1, representing "Good", "Acceptable", "Marginal", "Poor" and "Not observed" skill. The total score ranges between

15 and 75. Score < 26, 27-38, 39-50, 51-62, and > 63 indicate very poor, poor, marginal, acceptable, and good non-technical skills, respectively.

The original ANTS and its various translations showed good validity[16,-18] and reliability and the Cronbach's alpha of its different components ranged from 0.79 to 0.86 indicating its suitable internal consistency.[16] The ANTS was also translated and psychometrically tested in Iran and showed acceptable content validity ratio (CVR =0.54), content validity index (CVI = 0.84), and inter-rater intra-class coefficient reliability (ICC = 0.88).[19]

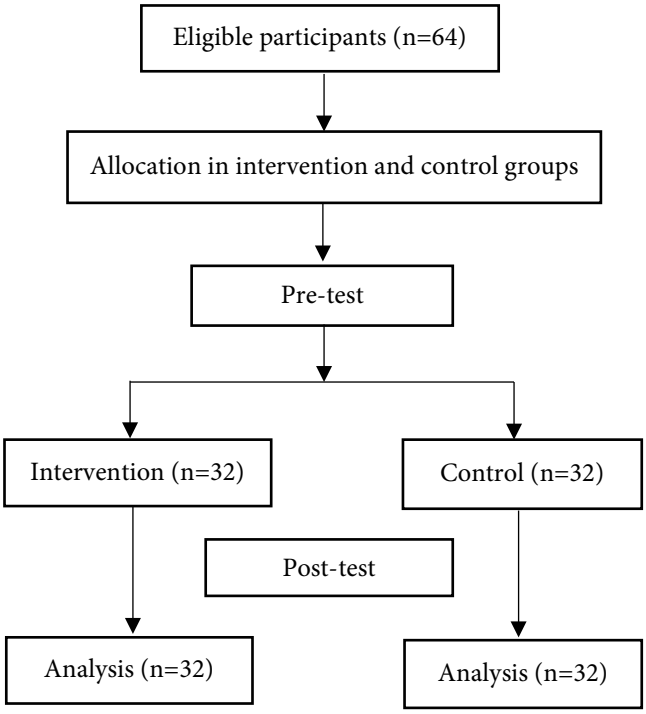

Figure 1. Flowchart of the study

Procedures

Pre- and post-tests were conducted one week before and one month after the intervention and by two observers in the actual setting while patients received local or general anesthesia. Observers were blind to group assignment during data collection. Prior to the commencement of the study, an anesthesiologist and a nurse anesthetist were selected and trained as observers. These observers had more than five years of work experience in the desired center and were fully familiar with the staff, operating room conditions, and staff relationships. The observers participated in a 2-hour training session to be trained on the structure of the ANTS and on how to complete it. They then independently observed three cases of local and general anesthesia. Then the Cohen's kappa agreement was calculated. The kappa coefficients for the three observations ranged from one to 0.85.

Intervention

The intervention group received three hours of interprofessional education in small groups, as presented in Table 1. The intervention started with an introduction where participants got familiar with task management, teamwork, situation awareness, and decision-making in order to apply the ANTS criteria most effectively. They also discussed their experiences in the face of acute situations. An anesthesiologist and a nurse anesthetist facilitated the educational sessions. After the introduction, the participants were taken to one of the inactive operating rooms to get familiar with the patient simulator and the available drugs and equipment. During each session, three scenarios of acute anesthesia situations were discussed by interprofessional teams and practiced on the patient simulator. Participants who were not actively involved in the simulation could watch the simulation via a monitor in a separate room. All participants actively participated in at least one scenario. The scenarios were designed and approved by an interprofessional team including anesthesiologists, nurse anesthetists, and medical education professionals who are faculty members at Jundishapur University of Medical Sciences.

The first scenario was related to the natural delivery of a 28-year-old primiparous woman. Epidural anesthesia was administered to the patient. Five minutes later, the patient felt a metallic taste in her mouth and experienced tinnitus, both of which are the precursors of intoxication with local anesthetics. After one minute, an electrocardiogram showed a widening of the QRS complexes and ventricular fibrillation (cardiac arrest) was presented to the participants. The criterion of correct performance in this scenario was to diagnose cardiac arrest, start chest compression, start mechanical ventilation, place the patient simulator in the left lateral tilt position, and contact a midwife or obstetrician for further management of this acute situation.

The second scenario simulated a grade four anaphylactic shock following antibiotic infusion, where the patient felt unwell and fainted, and showed reduced arterial oxygen saturation, sinus bradycardia, and arterial hypotension following the infusion. These symptoms ended in asystole (cardiac arrest) one minute later. The criteria for correct performance in this scenario focused largely on correct diagnosis and proper and timely administration of fluids and epinephrine.

The last scenario involved the simulation of bronchospasm. Shortly after intubation, a patient with known Chronic obstructive pulmonary disease (COPD) experienced an exacerbation and bronchospasm with high

airway pressure, low tidal volume, carbon dioxide retention, and decreased arterial oxygen saturation. The criteria for correct performance included considering the differential diagnoses of difficult ventilation, appropriate administration of bronchodilators, and increasing the concentration of inhalational anesthetics.

In all three scenarios, the nurse anesthetist was present next to the patient simulator at the onset of the problem, while the anesthesiologist was in another room and could be accessed by phone. After assessing the situation and in case of feeling the need for help, the nurse anesthetist would call the anesthesiologist and give them a short-structured summary. After the anesthesiologist entered the room, they re-evaluated the situation, and then both the anesthesiologist and the nurse anesthetist worked together to provide the corresponding treatment according to the situation they faced. Each scenario lasted 20 minutes. After the simulation phase, a debriefing session focusing on non-technical skills was held by an anesthesiologist and a nurse anesthetist who was a faculty member of the university. In the control group, simulation-based uniprofessional training was carried out in small groups. In other words, anesthesiologists and nurse anesthetists were trained separately. For the anesthesiologists, the training was conducted by an anesthesiologist. The evaluation and management of the hypothetical patients in the scenarios were also performed by a team of two anesthesiologists, one of whom played the role of a nurse anesthetist. For the nurse anesthetists, the training was conducted by a nurse anesthetist. The evaluation and management of the hypothetical patients in the scenarios was also performed by a team of two nurse anesthetists. After examining the patient and detecting the danger, one of them called a hypothetical anesthesiologist and informed him of the situation. Then, they took the necessary steps without the presence of the anesthesiologist.

Ethical considerations

The present study was approved by the Ethics Committee of Ahvaz Jundishapur University of Medical Sciences (AJUMS) (IR.AJUMS.REC.1398.308) and was carried out in accordance with the provisions of the 2013 Declaration of Helsinki. The aims, procedures, and conditions of the study were fully explained to the potential participants. Written informed consent was obtained from all participating professionals. Also, the confidentiality of the data and the anonymity of the participants during the entire study process were guaranteed.

Data analysis

SPSS version 16 (Chicago, IL, USA) was used for the statistical analysis. The data were analyzed by means of descriptive statistics, including mean, standard deviation, frequency, and percentage. The normality of the data was checked by the Kolmogorov-Smirnov test. The independent t-test was used for between-group comparisons, while the paired t-test was used for within-group comparisons. Analysis of covariance was conducted to examine the effect of work experience on the post-test scores. The significance level was set at < 0.05 for all tests.

Results

In total, 64 anesthesia providers including anesthesiologists (25%) and nurse anesthetists (75%) participated in this study. The intervention and control groups were homogenous in all demographic characteristics ($P> 0.05$), with the exception of work experience ($P= 0.003$) [Table 2].

Table 1. Components of the educational intervention

Content
Educational objective
Improving non-technical skills of anesthesia providers including task management, team working, situation awareness, and decision-making.
Educational strategies
Interprofessional education.
Small group teaching.
Instructional methods
Interactive lectures.
Scenario-based simulation.
Debriefing.
Educational content
Educational concepts: Importance, basics, and application of non-technical skills based on ANTS scale along with relevant guidelines and articles.
Educational scenarios: Three scenarios of acute situations designed by the interprofessional team consisting of anesthesiologists and nurse anesthetists who are faculty members of the university.
Assessment
Assessment of non-technical skills by two observers based on the ANTS scale.

Table 3 compares the mean scores of the pre- and post-tests for the four components of the ANTS between the intervention and control groups. None of the mean scores of the four components differed significantly between the two groups at baseline ($P>0.05$). However, all mean scores of the post-test were significantly higher in the intervention group ($P<0.05$). Within-group comparisons also showed that in the intervention group, the mean scores of all four components increased significantly after

the intervention (P<0.05). However, none of the components changed significantly in the control group, with the exception of the task management component (P = 0.004) [Table 3]. The analysis of covariance also showed that work experience had no confounding effect on the posttest results.

Table 2. Demographic characteristics of participants [a]

Variables		Group		P-value
		Intervention	Control	
Profession				
	Anesthesiologist	8 (25)	8 (25)	0.99
	Nurse anesthetist	24 (75)	24 (75)	
Sex				
	Male	16 (50)	16 (50)	0.99
	Female	16 (50)	16 (50)	
Age (Year)		27.06 ± 8.79	28.44 ± 9.09	0.54
Work experience (Year)		7.05 ± 2.09	9.08 ± 3.01	0.003

[a] Data presented as Frequency (%) or Mean ± Standard deviation

Table 3. Comparison of non-technical skills between the intervention and control groups

Components/Time	Group [a]		P-value [b]
	Intervention	Control	
Task management			
Before	9.32 ± 2.29	9.20 ± 2.27	0.83
After	12.36 ± 2.18	10.76 ± 1.59	0.002
P-value [c]	<0.001	0.004	
Team working			
Before	7.96 ± 2.05	8.00 ± 2.17	0.93
After	12.28 ± 2.31	7.84 ± 2.48	<0.0001
P-value [c]	<0.001	0.668	
Situation awareness			
Before	7.84 ± 1.91	8.24 ± 1.71	0.38
After	12.28 ± 2.19	8.64 ± 2.25	<0.0001
P-value [c]	<0.001	0.399	
Decision making			
Before	6.00 ± 1.61	6.00 ± 2.04	0.99
After	10.04 ± 1.62	6.40 ± 1.83	<0.0001
P-value [c]	<0.001	0.246	

[a] Data presented as Mean ± Standard deviation, [b] t test, [c] paired t test

Table 4 also compares the pre-test and post-test mean scores for all 15 items of the ANTS between the intervention and control groups. None of the mean scores of the 15 items differed significantly between the two groups at baseline (P>0.05). However, all posttest mean scores were higher in the intervention group and the differences were statistically significant for seven of the 15 items (P<0.05).

The mean changes were also compared between the two groups. Between-group differences were statistically significant for the teamwork, situation awareness and decision-making components (P< 0.001). However, this was not the case for the task management component (P = 0.092) [Table 5].

Discussion

Our results showed that all the four components of the ANTS (i.e. task management, team working, situation awareness, and decision-making) improved significantly in the intervention group. However, in the control group who received uniprofessional training, there was a significant change only in task management component.

The small group interprofessional education and the scenarios implemented in the present study provided participants with an interactive opportunity to engage in participatory learning, have interprofessional discussions, exchange opinions, find solutions to the scenarios, and improve their non-technical skills through this participatory practice. It has been shown that interprofessional discussion is a powerful tool for teaching non-technical skills and strengthening professionalism behaviors.[20] Conducting interprofessional discussions appears to facilitate the recognition of others' attitudes and opinions and to promote communication and respect between team members.[21] Interprofessional education also reduces defensive and prejudicial behaviors, negative stereotypes, and moral conflicts by providing frequent contact between learners from different professions. Furthermore, discussions held within interprofessional education can shed light on interprofessional differences and improve mutual trust and respect.[20] Consistent with our findings, Hosseinpour *et al.* reported a significant improvement in the professional behaviors of surgical team members after participating in interprofessional training session.[20] Another study also reported improved cooperation and teamwork following an interprofessional training session for nursing, physiotherapy, nutrition, and pharmacy students.[22] However, in another study, nursing and medical students were assigned to a uni- or interprofessional training program and both methods significantly improved students' interprofessional competence.[23]

Table 4. Comparison of all items of non-technical skills between the study groups

Components	Items	Time	Group [a]		P-value [b]
			Intervention	Control	
Task management	Planning and preparing	Before	2.00 ± 0.95	2.08 ± 0.95	0.73
		After	3.28 ± 1.10	3.20 ± 1.08	0.77
		P-value [c]	<0.001	<0.001	
	Prioritizing	Before	2.16 ± 0.75	2.08 ± 0.86	0.69
		After	2.32 ± 0.80	2.20 ± 0.82	0.55
		P-value [c]	0.048	0.43	
	Providing and maintaining standards	Before	2.08 ± 0.99	2.08 ± 0.99	0.99
		After	3.48 ± 0.92	2.16 ± 0.89	<0.0001
		P-value [c]	< 0.001	0.63	
	Identifying and utilizing resources	Before	3.08 ± 0.76	2.96 ± 0.93	0.57
		After	3.28 ± 0.89	3.20 ± 1.19	0.76
		P-value [c]	0.050	0.21	
Team working	Coordinating activities with team	Before	1.96 ± 0.84	2.08 ± 0.95	0.59
		After	3.84 ± 0.85	1.84 ± 0.94	<0.0001
		P-value [c]	< 0.001	0.16	
	Exchanging information	Before	2.20 ± 1.00	2.20 ± 1.08	0.99
		After	2.48 ± 0.91	2.12 ± 1.13	0.16
		P-value [c]	0.043	0.68	
	Using authority and assertiveness	Before	1.72 ± 0.67	1.76 ± 0.88	0.83
		After	3.80 ± 0.87	1.84 ± 0.85	<0.0001
		P-value [c]	< 0.001	0.60	
	Assessing capabilities	Before	2.08 ± 0.95	1.96 ± 0.84	0.59
		After	2.16 ± 0.80	2.04 ± 1.13	0.62
		P-value [c]	0.45	0.64	
	Supporting others	Before	1.88 ± 0.83	2.08 ± 0.86	0.34
		After	3.80 ± 0.82	2.12 ± 0.88	<0.0001
		P-value [c]	< 0.001	0.79	
Situation awareness	Gathering information	Before	1.72 ± 0.84	2.08 ± 1.19	0.16
		After	3.76 ± 0.88	1.92 ± 0.86	<0.0001
		P-value [c]	< 0.001	0.37	
	Recognizing and understanding	Before	2.24 ± 1.05	2.08 ± 0.86	0.51
		After	2.28 ± 0.98	2.12 ± 1.17	0.55
		P-value [c]	0.82	0.80	
	Anticipating	Before	2.00 ± 0.71	2.00 ± 0.71	0.99
		After	2.44 ± 1.00	2.48 ± 1.26	0.88
		P-value [c]	0.006	0.03	
Decision making	Identifying options	Before	2.36 ± 0.95	2.24 ± 1.09	0.64
		After	1.96 ± 0.84	2.32 ± 0.95	0.11
		P-value [c]	0.016	0.65	
	Balancing risks and selecting options	Before	1.68 ± 0.75	1.88 ± 1.01	0.37
		After	4.04 ± 0.68	2.00 ± 1.12	<0.0001
		P-value [c]	< 0.001	0.52	
	Reevaluating	Before	1.96 ± 0.98	1.88 ± 0.97	0.74
		After	4.04 ± 0.89	2.08 ± 0.95	<0.0001
		P-value [c]	< 0.001	0.25	

[a] Data presented as Mean ± Standard deviation, [b] t test, [c] paired t test

Table 5. Comparison of changes in subscales of non-technical skills in the study groups

Components	Pre- and post-intervention changes [a]		P-value [b]
	Intervention group	Control group	
Task management	3.53 ± 3.04	2.47 ± 1.56	0.092
Team working	3.76 ± 4.32	1.84 ± 0.16	<0.001
Situation awareness	3.34 ± 4.44	1.68 ± 0.40	<0.001
Decision making	1.68 ± 0.40	2.39 ± 4.04	<0.001

[a] Data presented as Mean ± Standard deviation, [b] t test

In the present study, the score of task management component of the ANTS increased significantly in the control group. This finding might be attributed to the fact that anesthesia providers in the control group received uniprofessional training, where an anesthesiologist played the role of a nurse (and vice versa). Perhaps, such a role-play practice could improve attitude and perspective of the participants in the control group towards the role and duties of other anesthesia team members.

Simulation studies usually evaluate behavioral changes in a simulated environment. This study is particularly worthwhile in that it evaluated changes in clinical performance at the third level of Kirkpatrick's model.[24] Despite the paucity of research on the transfer of knowledge obtained through simulation into clinical practice based on ANTS, our study showed that after the participants demonstrated their ability to transfer newly acquired skills to daily practice even after only one simulation training session.

This study had some limitations. First, we did not assess the long-term effects of the intervention. Therefore, it would have been ideal to conduct the third round of observations a few months after the simulation to evaluate skill retention. This study was also susceptible to the Hawthorne effect, because participants knew that they were under observation.[25] The reason for the improvement of skills in the task management component in the control group can be attributed to the Hawthorne effect. Although we tried to minimize this effect by selecting observers who were at the same level as the participants in terms of their rank in the organizational hierarchy, this effect could not be completely eliminated. Another limitation is that the behavior will not change sustainably without the support of all members of the surgical team. Further studies should therefore investigate the effectiveness of this model in teaching non-technical skills to nursing, anesthesia, and surgical teams.

Conclusions

The training of anesthesia providers should include technical and non-technical skills to ensure patient safety. Teaching non-technical skills is necessary for the effective cooperation of anesthesia team members. SBIPE in small groups can effectively improve the non-technical skills of anesthesia providers. Therefore, similar educational programs can be used to improve non-technical skills of anesthesiologists and nurse anesthetists. Finally, the infrastructure of a team involving health care professionals and policy initiatives using an interprofessional-based training platform to practice non-technical skills could be further tested and evaluated.

Acknowledgment

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Competing interests

The authors declare that they have no competing interests.

Abbreviations

SBIPE: Simulation-Based Interprofessional Education, ANTS: Anesthetists' Non-Technical Skills, CVR: Content Validity Ratio, CVI: Content Validity Index, ICC: Inter-rater Intra-class Coefficient.

Authors' contributions

Conceptualization: AK, NS, MA, SA, VS. Data curation: AK, SA. Methodology/analysis: SA, VS. Project administration: AK, MA. Funding acquisition: NS, AK, MA, SA, VS. Writing original draft: AK, NS. Writing, review and editing: AK, NS, MA, SA, VS. All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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Availability of data and materials

The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

The present study was approved by the Ethics Committee of Ahvaz Jundishapur University of Medical Sciences (AJUMS) (IR.AJUMS.REC.1398.308) and was carried out in

accordance with the provisions of the 2013 Declaration of Helsinki. All participants signed an informed consent form.

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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