Research Square

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The Effect of Core Muscle-Strengthening on Pain, Balance and Ankle Function in Athletes with Sub-acute Lateral Ankle Sprain

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Abstract

Objectives: To assess the effects of core-strengthening exercises on pain, static balance, and ankle function among amateur athletes with subacute grade I and II lateral ankle sprain

Design: A triple-blind randomized controlled trial

Setting: An orthopedic rehabilitation center

Trial Registration: The registration number is IRCT20240309061219N1 and the registration date is 05/06/2024.

Participants: Forty amateur athletes with subacute grade I and II lateral ankle sprain were randomized into two rehabilitation groups.

Intervention(s): The Protocols were completed over a total of 12 sessions, conducted 3 times per week for 4 weeks. The control group underwent conventional physiotherapy consisting of pulsed ultrasound, high-frequency TENS and range of motion (ROM) exercises. In contrast, the experimental group in addition to conventional physiotherapy, performed core muscle-strengthening exercises at the end of each treatment session.

Main Outcome Measure(s): Variables were assessed pre-intervention and after 4 weeks of intervention. The primary outcome was pain intensity, measured using short form of McGill pain questionnaire (SF-MPQ), static balance was assessed via the Balance Error Scoring System (BESS), and ankle function was evaluated using the Foot and Ankle Ability Measure (FAAM).

Results: The results demonstrated a significant pain reduction within both the experimental and control groups ($p < 0.05$). The results of Cohen's d effect size revealed the larger effect of core strengthening on pain reduction. Further, significant improvements in static balance and ankle function were observed exclusively in the experimental group. In contrast, the control group exhibited no significant difference in the mentioned outcomes after four-week intervention ($p > 0.05$).

Conclusion: The results of this study represented that core strengthening could relieve pain, enhance static balance, and improve ankle function in amateur athletes with subacute lateral ankle sprain. Hence, the integration of core muscle-strengthening exercises with conventional physiotherapy interventions is recommended for these patients.

Highlights

- Core-strengthening exercise is a useful intervention in individuals with subacute grade I and II LAS.
- Twelve sessions of core-strengthening exercises are effective in alleviating pain, reducing disability, and enhancing static balance.

- Lateral core muscles can assist in decreasing body movement in frontal plane, and consequently improving balance.
- Core muscle strengthening in the early stages of injury can accelerate the rehabilitation process.

Introduction

According to the International Ankle Consortium, lateral ankle sprain (LAS) is defined as a traumatic injury of the ankle lateral ligaments, resulting from excessive rotation of the rearfoot (heel) inwards or a combination of plantar flexion and adduction (1). LAS is considered one of the most prevalent musculoskeletal injuries among both athletic and general populations (1, 2). Half of all ankle sprains occur among athletes, which constitutes approximately 16–40% of all sport-related traumatic injuries in this population (2). It is worth noting that around 40–50% of individuals experience persistent symptoms and injury recurrence over the long term (2). Additionally, associated injuries such as tendon injuries, bone cartilage injuries or bone fractures are frequently reported among this population (3). Consequently, the intervention costs for addressing this issue and associated injuries can lead to significant social and economic burdens (2). The accurate identification and modification of risk factors which can be altered through therapeutic exercises or changes in the rules of sports competitions are effective in the success of preventive programs (4). The decreased range of ankle dorsiflexion, as well as reducing proprioception and balance disorders, which may be caused by core muscle weakness, is among the modifiable risk factors in this complication (2). Intervention strategies for acute ankle sprain injury include Protection, Optimal Loading, Ice, Compression, and Elevation (POLICE), bracing, immobilization (short-term), appropriate early weight-bearing, manual therapy, therapeutic exercise, and various modalities, among which therapeutic exercise and bracing are supported by the strongest clinical evidence (2). It should be noted that no muscles are directly connected to the talus, emphasizing the role of both proximal and distal muscles in the ankle stability (5).

Lee and Powers (2013) demonstrated that hip abductor fatigue increased medial–lateral center of pressure displacement during a single-leg drop task, likely due to increased frontal-plane trunk oscillations induced by proximal muscle weakness (6). Supporting the contribution of trunk musculature, Calicchio et al. (2016) reported a significant association between lumbar extensor endurance and chronic ankle instability, suggesting that impaired core strength may exacerbate balance deficits (7). In line with these findings, another study by Dastmanesh et al. (2012) indicated that eight weeks of core stability exercises significantly improved star-excursion balance performance in both healthy individuals and those with chronic ankle instability (8). Similarly, Smith et al. found that a four-week hip abductor strengthening protocol led to superior improvements in static and dynamic balance compared with control group (9). More recently, Sulaiman et al. (2023) confirmed that six weeks of core strengthening resulted in greater pain reduction and enhanced dynamic balance in patients with ankle sprain (10).

The majority of prior research has been observational, with clinical trials mainly addressing chronic ankle instability (8, 9). To our knowledge, only Sulaiman et al. (2023) evaluated core strengthening after ankle

sprain; however, their study focused solely on dynamic balance and did not report injury timing or phase (10).

To the best of our knowledge, limited clinical trial studies have evaluated the effects of core muscle strengthening in enhancing static balance and relieving ankle pain in the initial phases following ankle sprain. Regarding the subacute phases, peroneal muscle-strengthening exercises cannot be performed due to the presence of pain and inflammation. Thus, the present study evaluated the effects of strengthening distal muscles from ankle (i.e., core muscles) on pain, static balance, and overall ankle function.

Methods

Design

The present study was conducted as a triple-blind (participants, assessor, and data analyst), randomized controlled trial at the Physiotherapy Clinic of the School of Rehabilitation, Tehran University of Medical Sciences during April-September 2024 (Registration number: IRCT20240309061219N1, Registration Date:05/06/2024). Ethical approval for this study was obtained from the Ethics Committee of Tehran University of Medical Sciences (Approval Number: IR.TUMS.FNM.REC.1402.234). No funding was received for this study. The reporting of this randomized controlled trial follows the CONSORT 2025 statement.

Participants

Following ethics approval and trial registration, amateur athletes meeting inclusion criteria were recruited via advertisements, orthopedic clinics, and dormitories at Tehran University of Medical Sciences and referred to the Physiotherapy Clinic at the School of Rehabilitation of this university. Individuals whose injuries were confirmed by an orthopedic specialist, patients meeting inclusion criteria, and those willing to participate were included in the study. Thus, a total of 40 amateur athletes (Control group: 12 males / 8 females; Experimental group: 10 males/ 10 females) were enrolled in the study (Fig. 1). After explaining the treatment protocols and assessment procedures to all participants in simple language, they provided written informed consent in accordance with the Declaration of Helsinki. Participant confidentiality and rights were strictly protected throughout the study.

Eligible participants were classified randomly into two groups (control group, experimental group), both of which were treated by the same physiotherapist. The patients received treatment protocols over a total of 12 sessions, conducted three times per week, with each session lasting approximately one hour. Another physiotherapist assessed the pain intensity and static balance of the ankle. In order to evaluate ankle function, the patients completed the Foot and Ankle Ability Measure (FAAM) questionnaire.

Considering previous studies (9, 11) and substituting numbers into the formula with α level of 5% and β level of 90%, sample sizes for pain and static balance were obtained 10 and 18, respectively, each of which increased to 20 due to a 10% dropout rate. In case of normal distribution, within-group Cohen's d effect size was calculated regarding all outcome measures. Effect sizes were interpreted as trivial (< 0.2), small (0.2–0.5), medium (0.5–0.8), and large (> 0.8). Furthermore, a p-value less than < 0.05 was considered significant.

Inclusion criteria were the age range of 18–35 years and diagnosis of grade I and II LAS by an orthopedic specialist, as well as being an amateur athlete with weekly exercise volume of 2–4 hours (12) and having an injury occurring within the preceding 5 to 14 days (13).

However, the patients having grade III ankle ligament injury, chronic ankle injuries or open wounds in the ankle region (14), accompanying fracture in the lower limb (12), and painful syndromes such as rheumatoid arthritis or fibromyalgia (as reported by the patient) (15) were excluded from the study. Further, the use of analgesic medication within seven days prior to the study initiation, as well as prior physiotherapy intervention (e.g., electrotherapy, manual therapy, or ankle exercise therapy).

In this triple-blind study, each group comprised 20 individuals, whom were allocated randomly to one group by selecting sealed envelopes (0–40, even numbers: Control group; odd numbers: Experimental group).

Outcome measures

A qualified physiotherapist, blinded to the intervention condition, assessed all outcomes at the baseline and three days after the final intervention session.

Pain

The primary outcome measure was the short-form McGill pain questionnaire (SF-MPQ), contains 15 descriptors, 11 of which are related to the sensory dimension of pain (e.g., sharp and shooting) and 4 correspond to its affective dimension (e.g., tiring and frightening). Each descriptor is rated based on a four-point scale (0 to 3). Additionally, the questionnaire includes Present Pain Intensity (PPI) index and a Visual Analog Scale (VAS). The results of previous studies have demonstrated the high reliability of the Persian version of the questionnaire (total = 0.91, VAS = 0.87, PPI = 0.82) (16).

Static balance

As for static balance, the BESS (Fig. 2) was employed, which consists of three standing positions of double-leg, single-leg, and tandem. Each stance was maintained for 20 seconds with eyes closed, performed on both a firm surface and a foam one (60 cm length × 60 cm width ×10 cm thickness). Opening the eyes, removing hands from the hips, taking steps, leaving a standing position, lifting the heel

or toes, abducting the hip more than 30̊, and failing to return to the testing position within more than five seconds were considered as errors. The total number of errors was counted for each participant. The reliability of this test was moderate to good in clinical evaluations (0.57–0.74) (17).

Ankle function

The ankle function was examined by using the FAAM questionnaire (18) with 29 questions, of which 21 assess the Activities of Daily Living (ADL) and 8 focus on special sports activities. Each item is scored on a five-point scale ranging from 0 (unable to do) to 4 (no difficulty). Regarding each subscale, a percentage is calculated, with higher percentages (closer to 100%) indicating greater ability to perform daily and sports activities. Based on the results of previous studies, the Persian version of this questionnaire is highly reliable and valid (ADL = 0.98, Sport = 0.98) (18).

Interventions

The control group received conventional physiotherapy, which included pulsed ultrasound, high-frequency Transcutaneous Electrical Nerve Stimulation (TENS), and Range of Motion exercises (ROM exercises). Regarding pulsed ultrasound, an ultrasound machine (Novin Medical Engineering Company, Iran, model 215M, with 4 cm probe head diameter) was utilized to apply pulsed ultrasound to the painful area around the lateral malleolus during four weeks. In the first two weeks, pulsed ultrasound with a frequency of 3 MHz, an intensity of 0.3 W/cm^2, and a duty cycle of 30% was used for 10 minutes, followed by utilizing six minutes of pulsed ultrasound at a frequency of 3 MHz, an intensity of 0.5 W/cm^2, and a duty cycle of 50% in the second two weeks (19). High-frequency TENS (120 Hz and 50 μs pulse width) was applied for 30 minutes (20) by using a 735M stimulator (Novin Medical Engineering Company, Iran). Furthermore, the participants performed ROM exercises (i.e., the plantar flexion, dorsiflexion, inversion, and eversion of the ankle) in a pain-free range for 3 sets with 20 repetitions per set every day. It should be noting that both stimulator and ultrasound machine were calibrated prior to the study initiation.

Along with receiving conventional physiotherapy, the experimental group was requested to execute core muscle-strengthening exercises at the end of each session (21). To strengthen the lateral core muscles, participants were instructed to lie on the non-affected side on a treatment table, with the trunk and upper extremities hanging off the edge of the table, such that the injured side was positioned superiorly. Participants then attempted to approximate the shoulder toward the pelvis by contracting the lateral core muscles, while the therapist simultaneously stabilized the pelvis and lower extremities. At the beginning of the exercise, the participant's upper hand was placed on the pelvis and the lower hand on the superior shoulder (Fig. 3, A). As core muscles strength increased, the exercise difficulty was progressed by positioning both the upper and lower hands behind the head (Fig. 3, B). For further progression, the exercise was performed while the participant was lying on a Swiss ball (Fig. 3, C-D). Each contraction was held for 15–30 seconds and performed 3–5 times per session. In addition, participants performed

the side plank exercise. Initially, the participant lay on the affected side, supported on the elbow as shown in the Fig. 2, with the upper hand placed on the pelvis and both hips and knees were flexed to 45°. From this position, the pelvis and trunk were lifted (Fig. 4, A). To increase exercise difficulty with improved muscle strength, patients performed mentioned exercise with the hips and knees extended (Fig. 4, B). Both exercises were held for 10–60 seconds and performed 3–5 repetitions per session.

Statistical analysis

The data were statistically analyzed by using SPSS statistical software v25.0. The Shapiro-Wilk test was utilized for the normality of data distribution. As for normally-distributed data, within-group changes were evaluated using paired sample t-test, while the Wilcoxon test was used for within-group comparisons regarding the data not distributed normally. Finally, between-group comparisons were conducted using the Mann-Whitney U test.

Results

In the present study, 22 males and 18 females participated (Control group: 12 males / 8 females; Experimental group: 10 males/ 10 females), all of whom attended all 12 intervention sessions. In terms of demographic characteristics, no significant differences were observed between the two groups (Table 1). Except for the data related to VAS and PPI, all other data were normally distributed. Thus, the Wilcoxon test was used to evaluate within-group changes in VAS and PPI scores. In addition, within-group changes in the pain descriptor (sensory/affective) items of the Short-Form of McGill Pain Questionnaire, BESS and FAAM outcomes were analyzed using the paired-samples t test. Given the non-normal distribution of the pre- and post-intervention mean differences for all outcome measures in the two groups, between-group comparisons were performed using the Mann- Whitney U test. The results of within-group analyses revealed a significant reduction in pain for both groups (Table 2) ($p < 0.001$). Considering the effect sizes in two groups, core muscle strengthening exerted a greater effect on pain reduction in the experimental group in the pain descriptor items of the SF-MPQ (Cohen's d of experimental group = 1.11, Cohen's d of control group = 1.07). In addition, significant improvement in static balance and ankle function was found exclusively in the experimental group ($p < 0.001$). Also, between-group comparisons indicated a significant difference favoring the experimental group for all outcome measures except VAS and PPI ($p > 0.05$) (Table 3). Mean values and standard deviation for outcome measures are showed in Fig. 5.

Table 1
Characteristics of participants at baseline.

Characteristics	Experimental Group (n = 20)	Control Group (n = 20)	p-value
Age (years), mean (SD)	26.2 (5.32)	27.4 (4.16)	0.432
Gender (n): male/ female	10/10	12/8	
Height (cm), mean (SD)	170.80 (6.41)	168.25 (6.34)	0.214
Weight (kg), mean (SD)	75.70 (7.49)	73.25 (7.10)	0.295
Body Mass Index (kg/m^2), mean (SD)	26.48 (2.10)	27.18 (2.78)	0.379
Grade I tear (n)	6	11	
Grade II tear (n)	14	9	

Table 2
Within-group comparisons in outcome measures (Pre-intervention versus after 4 weeks intervention)

Outcome measure	Pre-intervention, mean (SD)		After 4 weeks intervention, mean (SD)	
	Experimental group (n:20)	Control group (n:20)	Experimental group (n: 20)	Control group (n:20)
SF-MPQ	28.00 (6.69)	29.40 (3.51)	20.00 (7.66)	25.5 (3.73)
VAS (cm)	7.65 (0.58)	7.90 (0.71)	6.30 (1.17)	6.75 (1.16)
PPI	3.50 (0.51)	3.65 (0.48)	2.70 (1.03)	2.95 (0.88)
BESS	21.50 (4.34)	21.30 (4.99)	15.00 (4.27)	21.00 (5.01)
FAAM-ADL	84.10 (7.02)	83.85 (7.71)	92.10 (4.78)	84.25 (7.65)
FAAM-Sport	74.31 (12.36)	79.01 (6.58)	85.33 (9.43)	80.06 (5.68)

SF-MPQ: Short-Form McGill Pain Questionnaire; VAS: Visual Analog Scale; PPI: Present Pain Intensity; BESS: Balance Error Scoring System; FAAM-ADL: Foot and Ankle Ability Measure–Activities of Daily Living; FAAM-Sport: Foot and Ankle Ability Measure–Sports; SD: Standard Deviation

Table 3
Within-group and between-group differences*: mean differences (95% CI), Cohen's d effect sizes, and statistical significance (p-value).

Outcome measure	Experimental group (n:20)	Control group (n:20)	Between-group difference p-value (Z statistics)
SF-MPQ	MD = 8.00 (6.79–9.20) p< .001** d = 1.11	MD = 3.90 (3.23–4.56) p< .001** d = 1.07	< .001** (-4.764)
VAS (cm)* **	MD = 1.35 p< .001**	MD = 1.15 p= .001**	.581 (-0.553)
PPI* **	MD = 0.80 p= .001**	MD = 0.70 p= .004**	.703 (-0.381)
BESS	MD = 6.50 (5.36–7.63) p< .001** d = 1.50	MD = 0.35 (0.001–0.69) p= .08 d = 0.06	< .001** (-5.472)
FAAM-ADL	MD= -8.00 (-6.70 - -9.29) p< .001** (d = 1.33)	MD= -0.40 (-0.90- -0.09) p= .105 (d = 0.05)	< .001** (-5.378)
FAAM-Sport	MD= -11.02 (-12.75- -9.29) p< .001** (d = 1.00)	MD= -1.04 (-2.32- -0.22) p= .102 (d = 0.17)	< .001** (-5.103)

CI: Confidence Interval; MD: Mean Difference; SF-MPQ: Short-Form McGill Pain Questionnaire; VAS: Visual Analog Scale; PPI: Present Pain Intensity; BESS, Balance Error Scoring System; FAAM-ADL: Foot and Ankle Ability Measure–Activities of Daily Living; FAAM-Sport: Foot and Ankle Ability Measure–Sports; SD: Standard Deviation

* Within-group changes in VAS and PPI scores were assessed using the Wilcoxon signed-rank test, whereas changes in the sensory and affective dimensions of the Short-Form McGill Pain Questionnaire, as well as BESS and FAAM outcome measures, were evaluated using the paired-samples t test. Between-group comparisons were performed using the Mann–Whitney U test.

**A significant difference is found between measurements before intervention and after four-week intervention (p< .001).

***Due to the use of non-parametric tests, the effect sizes and 95% CIs were not calculated.

Discussion

Regarding pain outcomes, the present study demonstrated a significant reduction in pain intensity in both the control and intervention groups, with a greater improvement observed in the core muscle strengthening group. These findings are consistent with those reported by Sulaiman et al. (2023), who observed greater pain reduction following a six-week core muscle strengthening program in athletes with lateral ankle sprain. However, their study did not clearly define inclusion criteria or injury duration. Moreover, pain assessment in that study relied solely on the VAS, whereas the present study employed the SF-MPQ, which allowed for a multidimensional evaluation of pain intensity and quality. Similar to previous studies on patellofemoral pain syndrome, strengthening proximal musculature has been shown to result in faster pain reduction compared with distal-focused interventions alone (22–24), supporting the present findings.

The observed pain reduction in the control group can be attributed to the effects of physiotherapy modalities, including electrotherapy and ultrasound, as well as the natural process of tissue and neural healing during the subacute phase of injury. The greater pain reduction observed in the experimental group in the current study, suggests that core muscle strengthening provides additive benefits beyond standard care. Strengthening the lateral core muscles may reduce medial-lateral trunk sway and center of pressure displacement in the frontal plane, thereby decreasing the risk of foot inversion and excessive mechanical stress on the lateral ankle ligaments. This biomechanical mechanism offers a plausible explanation for the superior pain outcomes observed in the experimental group compared with the control group.

In terms of balance performance, the intervention group exhibited a significant improvement in static balance, consistent with previous findings in individuals with chronic ankle instability. Smith et al. (2017) reported a reduction in balance errors following four weeks of hip muscle strengthening (9), while another randomized controlled trial by Bahrami et al. (2023) demonstrated significant improvements in static balance following six weeks of core strengthening in volleyball players with chronic ankle instability (25). Although Akınoğlu et al. reported no association between lateral core muscle endurance and balance in a cross-sectional design (26), the present interventional findings suggest that targeted strengthening of the lateral core muscles can positively influence static balance. This improvement may be explained by a reduction in the velocity and amplitude of center of pressure movement in the medial–lateral direction, consistent with the established role of hip abductors in frontal plane postural control (6, 27).

Functional outcomes, as assessed by the FAAM questionnaire, further support the effectiveness of the intervention. Significant improvements were observed in both the ADL and sports subscales, consistent with previous studies by Smith et al. (2017) and Yeum et al. (2024), who reported improved ankle function following hip muscle strengthening in individuals with chronic or functional ankle instability (9, 28). Similarly, Lee et al. (2021) demonstrated significant improvements in ankle function following both hip and core muscle strengthening interventions (27). These functional improvements may be attributed

to enhanced lumbopelvic stability and improved hip control, facilitating more efficient force transmission along the lower extremity kinetic chain. Additionally, exercises such as the side plank may promote co-activation of the peroneal muscles to counter inversion moments, indirectly enhancing ankle stability, as suggested by Yeum et al. (2024). The relatively young and physically active participants in the present study (18–35 years) may have further contributed to the observed improvements, as younger individuals may respond more favorably to short-term neuromuscular interventions. Given that sport-specific activities such as running, jumping, and landing rely heavily on proximal stability, strengthening the core muscles may explain the greater improvements observed in the sports subscale of the FAAM questionnaire (28–30).

Overall, the results of the present study indicate that incorporating lateral core muscle strengthening into rehabilitation protocols during the subacute phase of lateral ankle sprain leads to superior outcomes in pain reduction, static balance, and ankle function compared with conventional physiotherapy alone. These findings are in line with previous researches and highlight the importance of proximal stability and neuromuscular control in distal joint rehabilitation.

The present study has several limitations, one of which is investigating the short-term effects of the interventions. Therefore, a longer follow-up period is needed to evaluate the persistence of the effects, as well as assessing their applicability during competitions and training. Not monitoring the participants for risk of re-injury is another limitation. The last limitation includes examining the effects of the interventions on only amateur athletes within a narrow age range. Accordingly, the generalizability of the results to older, younger, or professional athletic populations remains unclear. Future studies should be conducted to assess the long-term effects of these interventions over a longer period and frequent follow-ups. Additional research is recommended to evaluate the effects of the interventions on the recurrence of lateral ankle sprain and focus on professional athletes for broader effectiveness.

Conclusion

The results of the present controlled trial study suggested the significant contribution of strengthening the core muscles to pain reduction, as well as improving static balance and ankle function in individuals with subacute LAS. The improvement in static balance and ankle function observed in these patients may contribute to a reduced risk of recurrent ankle sprain and may help prevent the progression to chronic ankle instability. Therefore, incorporating core muscle-strengthening exercises into other common physiotherapy interventions is recommended for these patients.

Declarations

Conflicts of interest:

There is no conflict of interests in this study.

Ethics Approval

Ethical approval for this study was obtained from the Ethics Committee of Tehran University of Medical Sciences (Approval Number: IR.TUMS.FNM.REC.1402.234).

Consent to Participate

All participants provided written informed consent in accordance with the Declaration of Helsinki. Participant confidentiality and rights were strictly protected throughout the study.

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Author Contribution

Alireza Hosseinzadeh Chaijan and Siamak Bashardoust Tajali searched for articles to find out a suitable title for original article. Alireza Hosseinzadeh Chaijan also applied treatment on patients. Sara Fereydounnia helped in finding outcome measures and also writing of discussion. Seyedeh Zohreh Hosseini assessed patients as a blind physiotherapist who do not know about group of patients.Hadi Pashapour analysed scores before and after treatment as a blind analysor. All authors reviewed the manuscript

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Figures

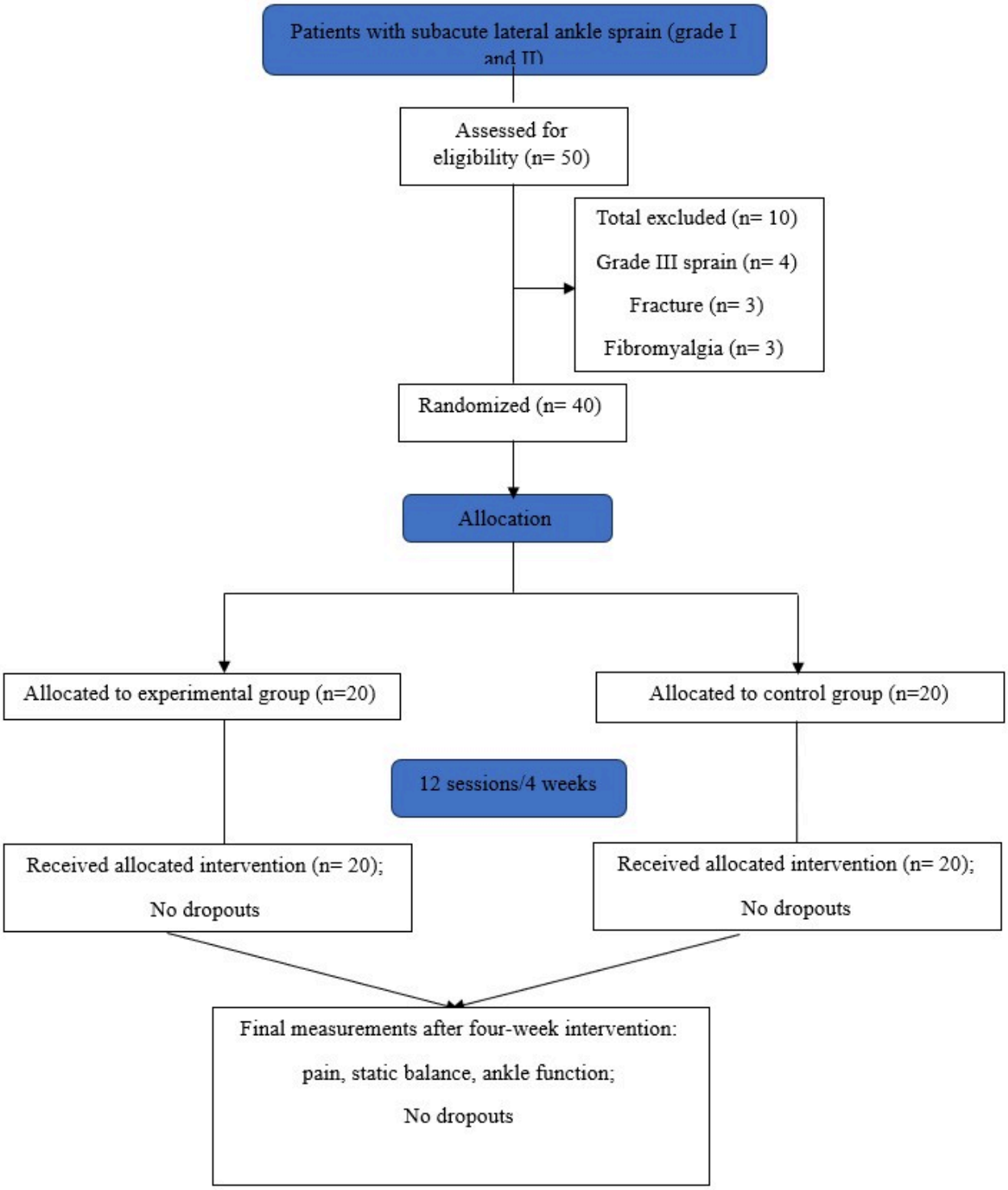


Figure 1

CONSORT flow diagram of participants

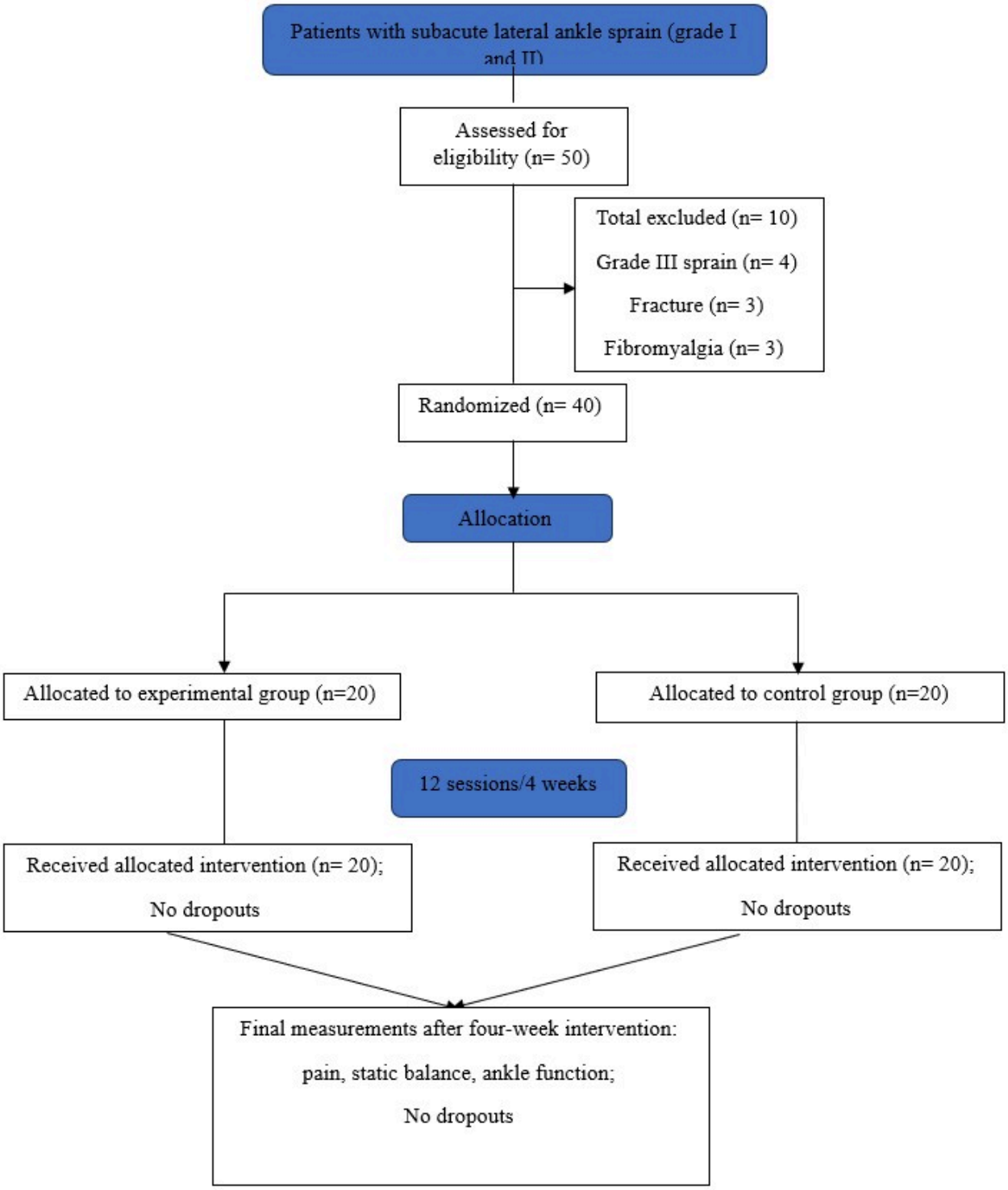


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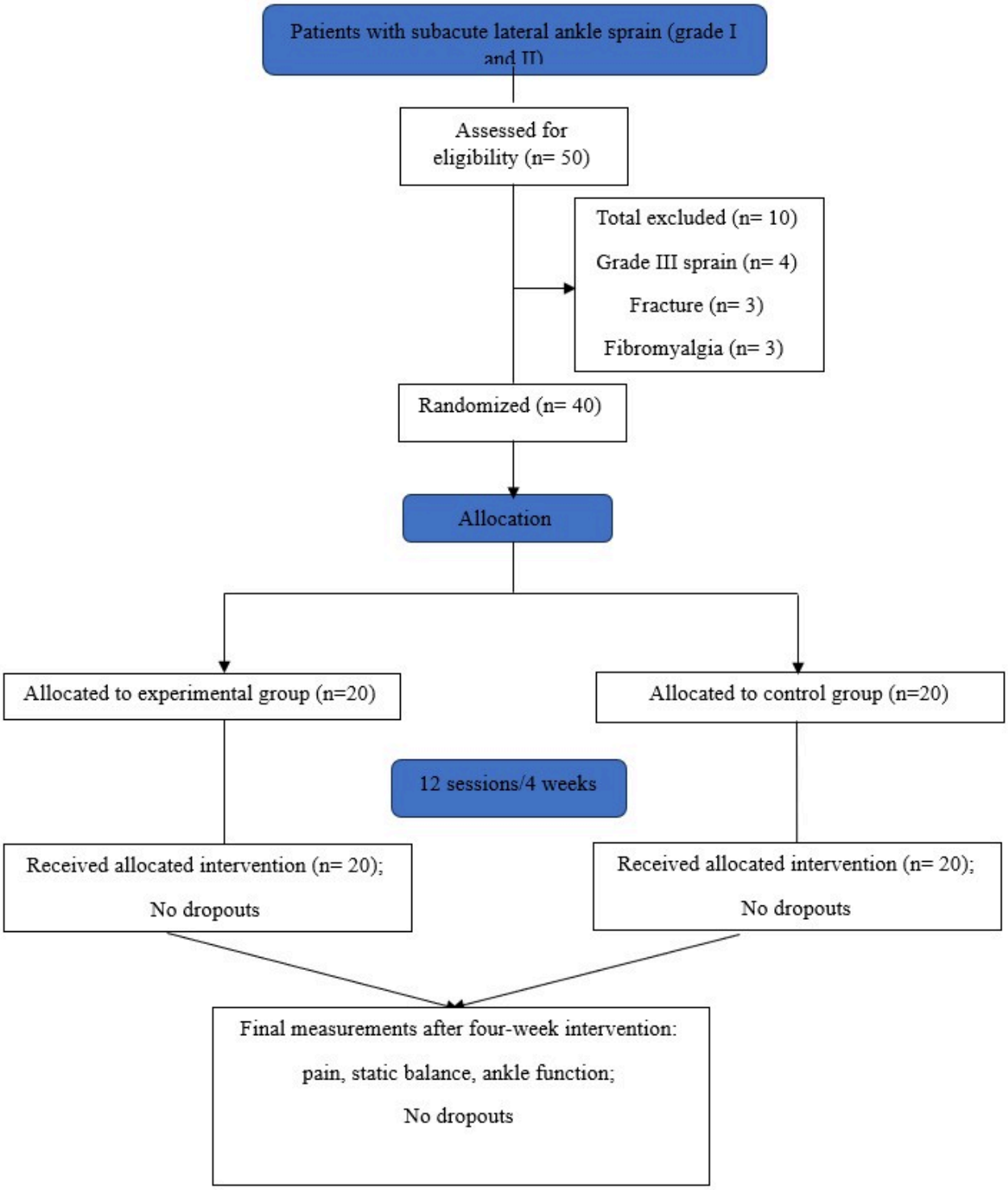


Figure 1

CONSORT flow diagram of participants



Figure 2

Stance positions for BESS assessment: (A) double-leg stance on firm surface, (B) tandem stance on firm surface, (C) single-leg stance on firm surface, (D) double-leg stance on foam surface, (E) tandem stance on foam surface, (F) single-leg stance on foam surface



Figure 2

Stance positions for BESS assessment: (A) double-leg stance on firm surface, (B) tandem stance on firm surface, (C) single-leg stance on firm surface, (D) double-leg stance on foam surface, (E) tandem stance on foam surface, (F) single-leg stance on foam surface



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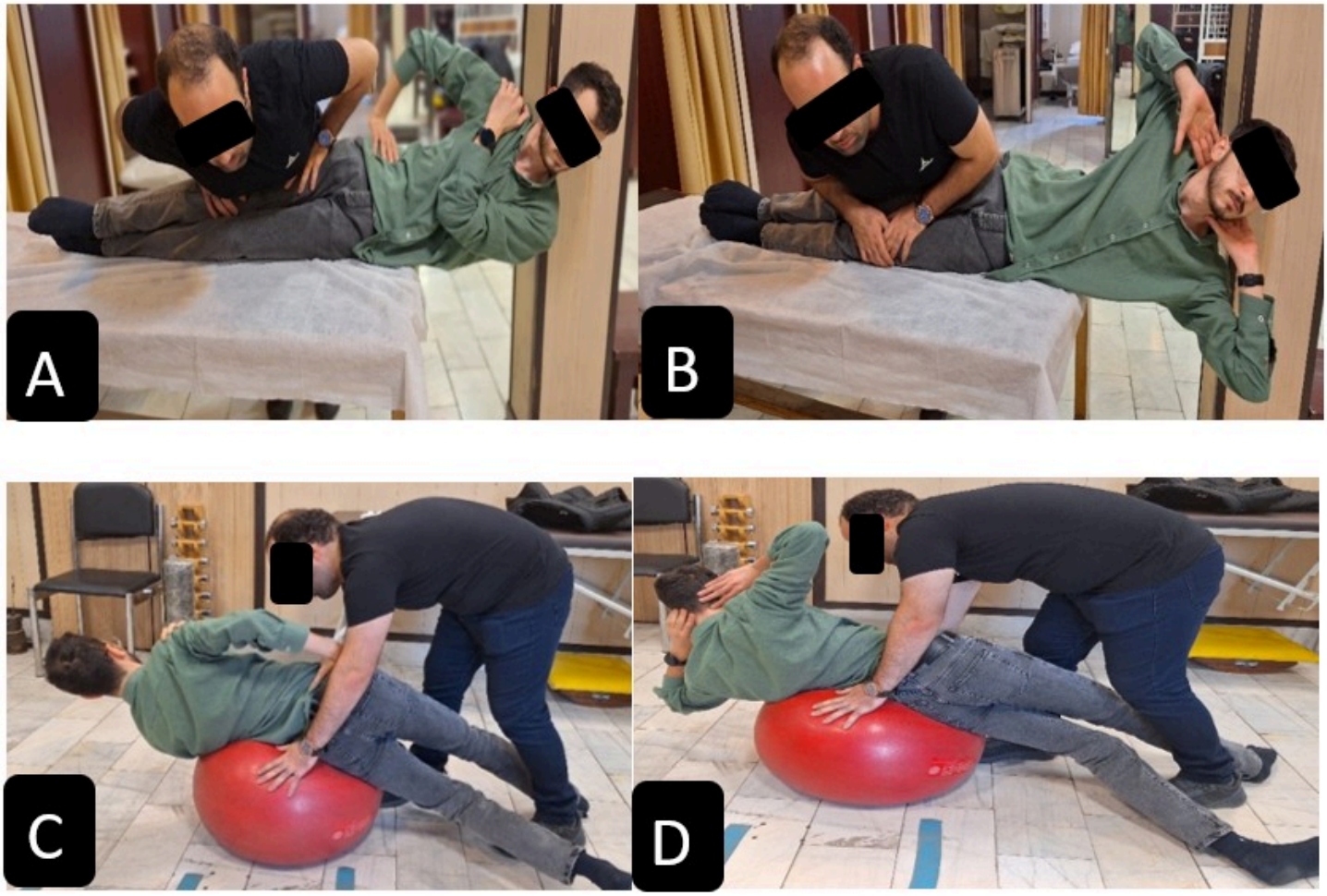


Figure 3

Lateral core muscle-strengthening exercises ordered by difficulty level. A: The lower hand is placed on the upper shoulder and the upper hand is positioned on the pelvis, B: Both hands are placed behind the head to increase the difficulty of the exercise, C-D: Mentioned exercises are performed on Swiss ball to further increase the difficulty

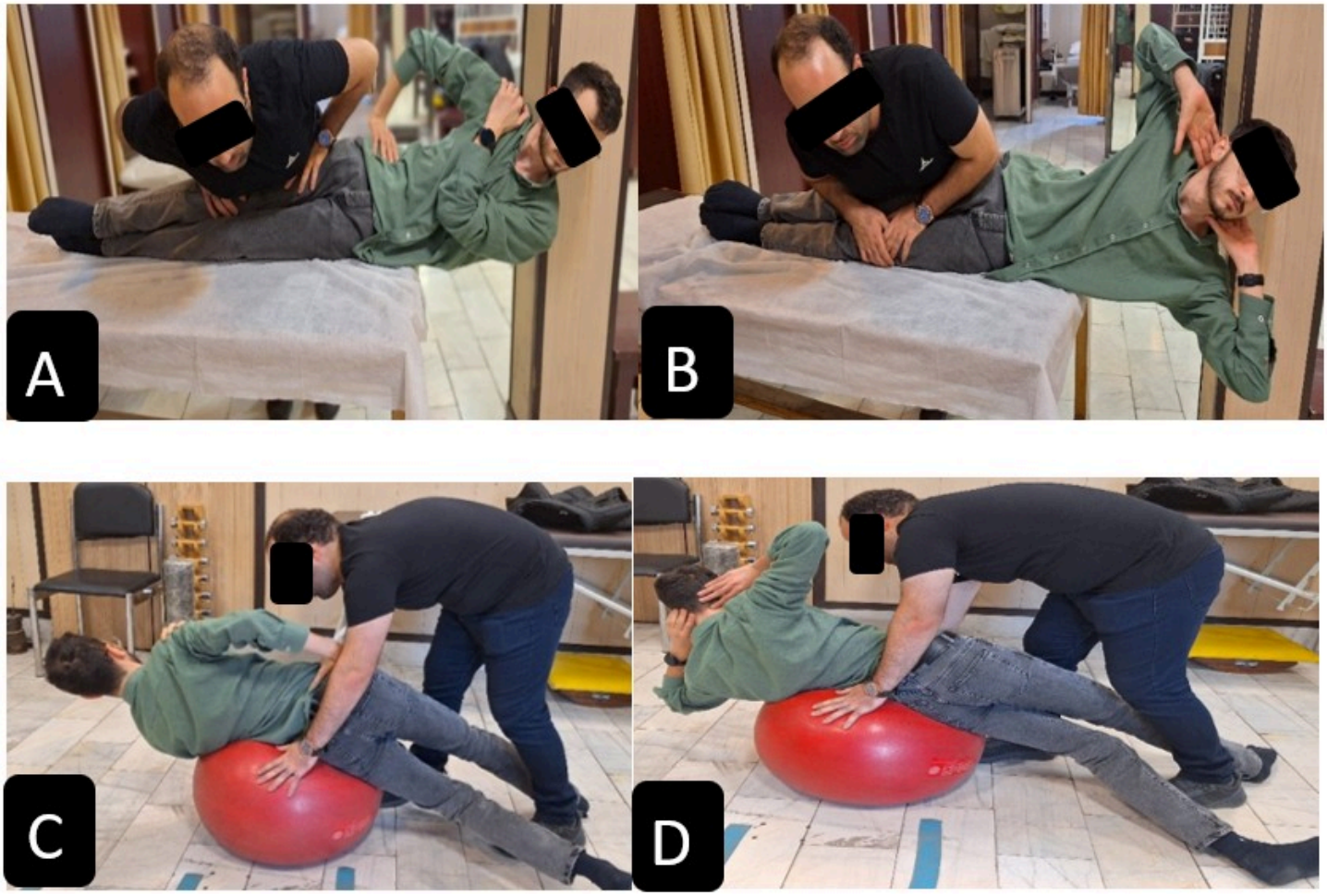


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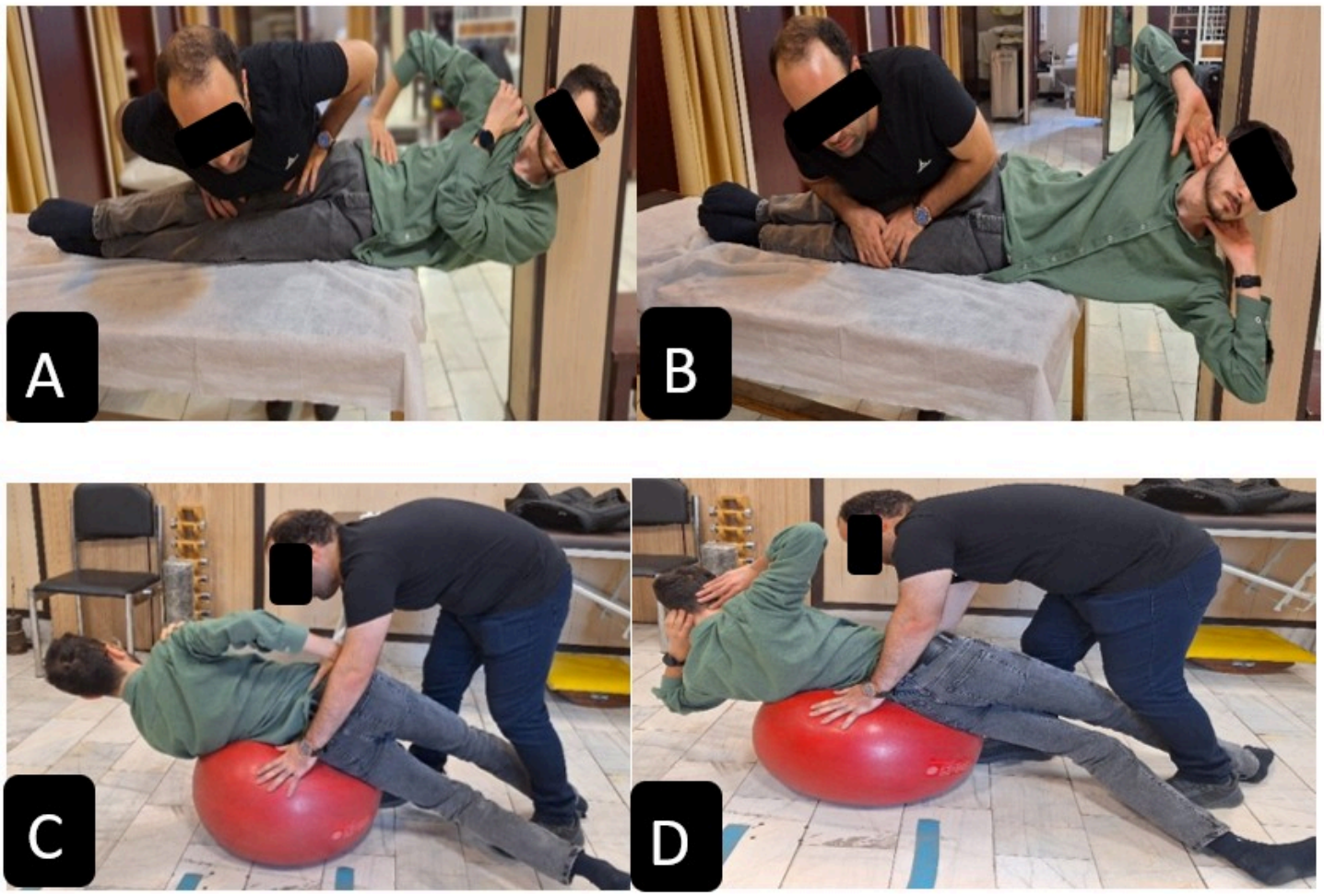


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Figure 4

Side plank exercises ordered by difficulty level. A: The knees and hips are placed in 45° flexion, B: The knees and hips are extended to increase the difficulty of exercise.



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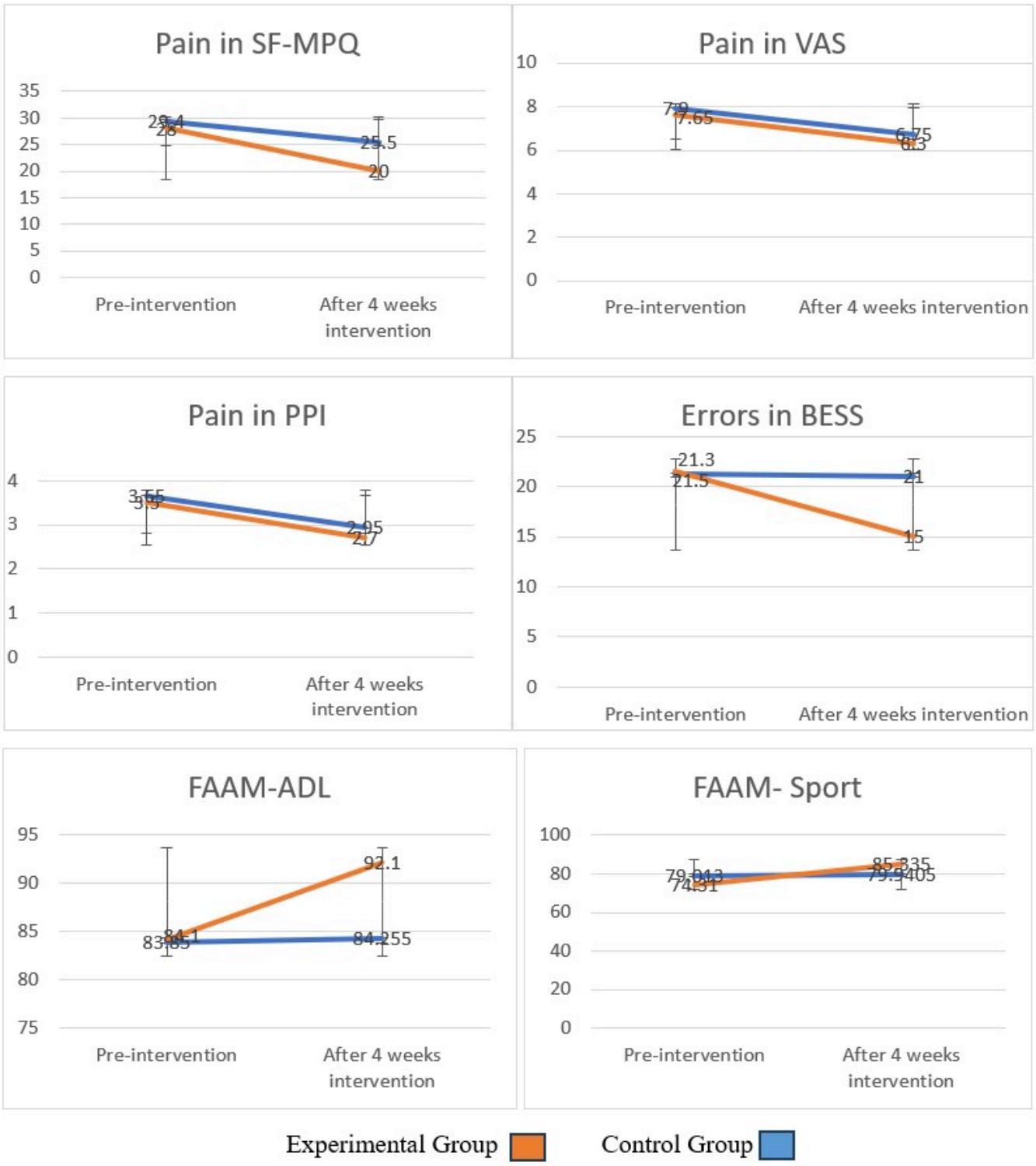


Figure 5

Line plot showing mean values with standard deviation (SD) for outcome measures pre-intervention and after 4 weeks intervention

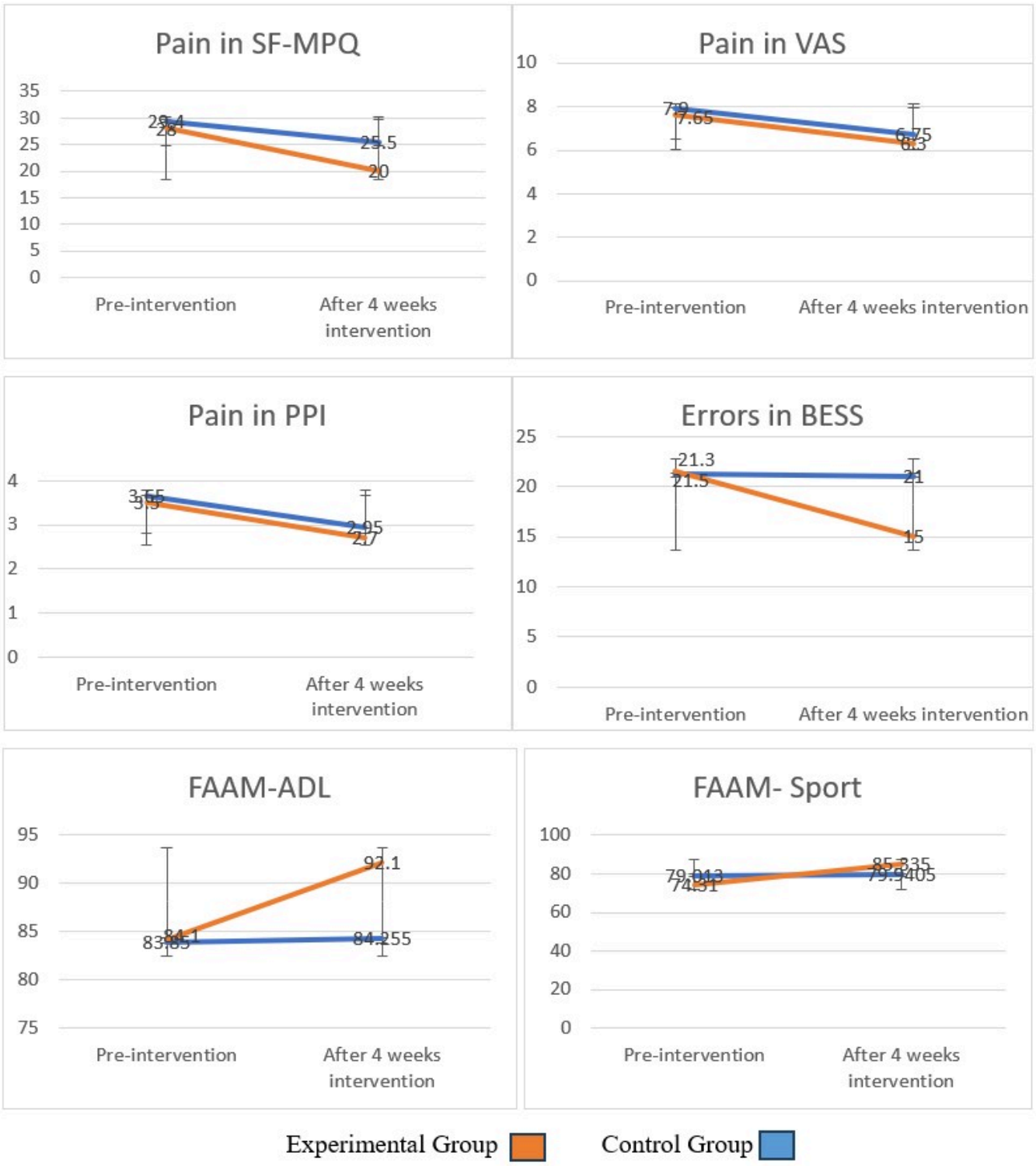


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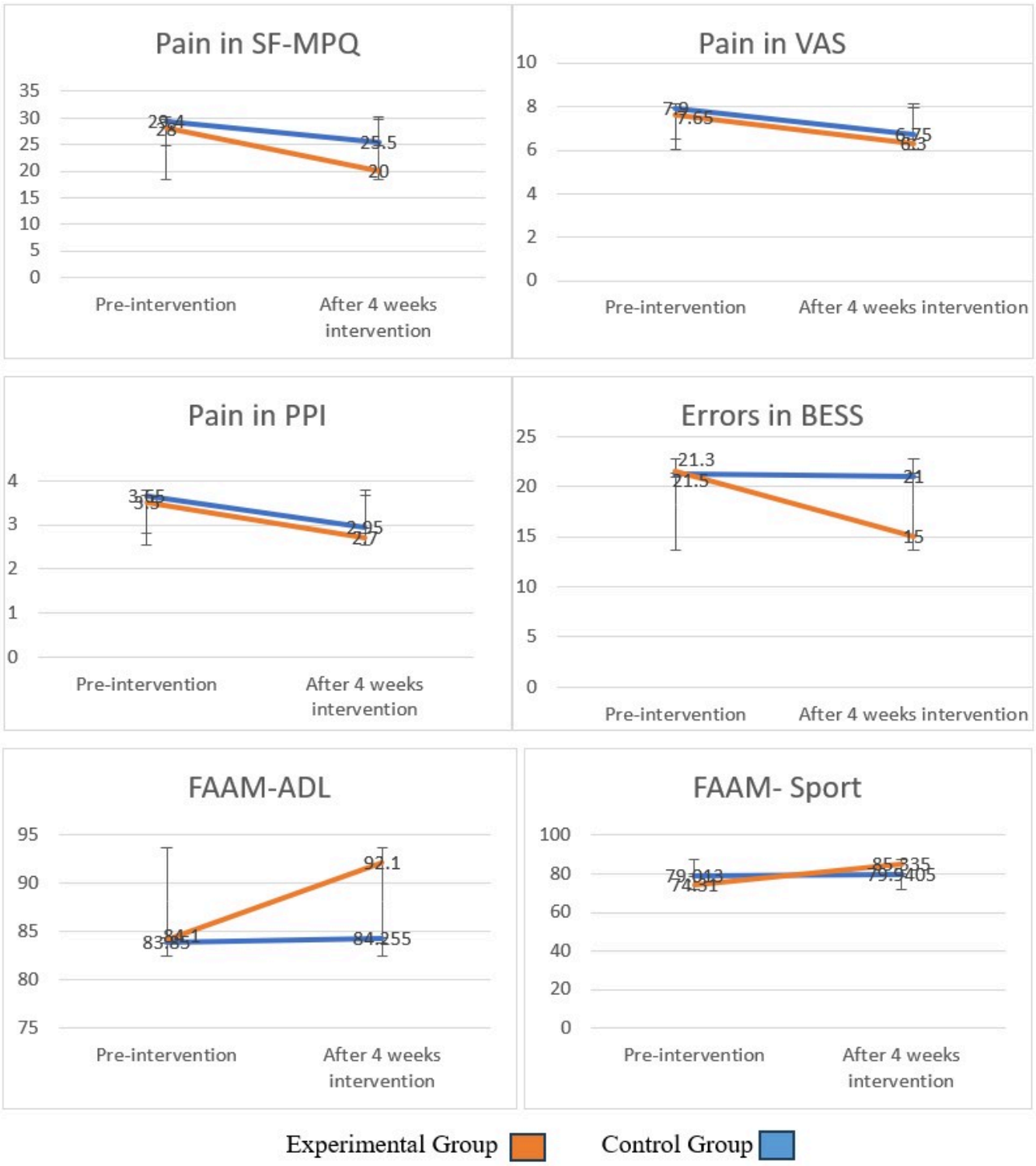


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