ORIGINAL ARTICLE

The effect of threshold inspiratory muscle training on the duration of weaning in intensive care unit-admitted patients: A randomized clinical trial

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Background: The purpose of this study was to evaluate the effect of threshold inspiratory muscle training (IMT) on the duration of weaning in intensive care unit (ICU)-admitted patients. **Materials and Methods:** This randomized clinical trial enrolled 79 ICU-admitted, mechanically ventilated patients in 2020–2021 in Imam Reza Hospital, Mashhad. Patients were randomly divided into intervention ($n = 40$) and control ($n = 39$) groups. The intervention group received threshold IMT and conventional chest physiotherapy, while the control group only received conventional chest physiotherapy once a day. Before and after the end of the intervention, the strength of inspiratory muscles and the duration of weaning were measured in both the groups. **Results:** The duration of weaning was shorter in the intervention group (8.4 ± 1.1 days) versus the control group (11.2 ± 0.6 days) ($P < 0.001$). The rapid shallow breathing index decreased by 46.5% in the intervention group and by 27.3% in the control group after the intervention (both $P < 0.001$), and the between-group comparison showed a significantly higher reduction in the intervention group than control group ($P < 0.001$). The patients' compliance after the intervention compared to the 1st day increased to 16.2 ± 6.6 in the intervention group and 9.6 ± 6.8 in the control group (both $P < 0.001$), and the between-group comparison showed a significantly higher increase in the intervention group than control group. The maximum inspiratory pressure increased by 13.7 ± 6.1 in the intervention group and by 9.1 ± 6.0 in the control group ($P < 0.001$). Furthermore, the weaning success was 54% more probable in the intervention group than control group ($P < 0.05$). **Conclusion:** The results of this study showed the positive effect of IMT with threshold IMT trainer on increased strength of respiratory muscles and reduced weaning duration.

Key words: Admitted patients, inspiratory muscle training, intensive care unit, threshold IMT trainer, weaning

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INTRODUCTION

Mechanical ventilation is a major and vital intervention in patients admitted to intensive care units (ICUs).[1] About 80%–90% of the patients in ICUs need respiratory support by mechanical ventilator (MV).[2] Unfortunately, prolonging the duration of MV increases the length of patient's stay in the ICUs, which can lead to a shortage of beds in these units and increase costs.[3] Therefore, the process of weaning from MV in eligible patients should be started as soon as possible. Recent findings suggest that about 70% of ICU patients can be weaned successfully within the 1st day, while in 30% of cases, the initial attempts fail with relevant negative

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implications in the weaning process.[4] Respiratory muscle weakness, especially diaphragm dysfunction, can lead to difficult and prolonged weaning.[5] To improve patient's respiratory function for weaning, measures such as respiratory muscle physiotherapy are suggested.[6]

Chest physiotherapy is currently used to prevent pulmonary complications in mechanically ventilated patients in the ICU, and rehabilitation efforts in these units have largely focused on peripheral muscle dysfunction. One of the strategies that help the patients' timely weaning is the use of inspiratory muscle training (IMT). IMT is a safe and practical technique in selecting ventilator-dependent patients and improving their inspiratory muscle strength and increasing the probability of weaning success.[7-10] It is evidently necessary for the patient to be conscious during the exercises, and many patients cannot actively participate in IMT at the ventilator-dependent stage (for example, due to sedation or delirium).[11] Threshold inspiratory device ranges from 9 to 41 cmH_2O.[12] This spring-loaded one-way valve provides titratable inspiratory resistance.[13] This means that threshold loading is the simplest method of IMT and its administration for patients in the ICU is helpful.[10] The results of some studies indicate that IMT is more efficacious than conventional chest physiotherapy in timely weaning.[14] Adding an objective inspiratory training device to IMT improved muscle strength and the rate of successful weaning.[15] IMT is feasible, safe, and well tolerated in critically ill patients.[1,10]

Due to the negative role of inspiratory muscle weakness on prolonged weaning, some authors have suggested that the threshold IMT trainer can improve inspiratory and expiratory muscle strength. Meanwhile, only a few studies have focused on the duration of weaning. For example, Condessa *et al*. assessed the usefulness of IMT on the shortening of weaning period.[16] In this study, no significant effect of IMT on the weaning period was found, but increasement in the respiratory muscle strength and tidal volume were reported. On the other side, shorter duration of ventilation and weaning were reported in a recent meta-analysis.[10] To address these outcome inconsistencies, the present study was designed to determine the effect of threshold IMT on the duration of weaning in ICU-admitted patients.

MATERIALS AND METHODS

Study design

This study was a randomized, controlled, clinical trial with concealed allocation and double-blinded outcome assessment performed in 2020–2021 at the ICUs of Imam Reza Hospital, Mashhad.

Research population

Mechanically ventilated patients who were admitted to the ICUs of Imam Reza Hospital and met all the eligibility criteria were included in this study.

The inclusion criteria were mechanical ventilation for 1 week; consciousness, without the use of sedatives (−1 < RASS<+1); stability in hemodynamic status, respiration, and oxygenation; respiratory rate < 25; PSV/CPAP; FIO2 < 0.60; Peep <10; and PSV ≤12.[1]

The exclusion criteria were failure to perform breathing exercises for any reason, receiving sedative or muscle relaxant medications, prohibition of physiotherapy, or having neuromuscular diseases affecting respiratory muscle function.

Sample size, recruitment, randomization, and blinding

The sample size was calculated based on the results of a pilot study of ten subjects in each group to compare the means of weaning duration with a 95% confidence interval (CI) and 80% test power. The mean and standard deviation (SD) from the pilot study were 9.5 ± 2.4 in the intervention group and 10.8 ± 1.3 in the control group. G-Power software version 3.1 calculated the sample size as 70 patients (35 per group). Taking into account a potential attrition of about 15%, the sample size was raised to 40 per group. The patients were randomly divided into intervention and control groups with a randomized block procedure in a block size of four. The random sequence was generated by MS Excel 2013 software.

Both patients and researchers were not aware of the treatment the patients received, so we had a double-blind clinical trial.

Primary and secondary outcomes

The primary outcomes of the study were duration of mechanical ventilation (day), weaning duration (day), weaning success, maximum inspiratory pressure (cmH2O), peak expiratory flow (PEF) (L/min), rapid shallow breathing index (RSBI) (breaths/min/L), and pulmonary compliance (ml/cm H2O), and the secondary outcome measures were continuation of invasive ventilation via a tracheostoma, continue mechanical ventilation, reintubation within 24 h, and mortality.

Preintervention

Patients meeting the inclusion criteria were evaluated for disease severity and level of consciousness based on APACHE II, sequential organ failure assessment (SOFA), and RASS. Then, maximum inspiratory pressure (MIP), RSBI, and pulmonary compliance were measured and recorded for patients in both the groups with the help of a blinded researcher. The patients' MIP was measured by a

ventilator and the minimum inspiratory pressure was −18 cmH2O (IMT was performed by the threshold IMT trainer using 50% of MIP). Threshold IMT trainer is a calibrated device with a range of 9–41 cmH2O, with its lowest setting being −9 cmH2O−, which is 50% of MIP.

RSBI was calculated using a ventilator with a cutoff point of RSBI ≤105 breaths/min/L. To measure RSBI, the following ventilator settings were used: PS = 5, Peep = 5, and FIO2 = 40%.

PEF was measured with Bellavista 1000 e (IMT Medical, Switzerland).

To measure pulmonary compliance, an inspiratory pause of at least 0.2 s was initially set on the ventilator.

Weaning duration was measured from the beginning of the intervention until successful weaning.

Weaning failure was defined as spontaneous breathing trial failure or the need for reintubation within 48 h following extubation or patient's death.

Intervention stage

Control group: Strengthening the inspiratory muscles with conventional physiotherapy

Before daily exercises, MIP was measured by the ventilator, in both the groups. Conventional physiotherapy interventions included a range of passive to active movements of the limbs, chest physiotherapy (vibration and percussion), and repositioning. Physiotherapy was performed for an average of 15 min with an intensity appropriate for the patient's cooperation and vital signs.

Intervention group: Conventional physiotherapy with threshold inspiratory muscle training

The intervention group received conventional physiotherapy, too.

For threshold IMT:

- Patient was positioned at 45° on bed
- The device was adapted and connected to the patient's endotracheal tube. Patients were instructed to breathe until an auditory cue came from the device
- Five sets of six breath repetitions were performed
- One-minute rest was given between each set on MV support
- Training threshold pressure setting was initially kept at 50% of MIP, and IMT was then performed in five sets of six breaths for 5 min
- Threshold training pressure was increased daily by 10% of the patient's MIP
- Conventional physiotherapy was continued (as mentioned in the control group) in another session to prevent fatigue.

The interventions were performed daily until successful weaning.[1]

Training was discontinued when respiratory failure and/or hemodynamic instability was observed with one of the following: respiratory rate >35 breaths/min (or >50% of the baseline), SpO2 <90%, systolic blood pressure >180 mmHg or <80 mmHg, tachycardia >140 beats per minute or 20% more than the initial measurement, paradoxical breathing, agitation, depression, hemoptysis, and arrhythmia and/or sweating. If any of the above clinical signs were observed, the next training session did not involve an additional load. Instead, the exercise was performed at the same level as the previous session.

Threshold IMT was performed on the 1st day the patient began spontaneous ventilation and continued until the last moment before extubation.

After the intervention

MIP, PEF, RSBI, and pulmonary compliance were measured with a ventilator.

Instruments

1. Threshold IMT is a calibrated device with a range of 9–41 cmH2O that can be connected to an ETT via a flexible or rigid connector. This was a commercially available spring-loaded threshold IMT device that can usually provide an appropriate training resistance for ICU patients. Resistance training was increased daily
2. Assessment of the patient's consciousness was performed with RASS tool. This scale is a continuum of 10 points from −5 to +4 with three levels of consciousness (aggressive state to severe drowsiness and lack of consciousness)
3. SOFA and APACHE II scoring systems were used to determine the severity of the disease. APACHE II was the first part of the form, examining 10 acute physiological parameters, including temperature, mean arterial pressure, heart rate, respiration rate, arterial blood oxygen pressure, arterial blood pH, serum bicarbonate, serum sodium, serum potassium, serum creatinine, serum hematocrit, and white blood cell count. The second part of the scoring system consisted of the Glasgow Coma Scale. The first 12 physiological parameters were ranked as 3–4. Glasgow Coma Scale scoring was based on its form in such a way that for normal state (GCS = 15), any reduction score of normal state normal was considered the disease severity score. The scoring of the second part is the adaptation of age and the third part is the adaptation of chronic underlying diseases. The total score of the three parts of APACHE II ranges from 0 (no severity) to 71 (maximum severity)[17,18] SOFA includes the scores of the six major parameters:

respiration, cardiovascular system, liver, kidney, coagulation system, and Glasgow Coma Scale, each of which scores from 0 to 4. Maximum score 16 indicates the highest severity of organ failure and the highest probability of mortality.[7]

4. The weaning criteria checklist examines various parameters affecting weaning in patients under MV (MIP, tidal volume, RSBI, and compliance).

Ethics approval and consent to participate

This study was approved by the Ethics Committee of MUMS (code: IR.MUMS.MEDICAL.REC.1399.350) and registered at the Iranian Registry of Clinical Trials (code: IRCT20200915048728N1). The information was kept confidential and written informed consent was obtained from the patients.

Background variables

Patients' characteristics in the intervention and control groups included patients' age (in years), sex (1: male, 2: female), body mass index (kg/m^2), APACHE score, SOFA score, RASS score, and medical diagnosis (1: COPD, 2: pneumonia, 3: pulmonary abscess, 4: septicemia, and 5: others).

Statistical analyses

Data were expressed as mean (SD)/median (percentile 25–percentile 75) and frequency (percentages) for numeric and categorical variables, respectively. The normality of the variables was assessed by descriptive measures of distribution, skewness (within ± 1.5), and kurtosis (within ± 2). To compare between the intervention and control groups, we carried out the Chi-square test and Fisher's exact test for categorical variables, independent *t*-test for numeric normal variables, and Mann–Whitney test for numeric nonnormal variables. Within-group comparison of the quantitative variables was carried out by paired *t*-test.

To assess the intervention effect, ANCOVA was used for the between-group comparisons. In this analysis, the groups were compared and the baseline measurements were adjusted for by using this measure as a covariate in the model. In addition for binary outcomes, we computed the absolute risk reduction (ARR) and relative risk (RR) along with their 95% CI. The analyses were performed in IBM SPSS software, version 28 (IBM Corp., ARMONK, USA) by an alpha level set at 0.05.

RESULTS

Study participants

A total of 79 patients admitted to the ICU and under MV were included in this study, of which 41 (51.8%) were male and 38 (48.1%) female. Table 1 summarizes the patients' characteristics in the intervention and control groups.

In the IMT group, 87.5% of the patients completed all the intended IMT treatments (14 potential treatments for each patient). Fatigue caused some delay in the prescribed IMT sessions in three participants (7.5%) and emotional stress in two patients (5%), but no one rejected the treatments. IMT was generally well tolerated without any adverse effects during or immediately after training.

Research outcomes

The duration of weaning was 8.4 ± 1.1 days in the intervention group and 11.2 ± 0.6 days in the control group. Mann–Whitney's test showed that the difference was significant ($P < 0.001$) [Table 2].

Table 3 presents the mean and SD of the pre- and postintervention values of MIP, PEF, RSBI, and pulmonary compliance.

Considering the baseline measurements, no significant differences were observed in maximum inspiratory pressure ($P = 0.930$), PEF ($P = 0.667$), RSBI ($P = 0.936$), and pulmonary compliance ($P = 0.510$), indicating the group homogeneity in the abovementioned variables at baseline.

The Maximum inspiratpry pressure significantly in both intervention (13.70) and control (9.08) groups (both $P < 0.001$), with significantly higher increase in the intervention group (ANCOVA $P < 0.001$). Furthermore, the PEF experiences a significant increase in both intervention (20.60) and control (11.79) groups (both $P < 0.001$), however, significantly higher increases were observed in the intervention group (ANCOVA $P = 0.011$). Moreover, significant declines were evident for rapid shallow index in both intervention (46.45) and control (27.33) groups, but the amount of decline was significantly bigger in the intervention group (ANCOVA

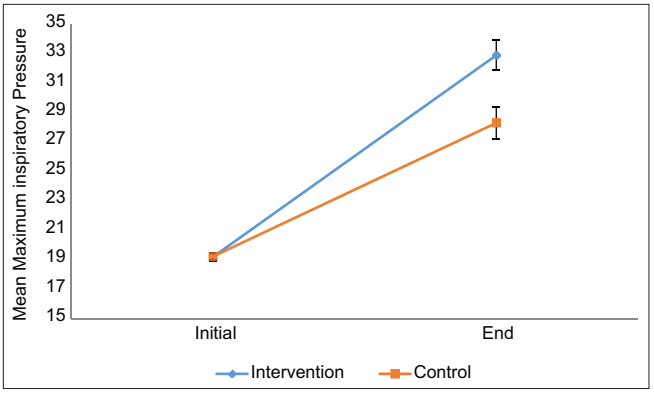

Figure 1: Maximum inspiratory Pressure in intervention and control groups at baseline and at after intervention

Table 1: Patient's characteristics in the intervention and control groups

	Intervention (*n*=40)		Control (*n*=39)		*P*
	Mean/median/n	SD/(P25-P75)/%	Mean/median/n	SD/(P25-P75)/%	
Age (year)*	64.6	15.3	67.4	13.8	0.390[T]
Sex (male)*	24	60	17	43.6	0.179[T]
BMI (kg/m^2)*	28.7	3.0	29.5	2.3	0.171[T]
APACHE II*	15.7	3.4	14.9	2.8	0.312[T]
SOFA*	7.5	1.5	7.5	1.5	0.972[T]
RASS*	−1.0	−1.0-0.0	−0.5	−1.0-0.0	0.570[MW]
Medical diagnosis					
COPD	13	32.5	15	38.5	0.863[F]
Pneumonia	13	32.5	12	30.8	
Pulmonary abscess	3	7.5	1	2.6	
Septicemia	10	25	9	23.1	
Others**	1	2.5	2	5.1	

*No significant differences between groups; **Including: asthma and ARDS; [T]Independent *t*-test; [MW]Mann-Whitney *U*-test; [F]Fisher's exact test. BMI=Body mass index; APACHE=Acute physiology and chronic health evaluation; SOFA=Sequential organ failure assessment; RASS=Richmond Agitation Sedation Scale; COPD=Chronic obstructive pulmonary disease; SD=Standard deviation

Table 2: Mean and standard deviation of mechanical ventilation and weaning duration in the intervention and control groups

Duration (day)	Mean±SD		*P*[#]
	Intervention (*n*=40)	Control (*n*=39)	
Duration of mechanical ventilation	21.9±5.9	24.4±4.7	0.040
Weaning duration	8.42±1.06	11.25±0.62	<0.001

[#]*P*-values were computed using independent t-tests. SD=Standard deviation

$P < 0.001$). Finally, significant increases were observed for pulmonary compliance in both intervention (16.23), and control (9.62) groups (both $P < 0.001$), though the increase was significantly greater in the intervention group (ANCOVA $P < 0.001$) [Table 3 and Figures 1-4].

The results of some of the main outcomes are presented in Table 4. The results showed that the weaning success was significantly higher in the intervention group than in the control group ($P < 0.05$), also, according to ARR = 0.21, utilizing intervention, increased the probability of weaning success with 21%. In addition, according to the RR = 1.54, the weaning success is 54% more probable in intervention group than control group. Although the results were not significant for other outcomes (all $P > 0.05$), continuation of invasive ventilation via a tracheostoma was 9% more probable in the intervention group compared to the control group. On the other hand, continue mechanical ventilation was around 43% less likely, reintubation within 24 h was around 16%, and the death probability was around 31%, less likely in the intervention group compared to the control group.

DISCUSSION

The present findings on the effect of threshold IMT on the duration of weaning in the ICU-admitted patients showed

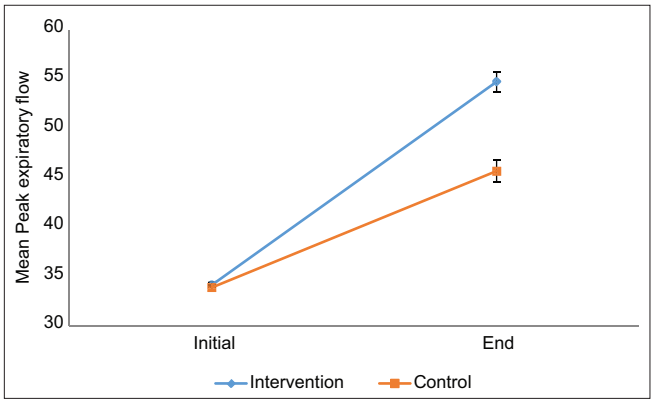

Figure 2: Peak expiratory flow in intervention and control groups at baseline and at after intervention

that patients who performed IMT by the threshold IMT trainer had improved time to weaning, RSBI, compliance, MIP, and PEF compared to the control group.

The primary outcome was the duration of weaning from mechanical ventilation. The duration of weaning was significantly shorter in the intervention group than that of the control group (8.4 ± 1.1 days, 11.2 ± 0.6 days, respectively). Dixit and Prakash also demonstrated that the threshold IMT trainer along with conventional physiotherapy produces more significant changes in MIP and weaning time in patients receiving MV compared to conventional physiotherapy alone.[14] According to a systematic review, IMT reduced time to weaning but did not affect the duration of MV.[9] Furthermore, a more recent systematic review revealed that IMT improves inspiratory muscle strength in ICU patients and is associated with reductions in the weaning duration and MV duration by IMT.[10] Furthermore, IMT may enhance weaning success in patients who have failed to wean from MV.[19] However, some studies have shown IMT did not significantly change the weaning duration, weaning success, or reintubation rate.[16,19-21]

Table 3: Mean and SD of maximum inspiratory pressure, peak expiratory flow, rapid shallow breathing index, and pulmonary compliance in the intervention and control groups

Variables	Intervention (n=40)		Control (n=39)		MD (95%CI), *P*#
	Mean	SD	Mean	SD	
Maximum inspiratory Pressure (cmH_2O)					
First day	19.23	1.64	19.26	1.53	-0.03 (-0.74 to 0.68), 0.930
Last day	32.93	6.50	28.33	6.97	4.64 (2.12 to 7.22), <0.001
Within-group MD (95%CI), *P* ##	13.70 (11.76-15.63), <0.001		9.08 (7.14-11.02), <0.001		
Peak expiratory Flow (L/min)					
First day	34.15	2.77	33.90	2.40	0.25 (-0.91 to 1.42), 0.667
Last day	54.75	8.83	45.69	19.72	8.70 (2.03 to 15.37), 0.011
Within-group MD (95%CI), *P* ##	20.60 (18.07-23.13), <0.001		11.79 (5.48-18.11), <0.001		
Rapid shallow breathing index (breaths/min/L)					
First day	101.60	3.12	101.54	3.66	0.06 (-1.46-1.58), 0.936
Last day	55.1	19.3	74.2	19.1	-19.18 (-27.25–11.12), <0.001
Within-group MD (95%CI), *P* ##	-46.45 (-52.30–40.60), <0.001		-27.33 (-33.23–21.44), <0.001		
Pulmonary compliance (ml/cm H_2O)					
First day	21.77	2.52	21.46	1.57	0.31 (-0.63 to 1.26), 0.510
Last day	38.00	8.02	31.08	7.63	6.18 (3.44 to 8.92), <0.001
Within-group MD (95%CI), *P* ##	16.23 (14.11-18.34), <0.001		9.62 (7.42-11.81), <0.001		

#*P* values were computed using Independent T for baseline measurements and analysis of covariance for after intervention measurements after adjusting for baseline values.
##Within-group comparisons using paired t-test. MD: Mean difference, CI: Confidence Interval

Table 4: Patient's primary outcome in the intervention and control groups

	Intervention (*n*=40), *n* (%)	Control (*n*=39), *n* (%)	ARR (95% CI)	RR (95% CI)	*P*#
Weaning success	22 (55)	13 (33.3)	0.21 (.003-0.44)	1.54 (1.01-2.38)	0.042
Weaning failure					
Continuation of invasive ventilation via a tracheostoma	6 (15)	5 (12.9)	0.05 (−0.27-0.36)	1.09 (0.61-1.97)	0.518
Continue mechanical ventilation	4 (10)	9 (23.1)	−0.24 (−0.52-0.04)	0.57 (0.24-1.31)	0.139
Reintubation within 24 h	4 (10)	5 (12.8)	−0.07 (−0.42-0.28)	0.86 (0.40-1.86)	0.737
Death	4 (10)	7 (17.9)	−0.17 (−0.47-0.14)	0.69 (0.31-1.55)	0.348

#*P*-value based on Fisher's exact test. ARR=Absolute risk reduction; RR=Relative risk, CI=Confidence interval

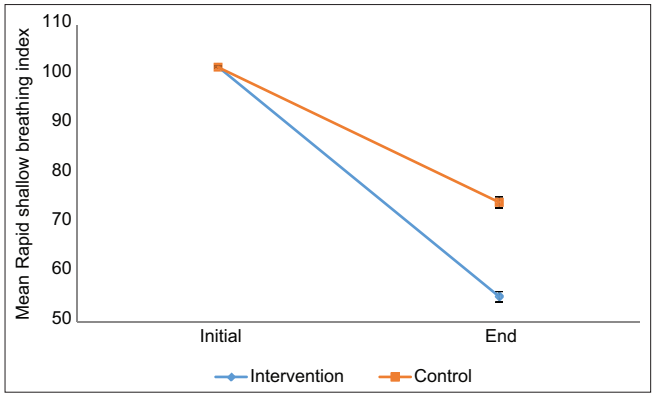

Figure 3: Rapid shallow breathing index in intervention and control groups at baseline and at after intervention

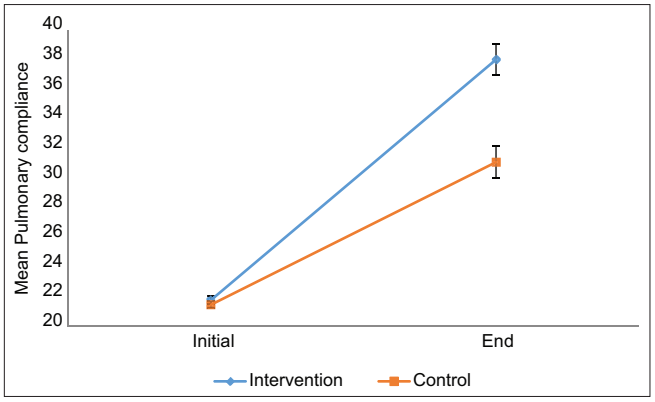

Figure 4: Pulmonary compliance in intervention and control groups at baseline and at after intervention

To reduce the duration of weaning, MIP should also be improved. MIP was evaluated for our patients before each session and the training load was fixed at 50% of its value, which equaled to a mean of approximately 9.6 cmH2O initially. Therefore, the initial load was higher in our study compared to other similar studies.[14,16,21] This may have contributed to the large improvement in MIP, which was roughly equal to the greatest improvement seen in any of the other studies. It should be noted that inspiratory muscles, which are skeletal muscles, respond to training based on the principles of overload, specificity, and reversibility. Therefore, training improves the function of these muscles and reduces fatigue.[22] The present findings further demonstrated that strengthening the inspiratory muscles

of patients under ventilator using threshold IMT trainer improves the inspiratory muscle strength and shortens the duration of MV.

RSBI is an important predictor of weaning success, and has been used as an adjunct to pulmonary compliance, in predicting successful weaning.[23] The results of the present study showed that the threshold IMT trainer improved pulmonary compliance in our intervention group (more than 75%). Similarly, RSBI score decreased in both the groups: from 101.60 to 55.1 breaths/min/Lin in the intervention group, and from 101.54 to 74.2 breaths/min/L in the control group. An increase in RSBI to more than 105 breaths/min/L due to increased respiratory rate or decreased tidal volume can lead to extubation failure.[24] The results of the present study also showed that performing inspiratory muscle strength training reduces RSBI, which could be due to the increase in the strength of the respiratory muscles and tidal volume, as consistent with the findings reported by Condessa on the duration of training and reduction in this index.[16] Our patients experienced an increase in inspiratory muscle strength within 10 days of the start of IMT with the threshold IMT trainer. Other studies have also demonstrated a rapid increase in strength within 2 weeks of starting IMT with the IMT trainer.[17-19] Systematic reviews reported improvements in inspiratory muscle strength due to IMT in ICU patients, which was associated with accelerated weaning from the ventilator. In addition, in patients failing to separate from MV, IMT can increase the success of the weaning process,[9,10] while its effects on the duration of weaning have remained controversial.[25] The use of IMT trainer in mechanically ventilated patients is likely to increase inspiratory muscle strength due to neurocompatibility rather than muscle hypertrophy and to create a more efficient exercise program.[26]

Another important parameter for predicting successful extubation is the improvement of PEF. Although the training did not impose a load on the expiratory muscles, a significant effect on maximum inspiratory pressure was observed in our study. Although this counterintuitive result was considered a chance finding by Condessa *et al*.,[16] it has been confirmed by a recent systematic review, as well.[10] Condessa *et al*. believed that intercostal muscles may contribute to both inspiratory and expiratory efforts; therefore, these muscles may contribute to improvements in maximum inspiratory pressure. Other researchers have found that using the cough PEF rate increases the likelihood of extubation success and reduces adverse effects and is recommended to be used for extubation decision-making.[27]

According to our results, we had a mix of patients with short and difficult weaning. For difficult patients, threshold IMT continued until successful weaning or failure. The rate of successful weaning was 55% (n = 22) and 33.3% (n = 13) in the intervention and control groups, respectively. Failure was categorized as tracheostomy (the most common category in the intervention group), continuing MV (the most common category in the control group), death, or reintubation. Failures may be associated with the primary reason for intubation, disease severity, cough efficacy, amount of secretions, state of ventilation, state of oxygenation, hemodynamic stability, mental status, or state of consciousness, as described in previous studies.[25,28,29]

One of the limitations of the present study was that the threshold IMT trainer was used only in the morning shift due to its interference with the conventional physiotherapy program. Another limitation was the impossibility of performing IMT in patients with severe respiratory muscle weakness.

CONCLUSION

The present study was conducted to evaluate the effect of threshold IMT on the duration of weaning in the ICU-admitted patients. The homogeneity of the two groups in terms of all the demographic and confounding variables and the random assignment of the participants to the two groups eliminated the effect of many confounding factors and variables on the research findings and yielded a relatively high control of the research limitations. Therefore, the difference observed in the duration of weaning, an increase in MIP, and a decrease in RSBI in the intervention group can be attributed to the threshold IMT.

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Conflicts of interest

There are no conflicts of interest.

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