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Introduction:

Immobility in Intensive Care Unit (ICU) patients can cause serious complications. Early mobilization has been suggested as an effective strategy to improve patient outcomes, but its implementation remains limited in many settings. This study aimed to evaluate the effects of an early mobilization program on the treatment outcome of ICU patients.

Methods:

This quasi-experimental study with a non-concurrent control group was conducted in a hospital affiliated with Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran, from July to November 2025. Fifty ICU patients were selected through convenience sampling and assigned to intervention and control groups. The intervention group received an early mobilization program initiated within 72 hours of ICU admission, while the control group received routine care. Data were collected using a structured checklist and analyzed using SPSS version 22 with a significance level of $p < 0.05$. This study was registered in the Iranian Registry of Clinical Trials (IRCT20120414009469N5).

Results:

Baseline characteristics, including age, sex, APACHE II, initial GCS, and diagnosis, were comparable between groups (all $p > 0.05$). The intervention significantly reduced the incidence of VAP (12% vs. 44%, $\chi^2 = 6.34$, $p = 0.012$) and delirium (4% vs. 36%, $\chi^2 = 8.10$, $p = 0.005$), although ICU mortality was not significantly different (24% vs. 44%, $\chi^2 = 2.22$, $p = 0.136$). Patients in the intervention group had shorter mechanical ventilation (8.64 ± 2.37 vs. 11.16 ± 4.54 days, $p = 0.018$) and ICU stay (9.44 ± 2.72 vs. 13.28 ± 4.96 days, $p = 0.001$). Repeated Measures ANOVA over seven days showed significant group $\times$ time interactions for Braden, GCS, IMS, and MRC scores (all $p < 0.001$). Within-group analyses indicated substantial improvements in the intervention group over this 7-day period (all $p < 0.001$), reflecting enhanced consciousness, muscle strength, and pressure ulcer prevention, while control group changes were minimal.

Conclusion:

The results showed that structured and safely delivered early mobilization in ICU patients can reduce the incidence of VAP and delirium, shorten the duration of mechanical ventilation and ICU stay, lower the risk of pressure injuries, and improve consciousness, functional capacity, and muscle strength. Although determining the optimal dosing and long-term effects requires larger multicenter studies, the findings strongly support integrating early mobilization into routine ICU care.

Key words: Early Mobilization, Intensive Care Units, Critical Care, Treatment outcomes, Muscle Strength, Mobility.

Introduction

Mobility is a key factor in maintaining the function of the body's physiological systems, including the gastrointestinal, circulatory, and nervous systems. Intensive Care Unit (ICU) patients often experience reduced physical activity due to decreased consciousness, severe underlying conditions, prolonged mechanical ventilation, sedative drug use, and medical device constraints (1). Immobility can result in complications such as prolonged ICU stay, impaired daily functioning, reduced post-discharge quality of life, hemodynamic and physiological disturbances, muscle atrophy (1–1.5% loss per day, up to 50% in two weeks), ICU–Acquired Weakness (ICU-AW) (2), negative physical and psychological effects, and higher healthcare costs (3). Over 50% of ICU patients develop ICU-AW, with immobility being a major contributing factor (4).

Mobilization of ICU patients is generally initiated with caution and only after their clinical condition has stabilized, typically beginning with passive movements (assisted by a nurse or physiotherapist) and in-bed exercises (5–6). However, recent findings indicate that early mobilization, defined as initiating physical activity within the first 72 hours of ICU admission, can provide significant benefits for ICU patients (7). In this regard, a study by Lai et al. (2017) demonstrated that early mobilization reduces the duration of mechanical ventilation (4.7 days vs. 7.5 days) and shortens the length of ICU stay (6.9 days vs. 9.9 days) (8). Similarly, a meta-analysis by Zang et al. (2020) confirmed the effectiveness of this intervention in decreasing muscle weakness (from 49% to 26%), reducing ICU length of stay (from 3.90 to 1.82 days), and improving functional mobility (9).

Based on the existing evidence, the concept of early mobilization of ICU patients has gained attention as an effective strategy for improving treatment outcomes (10). This concept was first introduced in the 2000s, when studies demonstrated that prolonged immobility in the ICU could lead to severe muscle weakness and rapid loss of muscle mass. Since then, patient mobilization programs have been gradually implemented in many healthcare centers worldwide (11).

Despite substantial evidence supporting the benefits of early mobilization, implementing such programs remains challenging. Key obstacles include clinical risks, such as accidental disconnection of respiratory equipment (12); the need for trained personnel (13) and specialized equipment (14); careful risk assessment prior to mobilization (e.g., hemodynamic instability and hypotension) (15); and cultural or organizational resistance (16). Successful implementation also

requires interdisciplinary collaboration among physicians, nurses, and physiotherapists to ensure patient safety and program effectiveness (17). Furthermore, important uncertainties remain regarding early mobilization in ICU patients, which have been insufficiently addressed in previous studies. These include the optimal timing and methods of initiation, its effectiveness across different patient conditions, broader treatment outcomes, and the design of a comprehensive and safe mobilization protocol involving all healthcare team members.

In developing countries such as Iran, the implementation of early mobilization programs for ICU patients remains largely unstructured and faces challenges including a shortage of qualified personnel, limited equipment, lack of standardized protocols, and organizational resistance (18). Prolonged ICU stays due to immobility and related complications can impose significant financial and human burdens on both patients and the healthcare system, especially given the limited availability of ICU beds. Therefore, identifying and applying effective strategies, such as implementing an early mobilization program adapted to existing resources and conditions, is essential. Accordingly, this study was conducted to evaluate the effects of an early mobilization program on the treatment outcome of ICU patients.

Methods:

Design and Setting

This quasi-experimental study with a non-concurrent control group evaluated the effects of an early mobilization program on patients admitted to the Mega ICU of Imam Khomeini Hospital, affiliated with Ahvaz Jundishapur University of Medical Sciences, Iran, from July to November 2025. Randomization was not feasible due to the ICU setting, the nature of the intervention, and shared nursing staff; therefore, a quasi-experimental design was used. Patient blinding was not possible because many participants were mechanically ventilated and sedated; however, outcome assessors and data analysts were blinded to group allocation to minimize bias.

The study was conducted in a 23-bed general ICU staffed by 36 nurses, with an average nurse-to-bed ratio of 1:4. An intensivist was present during morning shifts to conduct daily patient rounds. Most patients were classified as Level 5, requiring mechanical ventilation and advanced life support. The study followed the CONSORT (Consolidated Standards of Reporting Trials)

guidelines, and neither patients nor the public were involved in its design, conduct, or dissemination. No major protocol modifications were made after study initiation.

Population

The sample size for this study was determined based on Lotfian et al. (19) and calculated using MedCalc software with a power of 90% and a 5% significance level, resulting in 40 participants (20 per group). Considering the possibility of attrition, the sample size was increased by 25%, resulting in a final total of 50 participants (25 in the intervention group and 25 in the control group).

The sample size calculation formula was as follows:

$$n = \frac{\left(z_{1-\alpha/2} + z_{1-\beta}\right)^2 * (SD_1^2 + SD_2^2)}{(\mu_1 - \mu_2)^2}$$

$$z_{1-\alpha/2} = 1.96 \quad z_{1-\beta} = 1.64 \quad SD_1 = 11.61 \quad SD_2 = 10.86 \quad \mu_1 = 65.52 \quad \mu_2 = 53.55$$

In this study, participants were selected based on eligibility criteria using a convenience sampling method. Data collection for the control group was completed first, followed by the implementation of the intervention and data collection for the intervention group. Inclusion criteria were: age 18–65 years, mechanical ventilation at the start of the study, ICU stay of at least 7 days after the initiation of the intervention, absence of physical disabilities or limb fractures, no history of neuromuscular disorders, Glasgow Coma Scale (GCS) score between 8 and 15, Acute Physiology and Chronic Health Evaluation II (APACHE II) score between 30 and 40, and written informed consent from the patient's legal guardian. Exclusion criteria included hemodynamic instability, administration of neuromuscular blocking agents, or physician orders requiring patient immobilization for any reason.

Intervention:

In this study, the early mobilization protocol for patients in the intervention group was initiated within 72 hours of ICU admission with the approval of the attending physician and continued until discharge from the unit. Patients in the control group received routine ICU care regarding mobilization and physiotherapy. Routine care included repositioning patients once per shift, chest

vibration using a vibratory device, and passive joint movements to maintain range of motion (ROM), which were performed daily by a physiotherapist, typically once per patient.

The early mobilization protocol for ICU patients was developed by the research team based on a review of relevant literature (1, 20–24). To incorporate expert input, the draft protocol was reviewed by five physiotherapists with ICU experience, two occupational therapists, and three critical care subspecialists. After consolidating and integrating their feedback, the final early mobilization program was established. Notably, the researcher and the physiotherapy expert involved in implementing the protocol received training on early mobilization under the supervision of physiotherapy and occupational therapy specialists.

The early mobilization program consisted of three types of exercises:

Resistance exercises: These were performed for the upper limbs three times per week and for the lower limbs twice per week. Movements included elbow flexion, arm pressing, external shoulder rotation, dorsiflexion, and leg raising. Exercises were conducted by a physiotherapist using approximately 450 g weights or manual resistance. Each exercise was performed in 2–5 sets of 8–12 repetitions per set, with a 2-minute rest between sets.

Endurance exercises: These were performed once daily using an active or passive pedal cycle. Patients were positioned supine with a pillow under the head to optimize movement. For inactive patients, the exercise duration was 20 minutes at a cadence of 20 cycles per minute, which could be gradually increased to 30–60 minutes depending on patient tolerance.

Mobilization exercises: These were also performed once daily and included passive joint rotation for all joints (1–2 sets of 3–10 repetitions per set), positioning, sitting on the bed, sitting at the edge of the bed, transferring to a chair, and assisted ambulation. The type of exercise was selected according to the patient's clinical status and functional capacity.

In this study, the type and intensity of early mobilization exercises were determined and administered daily by the researcher and physiotherapist based on assessments of muscle strength using the Medical Research Council (MRC) scale and functional capacity using the ICU Mobility Scale (IMS). Accordingly, patients were classified into six levels, ranging from Level 0 to Level 5. Details are listed in Table 1. At all levels, the mobilization program was tailored to each patient's clinical condition, tolerance, and cooperation, and was carried out under the continuous

supervision of a physiotherapist and the ICU care team to ensure patient safety throughout the exercises.

Table 1. Classification of early mobilization levels based on MRC and IMS scores.

Level	MRC / IMS Criteria	Patient Condition	Mobilization Program / Interventions
Level 0	MRC = 0; IMS = 0	No active participation	- Repositioning every 2 hours - Passive joint range-of-motion - Light passive resistance exercises - Minimal-duration passive cycling
Level 1	MRC < 36; IMS = 1	Muscle contractions without independent mobility	- Repositioning every 2 hours - Active/passive joint rotations - Active/passive resistance exercises - Active/passive cycling
Level 2	MRC = 2; IMS = 2	Able to move horizontally but unable to overcome gravity	- Repositioning every 2 hours - Passive transfer to chair - Active/passive joint exercises - Endurance and resistance training
Level 3	MRC $\geq$ 36; IMS = 3–4	Able to sit at bed edge, stand with assistance	- Repositioning every 2 hours - Joint exercises - Transfers to chair - Active/passive cycling - Progressive resistance training
Level 4	MRC $\geq$ 48; IMS = 5–7	Transfers and walks with assistance	-Active mobilization - Active cycling, -Active resistance exercises with increasing intensity
Level 5	MRC $\geq$ 48; IMS = 8–10	Walks $\geq$ 5 meters (with/without aid)	-Active mobilization and resistance training - Active cycling - Independent repositioning

Data collection method and tools

Data were collected using a two-part structured form. The first part recorded demographic and baseline clinical data (age, sex, diagnosis, APACHE II score) obtained from interviews, medical records, and patient assessment. The second part included treatment outcomes such as length of ICU stay, duration of mechanical ventilation, ICU mortality, GCS, muscle strength, mobility, and the incidence of Ventilator-Associated Pneumonia (VAP), delirium, and pressure ulcers.

Data were collected by trained research assistants who were blinded to group allocation. During the study, the principal investigator or a trained assistant supervised each shift, while an independent assistant collected outcome data. All data collectors were experienced ICU nurses (≥ 2 years of experience) who received standardized training to ensure accuracy and consistency.

Regular coordination meetings were also held to maintain protocol adherence throughout the study.

The primary outcomes of this study were muscle strength and functional capacity, with the mean differences between the two groups analyzed. Secondary outcomes included ICU length of stay (days from admission to ICU discharge), duration of mechanical ventilation (days from intubation to successful weaning), ICU mortality, GCS score, muscle strength, mobility capacity, incidence of VAP and delirium, and risk of developing pressure ulcers.

The severity of illness upon ICU admission was assessed using the APACHE II score, developed by Knaus in 1985, which includes 12 physiological variables evaluating major organ systems. According to standard reference tables, mortality rates for scores of 0–15, 16–19, 20–30, and >30 are approximately 10%, 15%, 35%, and 75%, respectively (25). In the study by Rahmatnejad et al., the area under the curve (AUC) for APACHE II was 0.775, confirming its high predictive accuracy for ICU mortality (26). Patient consciousness was evaluated using the GCS before and after each intervention. The reliability of this tool in Iran was verified by Adineh et al., with a test–retest correlation coefficient of 0.86 (27). Delirium was assessed daily using the Confusion Assessment Method for the ICU (CAM-ICU). Arabi et al. (2019) reported that this tool demonstrated 75% sensitivity, 96% specificity, and a kappa coefficient of 0.74 (28). VAP was monitored daily using the Clinical Pulmonary Infection Score (CPIS), which considers temperature, white blood cell count, tracheal secretions, oxygenation ($\text{PaO}_2/\text{FiO}_2$), chest X-ray findings, and culture results. Scores range from 0–12, with values above 6 indicating high VAP probability (29). Becerra-Hervás et al. (2024) reported a sensitivity of 80% and specificity of 73% for CPIS in diagnosing VAP (30). The Braden Scale was used daily to evaluate the risk of pressure ulcers, encompassing six domains (sensory perception, moisture, activity, mobility, nutrition, and friction/shear), with total scores ranging from 6 to 23; scores below 18 indicate high risk (31). Wei et al. reported moderate predictive validity for this scale, with 89% sensitivity and 28% specificity (32). Muscle strength was measured daily using the MRC scale before and after each intervention. The MRC evaluates six muscle groups in the upper and lower limbs, each scored from 0 (no contraction) to 5 (normal strength), yielding a total of 0–60; scores below 48 indicate ICU-AW (33). Hirakawa et al. (2022) reported a sensitivity of 0.99 and specificity of 0.66 for this scale (34). Finally, mobility capacity was assessed using the IMS, which rates mobility from 0 (no activity)

to 10 (independent walking for ≥ 5 m) (35). Tipping et al. confirmed the IMS as a valid and reliable tool for evaluating mobility among critically ill patients (36).

In this study, harms were defined as any adverse events associated with the implementation of the early mobilization protocol (e.g., disconnection of medical devices or hemodynamic instability). These events were systematically monitored through daily clinical assessments by the ICU team and documented in the study records. No predefined severity thresholds were established; however, all events were reported descriptively.

Statistical analysis:

Statistical analyses were performed using descriptive and inferential methods with SPSS software (version 22, SPSS Inc., Chicago, IL, USA). Continuous variables were presented as mean $\pm$ standard deviation and range, while categorical variables were reported as frequencies and percentages. The normality of continuous variables was assessed and confirmed using the Shapiro–Wilk test. For data analysis, independent t-tests were used to compare continuous variables between groups, chi-square tests were applied for categorical variables, and Repeated Measures ANOVA was employed to examine changes in variables over time. A p-value < 0.05 was considered statistically significant. No missing data were encountered for the primary outcomes; all randomized participants were included in the analysis (intention-to-treat principle).

Results:

A total of 66 patients were included in this study, and their data was subjected to statistical analysis (Figure 1). Based on the results presented in Table 2, there was no statistically significant difference between the intervention and control groups in terms of baseline and demographic characteristics. The mean age was 50.56 ± 11.80 years in the control group and 50.56 ± 11.06 years in the intervention group, and the independent t-test showed no significant difference between the two groups ($t = 0.114$, $df = 48$, $p = 0.986$). Similarly, the mean APACHE II score was comparable between the groups (35.16 ± 2.85 vs. 34.96 ± 2.77), and the small observed difference was not statistically significant ($t = 0.251$, $df = 48$, $p = 0.803$). The mean initial GCS score was 9.84 ± 1.70 in the control group and 10.40 ± 1.63 in the intervention group, with no significant difference between the groups ($t = -1.18$, $df = 48$, $p = 0.241$). Regarding sex distribution, 34% of participants in the control group and 30% in the intervention group were male, and chi-square analysis revealed no statistically significant difference in gender distribution ($\chi^2 = 0.347$, $df = 1$, $p = 0.556$).

Likewise, no significant difference was found between the groups in terms of the initial diagnosis category (traumatic vs. medical conditions) ($\chi^2 = 0.321$, $df = 1$, $p = 0.571$).

In Table 3, the incidence of VAP, delirium, and ICU mortality was compared between the two groups using the chi-square test. Accordingly, 11 patients (44%) in the control group developed VAP, whereas only 3 patients (12%) in the intervention group experienced this outcome, and this difference was statistically significant ($\chi^2 = 6.34$, $df = 1$, $p = 0.012$). Similarly, delirium occurred in 9 patients (36%) in the control group and in only 1 patient (4%) in the intervention group, indicating another statistically significant difference between the groups ($\chi^2 = 8.1$, $df = 1$, $p = 0.005$). However, although 11 patients (44%) in the control group and 6 patients (24%) in the intervention group died during their ICU stay, this difference was not statistically significant ($\chi^2 = 2.22$, $df = 1$, $p = 0.136$).

In Table 4, two groups were compared in terms of the mean duration of ICU stay and the duration of mechanical ventilation using the independent t-test. Accordingly, the mean duration of mechanical ventilation was 11.16 ± 4.54 days in the control group and 8.64 ± 2.37 days in the intervention group, and this difference was statistically significant ($t = 2.457$, $df = 48$, $p = 0.018$). Likewise, the mean length of ICU stay was 13.28 ± 4.96 days in the control group and 9.44 ± 2.72 days in the intervention group, and this difference between the groups was also statistically significant ($t = 3.391$, $df = 48$, $p = 0.001$).

In Table 5, two groups were compared in terms of the trend of changes in the mean scores of the Braden, GCS, IMS, and MRC scales over seven days from the start of the intervention (seven measurement points), using Repeated Measures ANOVA. According to the results presented in this table, the interaction effect between group and time for the mean Braden score was statistically significant ($p < 0.001$). Therefore, within-group changes were examined separately for each study group. The findings showed that the within-group changes were significant in both the control group ($p < 0.001$) and the intervention group ($p < 0.001$). However, considering the larger effect size in the intervention group (effect size = 0.722) compared with the control group (effect size = 0.229), it can be concluded that the magnitude of change was greater in the intervention group. Furthermore, as illustrated in Figure 2, the trend in the intervention group from Day 1 to Day 7 is almost entirely upward, indicating an improvement in Braden scores (i.e., reduced risk of pressure

ulcer). In contrast, the trend in the control group is downward, reflecting a decline in Braden scores (i.e., increased risk of pressure ulcer).

The results of the Repeated Measures ANOVA also showed that, for the mean difference in GCS scores before and after the intervention over the seven-day period, the interaction effect between group and time was statistically significant ($p < 0.001$). Therefore, within-group changes were examined separately for each study group. According to the findings, within-group changes in the control group were not statistically significant ($p = 0.531$), whereas these changes were significant in the intervention group ($p < 0.001$) (Table 5). As illustrated in Figure 3, the trend in the intervention group from Day 1 to Day 7 is generally upward, indicating an increase in GCS scores, while the changes in the control group are minimal and follow an almost stable pattern.

Regarding the difference in mean IMS scores before and after the intervention over seven days, the interaction effect between the experimental group and time was statistically significant ($p < 0.001$). Therefore, within-group changes were examined separately for each experimental group. According to the results, within-group changes were not significant in the control group ($p = 0.323$), whereas these changes were significant in the intervention group ($p < 0.001$) (Table 5). As shown in Figure 4, changes in the intervention group from day 1 to day 7 followed an approximately upward trend, reflecting an increase in IMS scores. In contrast, changes in the control group were minimal and exhibited a relatively stable trend.

Furthermore, according to the results of the Repeated Measures ANOVA, the interaction effect between the experimental group and time on the mean MRC scores before and after the intervention over seven days was statistically significant ($p < 0.001$). Therefore, within-group changes were examined separately for each experimental group. The results indicated that within-group changes were not significant in the control group ($p = 0.684$), whereas these changes were significant in the intervention group ($p < 0.001$) (Table 5). As shown in Figure 5, changes in the intervention group from day 1 to day 7 followed an approximately upward trend, indicating an increase in MRC scores. In contrast, changes in the control group were minimal and exhibited a relatively stable trend.

Discussion

In the present study, there were no significant differences between the two groups in terms of age, sex, baseline APACHE II and GCS scores, or the type of admission diagnosis. This baseline homogeneity allows for a more accurate interpretation of the intervention's effects, as the observed outcomes can be attributed with greater confidence to the early mobilization program. These findings are consistent with Menges et al. (2021), who emphasized in their meta-analysis that studies with comparable baseline characteristics provide stronger and more reliable results (6).

In the present study, the incidence of VAP in the intervention group was significantly lower than in the control group. Similarly, Zang et al. (2019) reported that early mobilization reduces ICU-related complications, including ventilator-associated pneumonia (9). Wang et al. (2020) also noted in their meta-analysis that early mobilization decreases ICU complications, including VAP (37). Studies focusing on surgical or mechanically ventilated patients have further elucidated mechanisms supporting VAP reduction; for example, Lotfian et al. (2019) reported that an early mobilization protocol after cardiac surgery preserved diaphragmatic strength, which can reduce ventilation duration and consequently lower the risk of respiratory infections (19). Conversely, Zhang et al. (2024) found no significant difference in VAP incidence, although long-term improvements in respiratory function were observed (38). These discrepancies suggest that the intensity, type, and duration of interventions may influence their effect on VAP. Sepúlveda et al. (2025), in a comprehensive review titled *Protocolized Strategies to Encourage Early Mobilization of Critical Care Patients*, also emphasized that structured implementation, team training, and safety screening can enhance the benefits of early mobilization on complications such as VAP (39). Overall, the present findings, specifically the significant reduction in VAP—are consistent with existing evidence, particularly when early mobilization programs are structured, supervised by physiotherapists, and implemented collaboratively with nurses and other ICU staff while adhering to safety precautions.

In the present study, the incidence of delirium was markedly lower in the intervention group. This significant reduction is not only statistically relevant but also clinically important, as delirium is associated with numerous complications, including increased mortality and prolonged ICU stay. This finding aligns with previous evidence; for instance, Shirvani et al. (2020) reported a significant decrease in delirium with an early mobilization program in patients after CABG (40).

Matsuoka et al. (2023), in their meta-analysis, showed that initiating rehabilitation within the first 72 hours of ICU admission can improve short-term cognitive function, correlating with reduced cognitive-behavioral disturbances (41). Similarly, Patel et al. (2023) found lower rates of cognitive impairment one year post-discharge among ICU patients who received early mobilization (3). Zhang et al. (2024) also reported a reduction in delirium in their clinical trial (38), whereas Wang et al. (2020) found no significant effect of early mobilization on delirium incidence (37). These discrepancies may stem from differences in mobilization protocols, patient severity and condition, or the tools used for delirium screening. Overall, plausible mechanisms for the anti-delirium effects of early mobilization include sensory and motor stimulation stabilizing the sleep–wake cycle, reduction of systemic inflammation, intermittent cerebral blood flow enhancement, and cognitive engagement during activities. The present study’s findings of a significant reduction in delirium strongly support these mechanisms (40–41).

The present study showed a reduction in ICU mortality; however, this difference was not statistically significant. Therefore, it cannot be conclusively stated that early mobilization alone reduces mortality, although the trend is clinically encouraging. Evidence in this area remains mixed. Coles et al. (2020), in a before-and-after study on trauma patients, reported reduced ICU and hospital mortality following the implementation of an early mobilization protocol, with results remaining significant after adjusting for confounding variables (42). Similarly, Zhang et al. (2024) observed decreased mortality in mechanically ventilated patients receiving early mobilization (38). In contrast, larger meta-analyses generally did not find a significant effect of early mobilization on ICU mortality (9, 37). These discrepancies may be attributed to factors such as patient population (trauma versus general ICU), sample size and statistical power, differences in intervention intensity and structure, timing of initiation, concomitant care, and overall quality of ICU management. For example, the study by Coles et al. was conducted in a trauma population, which differs in characteristics from the present study and other reviews (42). Hence, larger multicenter RCTs or subgroup meta-analyses are needed to draw definitive conclusions, as also emphasized by previous studies (37, 43).

In the present study, the mean duration of mechanical ventilation was lower in the intervention group. Similarly, Cordeiro et al. (2022) reported that early mobilization reduced the duration of mechanical ventilation in patients following cardiac surgery (44). Lotfian et al. also demonstrated that post-cardiac surgery mobilization helps preserve diaphragmatic strength and mitigates

respiratory muscle weakness, which can shorten mechanical ventilation time (19). Meta-analyses, including those by Wang et al. and Singam (2024), have likewise reported reductions in ventilation duration (37, 43). However, studies by Zang et al. (2019) (9) and Coles et al. (2020) (42) found that early mobilization did not significantly affect ventilator-free days. These discrepancies may relate to differences in protocols (e.g., exercise intensity), weaning criteria, and patient populations. Overall, based on the present study and most existing evidence, early mobilization can reduce mechanical ventilation duration by preventing rapid diaphragmatic and respiratory muscle atrophy, enhancing effective ventilation, secretion clearance, and oxygenation (44). Additionally, it may accelerate weaning by reducing sedation requirements, systemic inflammation, atelectasis, and complications such as delirium and VAP (37, 43). Collectively, these effects allow patients to regain spontaneous breathing earlier and shorten ventilator dependence.

In the present study, the average ICU length of stay was significantly shorter in the intervention group compared to the control group. This finding is clinically important, as reducing ICU stay can alleviate financial burden, lessen resource strain, and prevent additional serious complications for patients. In line with this, Zang et al. (2019) reported reduced ICU and hospital stays with early mobilization programs (9), and Wang et al. (2020) also observed a decrease in length of stay (37). Cordeiro et al. reported similar reductions in ICU and hospital stays among CABG patients (44), while Singam (2024) noted a shorter ICU stay with early mobilization (43). Moreover, Lee et al. (2025) demonstrated that mobilization programs involving nurses can further reduce ICU stay, highlighting the critical role of nursing staff in implementing these interventions (45). Conversely, Zhang (2024) and Coles et al. (2020) found no significant differences in ICU length of stay despite functional improvements (38, 42), suggesting that the impact on length of stay may also be influenced by other factors.

In the present study, the Braden score over seven days in the intervention group, unlike the control group, indicated a reduced risk of pressure ulcers. This suggests that regular mobilization and controlled repositioning can significantly decrease the risk of pressure injuries. Similarly, systematic reviews and meta-analyses have highlighted that prolonged immobility is associated with increased pressure ulcer risk (9, 37). Sepúlveda et al. (2025) specifically emphasized that implementing structured protocols, including positioning, functional mobilization, and documentation—is key to reducing ICU-acquired weakness and associated complications such as

pressure ulcers (39), aligning with the Braden score improvements observed in the present study. Therefore, the significant improvement in Braden scores is consistent with the notion that patient repositioning and activity enhance local tissue perfusion and reduce pressure-related trauma, underscoring the importance of team training and precise execution of skin care and repositioning protocols.

The present study demonstrated that the GCS score in the intervention group significantly increased over seven days, while no notable changes were observed in the control group. Previous studies have not always reported GCS directly, but evidence indicates improvements in cognitive function, delirium, and other cognitive-related outcomes, which align with GCS enhancement. For instance, Shirvani et al. (2020) reported reduced delirium associated with increased consciousness (40). Matsuoka et al. (2023) observed improved cognitive performance following rehabilitation initiated within the first 72 hours of ICU admission (37). Similarly, Zhang et al. (2024) reported both reduced delirium and functional improvements (38), consistent with the GCS increases observed in the present study. The likely mechanisms for improved consciousness include enhanced sensory stimulation, reduced sedation- or immobility-related somnolence, and support of natural sleep-wake cycle restoration, as suggested in previous reviews and clinical studies (40–41).

In the present study, the IMS score in the intervention group significantly increased over seven days, whereas the control group showed no notable changes. This rapid improvement in functional capacity reflects the positive impact of a daily mobility program, including resistance, endurance, and movement exercises, on functional rehabilitation. In line with this, Zang et al. (2024) reported improvements in the Barthel Index at discharge (9), and Zhang et al. observed sustained enhancements in functional capacity and mobility (Perme score) as well as IMS up to three months post-discharge (38). Cordeiro et al. (2022) also demonstrated that early mobilization after CABG significantly improved patients' clinical and functional outcomes (44). Furthermore, Menges et al. (2021) found that structured early mobilization, compared with delayed mobilization, enhanced physical performance scores and accelerated the achievement of independence (6). Singam (2024) similarly reported improvements in physical function (43). Overall, the findings of the present study regarding functional capacity are consistent with previous evidence, indicating that a combined program of resistance, endurance, and daily mobility exercises can expedite functional rehabilitation.

In the present study, MRC scores significantly increased over seven days in the intervention group, unlike the control group. Similarly, Zang et al. (2019) reported a reduction in ICU-AW and improvement in MRC scores (9), and Wang et al. (2020) also observed MRC improvements in their study (37). Zhang et al. (2024) reported increased muscle strength and reduced ICU-AW with high-intensity early mobilization (38). Lotfian et al. (2019) demonstrated that early mobilization after cardiac surgery helps preserve diaphragmatic strength, contributing partially to respiratory muscle rehabilitation (19). However, Lee et al. (2025) found no significant changes in muscle strength in certain nurse-led mobilization programs (45), likely due to differences in intensity, frequency, and team expertise. Singam (2024) highlighted practical challenges in implementation and the need for trained personnel to achieve effective muscular outcomes (43). Furthermore, Menges et al. (2021) showed that while early mobilization improved physical performance scores and accelerated independence, it did not significantly affect muscle strength or ICU-AW (6). Similarly, Matsuoka et al. (2023) reported only minor improvements in muscle strength (41). Therefore, successful improvement in MRC scores likely depends on the “dose” of the intervention, involvement of physiotherapists, and the design of resistance exercises—elements reflected in the present study’s protocol, which included supervised daily/weekly resistance training.

Study Limitations

This study has several limitations that should be considered when interpreting the results. First, the quasi-experimental design with a non-concurrent control group limits the ability to infer causality and increases the risk of selection bias. Second, the relatively small sample size and single-center setting restrict the generalizability of the findings to other ICU populations and healthcare systems. Third, due to the nature of the intervention and ICU conditions, patient blinding was not feasible, which may have influenced certain subjective outcomes, although outcome assessors were blinded. Finally, variations in intervention adherence, patient tolerance, and staff experience could have affected the results. Therefore, future studies with multicenter designs, larger sample sizes, and longer follow-up periods are recommended to determine the optimal and sustained effects of early mobilization.

Conclusion

The results of the present study demonstrated that implementing a structured, safe, and supervised early mobilization program in ICU patients can positively influence multiple clinical outcomes. Significant reductions in VAP and delirium incidence, shorter durations of mechanical ventilation and ICU stay, decreased risk of pressure injuries, and improvements in consciousness level, functional capacity, and muscle strength all indicate that early mobilization is not merely a rehabilitation intervention but a fundamental component of preventive and therapeutic ICU care. These findings suggest that early mobilization, through mechanisms such as enhanced ventilation and oxygenation, mitigation of immobility-related complications, stabilization of cognitive function, strengthening of skeletal and respiratory muscles, and reduction of systemic inflammation, can prevent complication progression and accelerate recovery. Therefore, this intervention has considerable potential to improve care quality and facilitate patient discharge. While further multicenter studies with larger sample sizes are needed to determine the optimal “dose” and long-term effects, the findings of this study emphasize the importance of integrating early mobilization as a routine, structured component of ICU care, implemented collaboratively by multidisciplinary teams.

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AUTHOR CONTRIBUTIONS

Study conception and design: "M A, A Ch, M R"- Data collection: "M A, A Ch, M Ra, M R" - Data analysis and interpretation: "MA, S G"- Drafting of the manuscript: "All authors"- Critical revision of the manuscript: "M A, A Ch, S G"

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Declarations:

Data Availability statement: The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request. Due to patient confidentiality and restrictions from the institutional ethics committee, the raw data are not publicly available but can be provided in a fully de-identified format.

Protocol Access: The full trial protocol is available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Ahvaz Jundishapur University of Medical Sciences (Ethics code: IR.AJUMS.REC.1404.190). All procedures were conducted in accordance with the Declaration of Helsinki (1995, revised 2001). Written informed consent was obtained from the patients' legal guardians prior to participation, and all participation was voluntary. Confidentiality and anonymity were strictly maintained by assigning unique identification numbers, which were stored separately from any personally identifying information.

Trial Registration

This study was registered in the Iranian Registry of Clinical Trials (<https://irct.behdasht.gov.ir>) on 20-08-2025 (Clinical Trial Registration ID: IRCT20120414009469N5).

Consent for publication: Not applicable.

Competing interests: All authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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Table2. Baseline Demographic and Clinical Characteristics of Participants

Variable	Group		Mean±SD/ N (%)	Total	t/x ²	DF	p-value
age	Control		50.56±11.80	50.56±11.32	0.114	48	0.986
	Intervention		50.56±11.06				
APACHE II	Control		35.16±2.85	35.06±2.78	0.251	48	0.803
	Intervention		34.96±2.77				
Initial GCS	Control		9.84±1.70	10.12±1.67	-1.18	48	0.241
	Intervention		10.401±1.63				
Gender	control	Male	17 (34)	25 (50)	0.347	1	0.556
		Female	8 (16)				
	intervention	Male	15 (30)	25 (50)			
		Female	10 (20)				
Initial Diagnosis	control	Traumatic	12 (24)	25 (50)	0.321	1	0.571
		Medical conditions	13 (26)				
	intervention	Traumatic	14 (28)	25 (50)			
		Medical conditions	11 (22)				

Table 3. Comparison of the Incidence of VAP, Delirium, and ICU Mortality between the Interventions and Control Groups

Group		VAP		X ²	df	p-value
		Yes	No			
Control	N	11	14	6.34	1	0.012
	% within Group	44.0%	56.0%			
	% within VAP	78.6%	38.9%			
	% of Total	22.0%	28.0%			
Intervention	N	3	22			
	% within Group	12.0%	88.0%			
	% within VAP	21.4%	61.1%			
	% of Total	6.0%	44.0%			
Group		Delirium				
		Yes	No			
Control	N	9	16	8	1	0.005
	% within Group	36.0%	64.0%			
	% within VAP	90.0%	40.0%			
	% of Total	18.0%	32.0%			
Intervention	N	1	24			
	% within Group	4.0%	96.0%			
	% within VAP	10.0%	60.0%			
	% of Total	2.0%	48.0%			
Group		ICU Mortality				
		Yes	No			
Control	N	11	14	2.22	1	0.136
	% within Group	44.0%	56.0%			
	% within VAP	64.7%	42.4%			
	% of Total	22.0%	28.0%			
Intervention	N	6	19			
	% within Group	24.0%	76.0%			
	% within VAP	35.3%	57.6%			
	% of Total	12.0%	38.0%			

Table4.Comparison of Mechanical Ventilation Duration and ICU Length of Stay between the Intervention and Control Groups

Variable	Group	Mean±SD	t	df	p-value
Duration of Mechanical ventilation	control	11.16±4.54	2.457	48	.018
	intervention	8.64±2.37			
Length of ICU stay	control	13.28±4.96	3.391	48	.001
	intervention	9.44±2.72			

Table 5. Repeated Measures ANOVA Results for Braden, GCS, IMS, and MRC Score Changes Over Seven Days

			Sum of Squares	df	Mean Square	F	Sig.	Effect size
Braden	Overall	Within-subject effect	80.389	6	13.398	17.731	< 0.001	.270
		Interaction (time*group)	266.274	6	44.379	58.731	< 0.001	.550
		error	217.623	288	.756			
		Between subject effect	401.786	1	401.786	7.846	0.007	.141
	Control	Within-subject effect	28.309	6	4.718	7.143	< 0.001	.229
		error	95.120	144	.661			
	Intervention	Within-subject effect	318.354	6	53.059	62.370	< 0.001	.722
		error	122.503	144	.851			
GCS	Overall	Within-subject effect	15.200	6	2.533	9.449	< 0.001	.164
		Interaction (time*group)	17.589	6	2.931	10.934	< 0.001	.186
		error	77.211	288	.268			
		Between subject effect	99.911	1	99.911	53.531	< 0.001	.527

	Control	Within-subject effect	.834	6	.139	.854	.531	.034
		error	23.451	144	.163			
	Intervention	Within-subject effect	31.954	6	5.326	14.265	< 0.001	.373
		error	53.760	144	.373			
IMS	Overall	Within-subject effect	14.469	6	2.411	7.807	< 0.001	.140
		Interaction (time*group)	15.429	6	2.571	8.325	< 0.001	.148
		error	88.960	288	.309			
		Between subject effect	115.431	1	115.431	189.750	< 0.001	.798
	Control	Within-subject effect	.720	6	.120	1.175	.323	.047
		error	14.709	144	.102			
	Intervention	Within-subject effect	29.177	6	4.863	9.431	< 0.001	.282
		error	74.251	144	.516			
MRC	Overall	Within-subject effect	9.749	6	1.625	2.401	.028	.048
		Interaction (time*group)	18.789	6	3.131	4.627	< 0.001	.088
		error	194.891	288	.677			
		Between subject effect	340.071	1	340.071	83.288	< 0.001	.634
	Control	Within-subject effect	1.737	6	.290	.658	.684	.027
		error	63.406	144	.440			
	Intervention	Within-subject effect	26.800	6	4.467	4.892	< 0.001	.169
		error	131.486	144	.913			

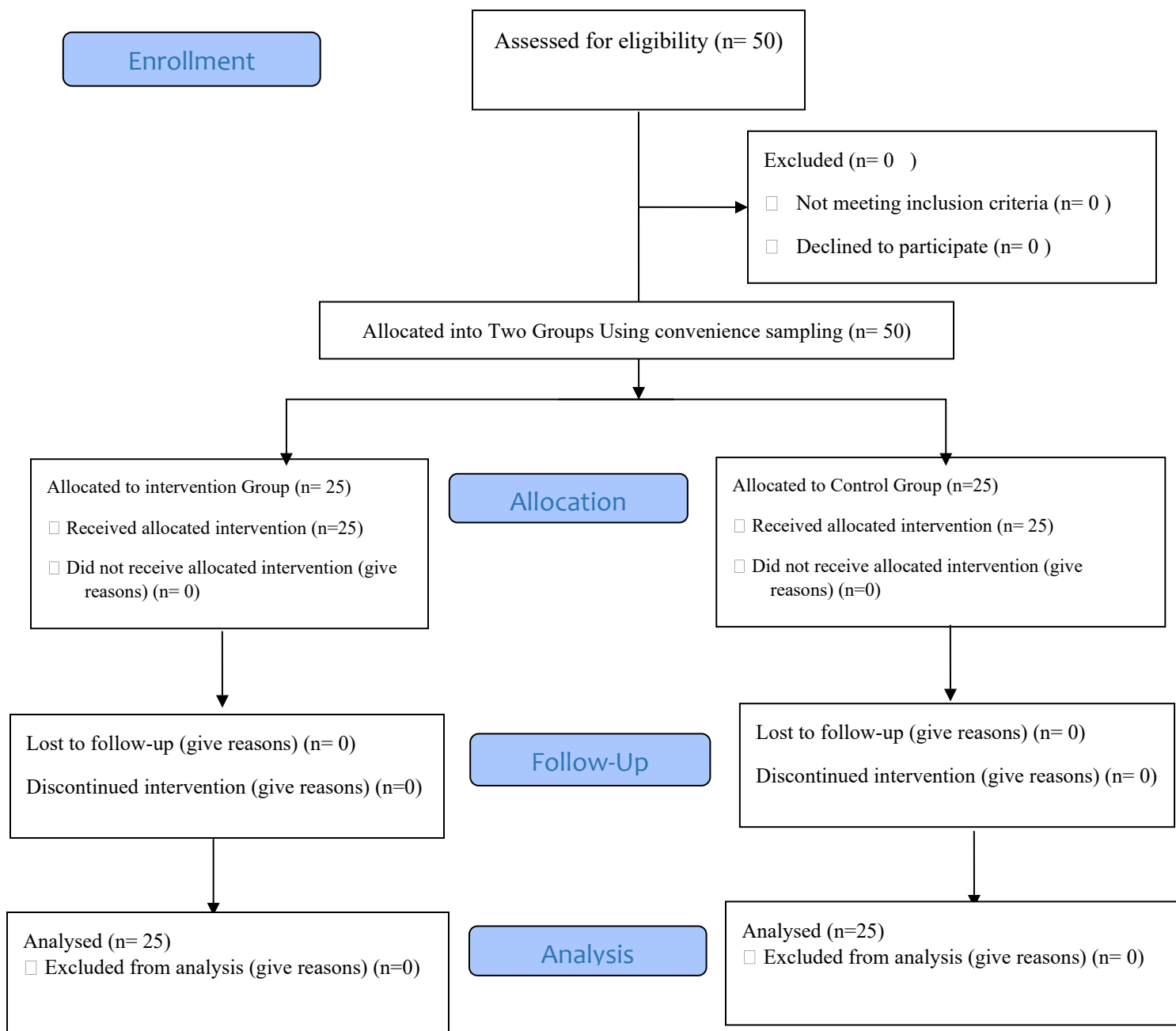


Figure.1: The consort flow diagram of patients participating in the study

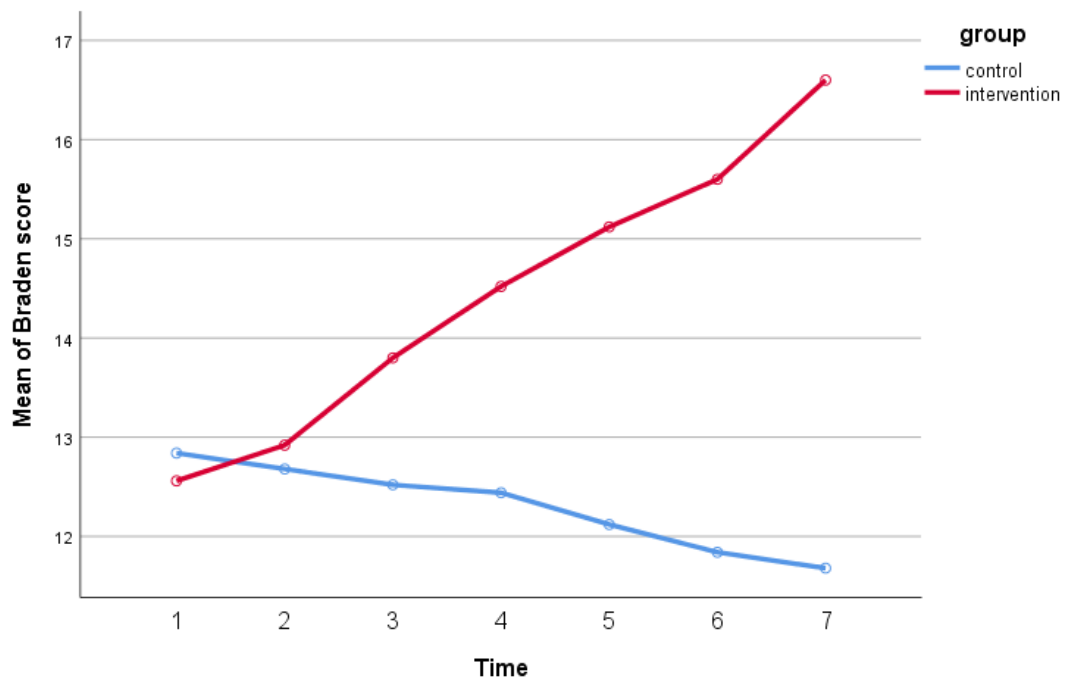


Figure 2. Trend of Mean Braden Scores Over Seven Days in the Study Groups

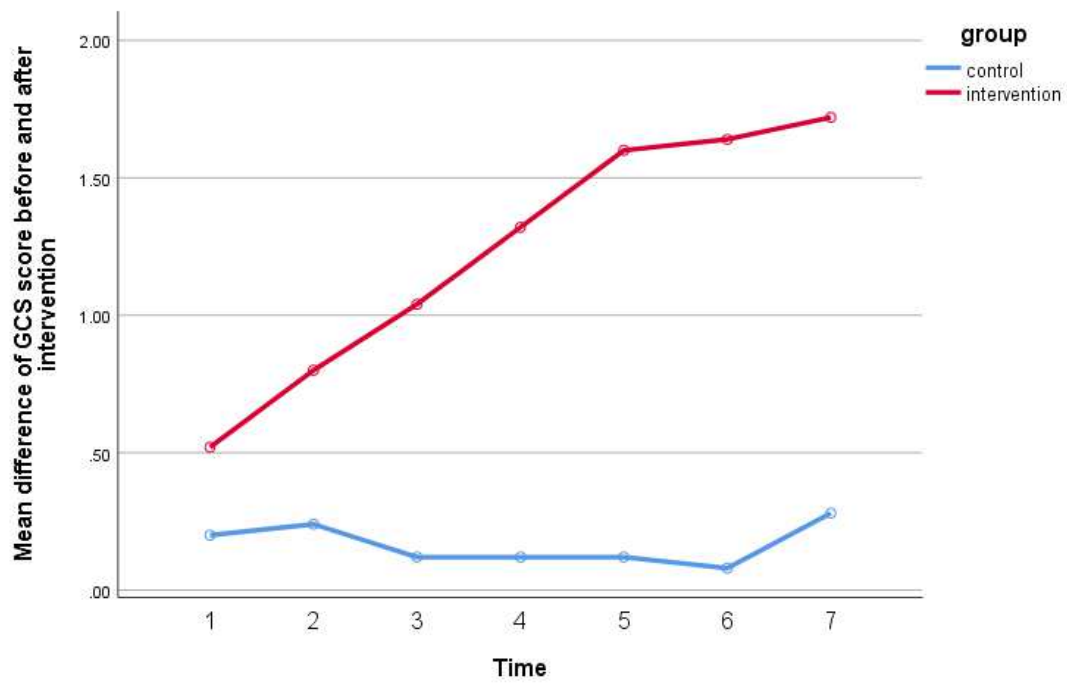


Figure 3. Trend of Mean Differences in GCS Scores Before and After the Intervention Over Seven Days in the Study Groups

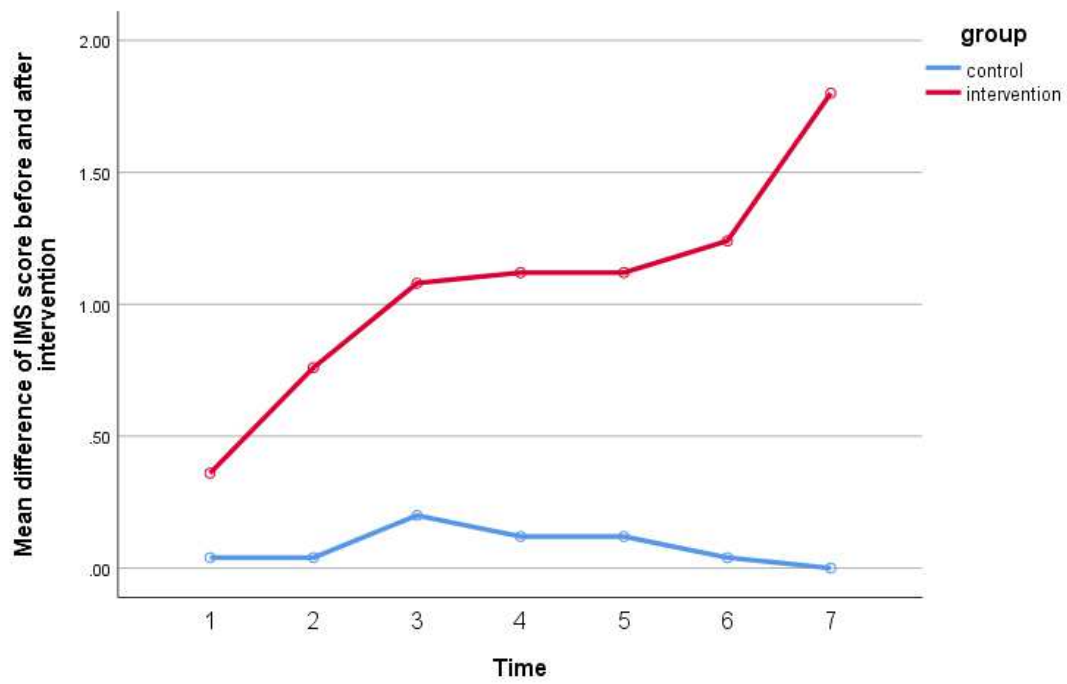


Figure 4. Trend of Mean Differences in IMS Scores Before and After the Intervention Over Seven Days in the Study Groups

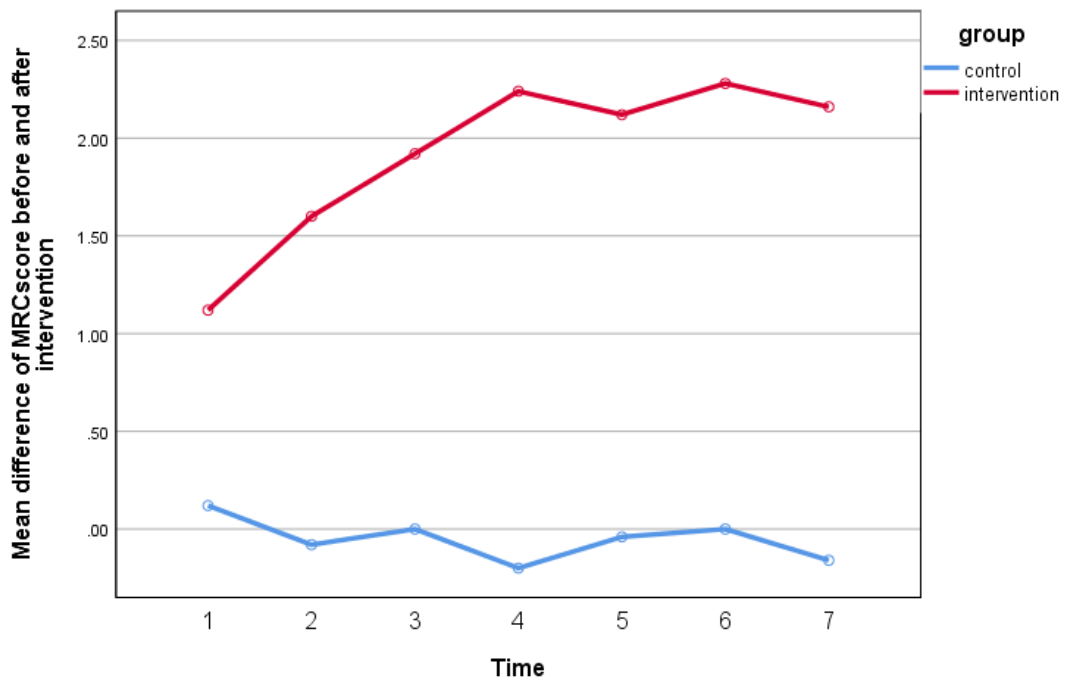


Figure 5. Trend of Mean Differences in MRC Scores Before and After the Intervention Over Seven Days in the Study Groups