Original Research

A Prospective, Randomized, Controlled Trial Comparing Conservative Treatment With Trunk Stabilization Exercise to Standard Hip Muscle Exercise for Treating Femoroacetabular Impingement: A Pilot Study

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Abstract

Objective: To assess the efficacy of conservative management of women with femoroacetabular impingement (FAI) using trunk stabilization. **Design:** Randomized controlled trial (level of evidence: I). **Subjects:** Twenty FAI female patients who met the inclusion FAI criteria. **Methods:** A prospective, randomized, controlled study was performed on 20 female patients with symptomatic FAI comprising 2 groups (10 hips in trunk stabilization exercise group vs 10 hips in control group). We evaluated hip range of motion, isometric muscle strength using a handheld dynamometer (μ-TasMF-01; Anima, Co), and patient-reported outcome measures, including modified Harris hip score, Vail hip score, and international hip outcome tool 12 (iHOT12) before and at 4 weeks and 8 weeks after the intervention. **Results:** There was a significant improvement in the range of motion of hip flexion in the trunk training group detected as early as 4 weeks after the intervention compared with the control group ($P < 0.05$). Hip abductor strength significantly improved in the trunk training group at 4 weeks after the intervention, whereas it did not improve in the control group ($P < 0.05$). Vail hip score and iHOT12 were significantly increased at 8 weeks after the intervention in the trunk training group compared with the control group (iHOT12: 78.7 ± 22.4 vs 53.0 ± 22.3; $P < 0.01$, Vail hip score: 81.6 ± 18.5 vs 61.1 ± 11.6; $P < 0.05$). There was no significant difference in the modified Harris hip score between both the groups at 4 and 8 weeks after the intervention. **Conclusions:** The addition of trunk stabilization exercise to a typical hip rehabilitation protocol improves short-term clinical outcomes and may augment nonoperative and postoperative rehabilitation.

Key Words: femoroacetabular impingement, trunk stabilization exercise, conservative treatment, trunk stabilization

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INTRODUCTION

Femoroacetabular impingement (FAI) has been defined as a condition resulting from abutment of the proximal femur against the acetabulum.[1–3] Repetitive impingement between

the femoral head–neck junction and anterior superior aspect of the acetabulum can result in hip pain, chondrolabral damage, and subsequent osteoarthritis.[4–6]

Surgical treatment for FAI comprises addressing labral pathology via repair, reconstruction, and, at times, selective debridement and eradication of causative osseous deformities.[7] Numerous studies demonstrate generally favorable clinical results and functional improvement following either open surgical dislocation or arthroscopic hip preservation procedures for FAI.[8–14] However, there are limited data regarding appropriate conservative treatment for FAI.[15,16]

Conservative treatment for FAI is controversial.[17,18] Patient education, activity and sport modification, and physical therapy seem to be beneficial.[16,17] However, there are no high level of evidence studies to substantiate this. Wall et al[17] stated that nonoperative treatment regimens need to be evaluated more extensively and rigorously, preferably compared with operative care, to determine true clinical effectiveness.[14] Initial conservative management is reasonable,[18] and it is important to validate the clinical efficacy and effectiveness of nonoperative treatment for patients with contraindication or lack of desire for elective surgery or both.

Recent studies have demonstrated the effectiveness of core stability training with contraction of the transverse abdominis and pelvic floor muscles for treating adductor-related groin

pain and osteitis pubis.[19–21] The purpose of this study was to investigate the effects of trunk muscle training on hip range of motion (ROM), hip muscle strength, and patient-reported outcome (PRO) scores in women with symptomatic FAI. We hypothesized that trunk stabilization exercise provides clinical benefit in female patients with symptomatic FAI.

METHODS

The local institutional review board approved the study, and all study subjects provided informed consent. Twenty-four female patients with unilateral symptomatic FAI from March 2014 to April 2016 at our hip specialty clinic were enrolled.

All patients met the inclusion criteria for FAI.[22] Inclusion criteria were symptomatic female patients between 15 and 55 years with FAI on physical examination and radiographs. Clinical inclusion criteria were groin pain for more than 3 months, restricted hip ROM (flexion < 105 degrees or restricted internal rotation in flexion < 20 degrees or both), and a positive anterior impingement test. Anterior impingement test was performed in the supine position with hip internal rotation applied to the flexed (90 degree) and adducted hip[1] with elicited pain at terminal range being a positive test. Radiographic evidence of a cam deformity was defined as an alpha angle of >50 degrees or head–neck offset of <8 mm on any radiographic, computed tomography, or magnetic resonance imaging view.[23,24] Radiographic evidence of a pincer deformity was defined as a positive crossover sign in the presence of a lateral center edge angle (LCEA) of ≥30 degrees, LCEA of 40 degrees, or acetabular inclination of <0 degree.[25–27] Radiographic FAI subtype was additionally classified as isolated cam, isolated pincer, or combined FAI. Exclusion criteria were patients with bilateral symptomatic FAI, older than 55 years at first presentation, history of hip surgery, presence of developmental dysplasia of the hip, slipped capital femoral epiphysis or Perthes disease, and significant osteoarthritis of the hip joint (Tönnis grade ≥ 2).

Twenty-four female patients met the inclusion criteria; however, 4 patients were excluded because they were lost to follow-up.

In accordance with the temporal order in which physical therapy was prescribed, patients were assigned to 2 groups alternately with odd number assigned to trunk training group and even number assigned to control group. Ten patients underwent pelvic floor muscle training with trunk training (trunk training group), and 10 patients underwent pelvic floor muscle training only (control group). Figure 1 shows the flow of patients through the trial. Of 635 patients treated during the study period, we excluded 154 male patients, and 420 patients met the following exclusion criteria: 188 patients had osteoarthritis of hip, 164 patients had developmental dysplasia of hip, 60 patients had previous surgery of hip, 7 patients had fracture of femur and pelvis, and 1 patient had history of Perthes disease. Of 61 female patients diagnosed with FAI, 12 patients with bilateral symptoms and 10 patients older than 55 years were excluded. Fifteen patients did not wish to participate in our study. Of the remaining 24 patients participated, 20 patients (83%) completed the intervention protocol with 2 patients lost to follow-up in each cohort, leaving 10 study and 10 control patients comprising the substance of this study.

No patients received intra-articular injections of any type. However, 4 patients (2 cases in control group and 2 cases in trunk training group) used occasional nonsteroidal anti-inflammatory drugs. There were no significant differences of cases and in the amount of nonsteroidal anti-inflammatory drugs consumed during intervention between the groups.

Rehabilitation Protocol

The rehabilitation protocol consisted of patient education including activity modification and the control of gluteal muscles, based on prior reports of conservative
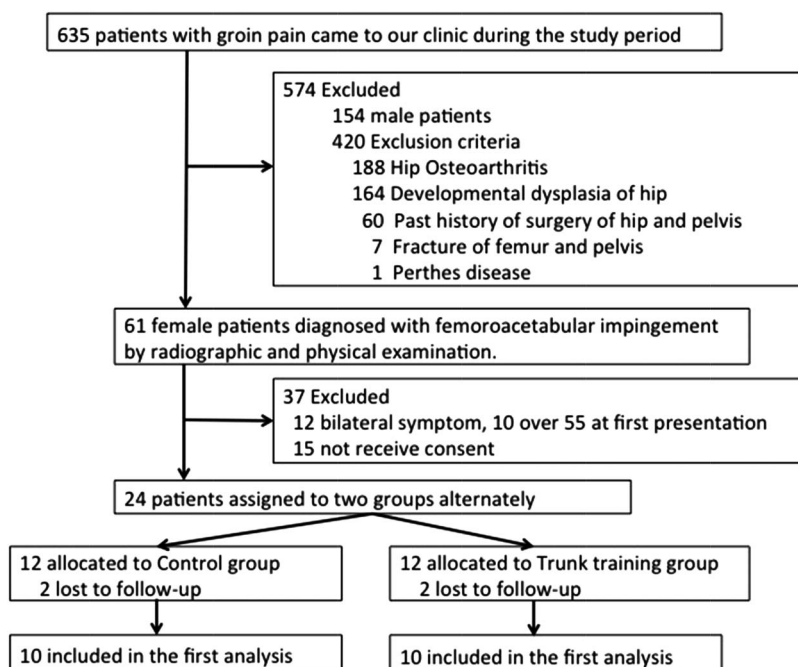

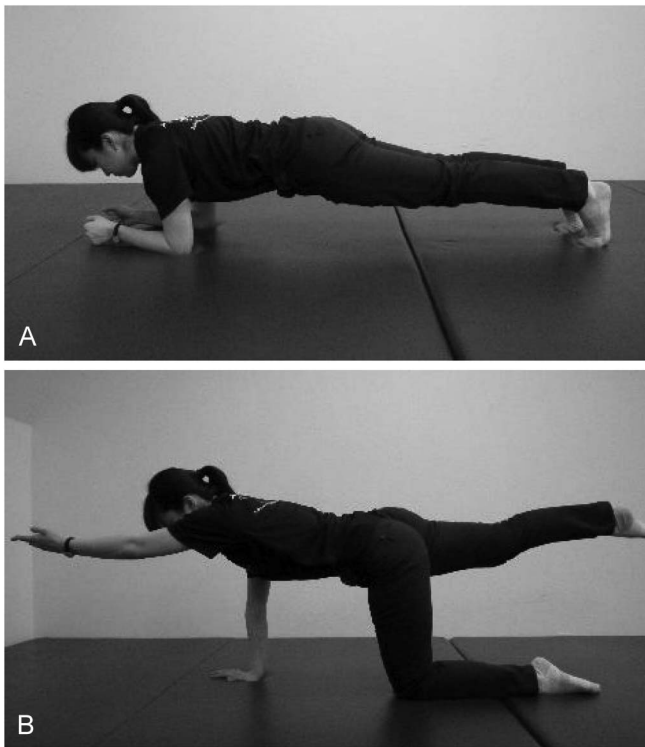
Figure 1. Participant flowchart.

Figure 2. Trunk stabilization training. A, Plank. B, Bird dog.

(Figure 2B) exercises, which induce contractile activity of the deep trunk muscles (eg, transverse abdominis and internal oblique).[30] (4) Plank exercises were performed for 30 seconds duration × 5 sets, and (5) bird dog exercises (quadruped exercise with contralateral arm and leg raise) were performed 20 times × 3 sets on left and right sides with postural retention for 3 seconds. The patients in the trunk training group underwent both protocols, but patients in control group received only hip and pelvic girdle protocol. To prescribe equivalent training loads to each group, (1) and (2) were performed for 5 sets and (3) was performed for 3 sets in the control group. Resultant training session durations were 20 minutes in both the groups. Daily training was performed for 8 weeks. Compliance status was confirmed verbally and with documented records during every visit (Table 1).

Clinical Assessment

We assessed the patients' age, height, weight, body mass index, the duration from onset pain to the beginning of intervention at the time of first visit, and Tegner activity score. We obtained PRO scores using the modified Harris hip score (MHHS),[10] Vail hip score,[31] and international hip outcome tool 12 (iHOT12)[32] at prerehabilitation and 4 weeks and 8 weeks during the intervention. The iHOT12 has almost equivalent responsiveness and validity to the iHOT33, which is highly responsive with a small minimal clinically important difference (6.1).[33] The MHHS is a commonly used PRO score, and its minimal clinically important difference has been reported as 8.[34] We documented hip-related symptoms that occurred in the previous week when assessing PRO scores.

Radiographic Assessment

Two authors (H.U. and S.K.) performed formal radiographic assessment of all patients using a picture archiving and communication system to determine which radiographic parameters were predictors for a worsened clinical outcome. We measured the LCEA, the Tönnis angle, and femoral neck shaft angle (FNSA) on a pelvic AP view, and the alpha angle on cross table lateral view or modified Dunn view.[23,35] The LCEA was used to define the lateral coverage of acetabulum.[36] The Tönnis angle was used as a measure of acetabular inclination.[37] The Sharp angle was used as a measure of acetabular index.[38] The FNSA was calculated by a line through the center of the neck and the center of the head and a line parallel to the femoral shaft, as determined by the direction of the shaft below the lesser trochanter.[39] We used the alpha angle as a measure of cam-type impingement,[24] recording the highest alpha angle obtained from an AP view, a lateral radiographic view, and a modified Dunn view of the symptomatic hip.[24,40]

treatment.[16,28,29] Before the beginning of intervention, 5 patients in the control group and 7 patients in the trunk training group had refrained from sports activities because of groin pain. All patients were instructed to modify activities of daily living, including avoidance of squatting, prolonged sitting, and cessation of any athletic activities causing groin pain during the intervention period.

Hip and Pelvic Girdle Protocol

Both cohorts received identical buttock muscle training and pelvic floor muscle training, that is, (1) hip abduction exercise 15 times × 3 sets in the lateral position, (2) buttock elevation exercise 20 times × 3 sets in hook lying position (supine position with 45 degrees hip flexion and 90 degrees knee flexion), and (3) anteroposterior (AP) pelvic tilt exercise for 5 seconds each 10 times × 2 sets in the same hook lying position. All exercises were to be performed at pain-free maximal ROM regardless of plane.

Trunk Stabilization Protocol

Patients in the study cohort additionally received demonstration and training of plank (Figure 2A) and bird dog

TABLE 1. Rehabilitation Protocol for the Trunk Training Group and the Control Group		
	Control Group	**Trunk Training Group**
General exercise	(1) Hip abduction exercise, 15 times × 5 sets	(1) Hip abduction exercise, 15 times × 1 sets
	(2) Buttock elevation exercise, 20 times × 5 sets	(2) Buttock elevation exercise, 20 times × 3 sets
	(3) Pelvis tilting exercise, 10 times × 3 sets	(3) Pelvis tilting exercise, 10 times × 2 sets
Trunk stabilization exercise		(4) Plank, 30 s × 5 sets
		(5) Bird dog, 20 times × 3 sets

TABLE 2. Group Characteristics

	Control Group (10)	Trunk Training Group (10)	Significance, *P*
Mean age (y)	45.8 (29-54)	43.3 (31-54)	0.55
Height (cm)	155.1 ± 3.5	158.5 ± 4.7	0.09
Weight (kg)	47.7 ± 3.6	48.8 ± 3.8	0.52
Body mass index	19.8 ± 1.6	19.5 ± 1.9	0.67
Tegner activity score	3.1 ± 0.6	3.2 ± 0.6	0.76
Anteversion (degree)	24.4 ± 4.3	23.8 ± 5.6	0.78
MHHS	79.7 ± 8.2	78.5 ± 13.0	0.82
Vail hip score	62.2 ± 9.9	58.9 ± 12.8	0.54
iHOT 12	45.8 ± 24.1	49.2 ± 18.4	0.73
Duration of pain (d)	456 (23-734)	167 (18-525)	0.19

Unpaired t *test, Mann–Whitney* U *test for duration of pain.*
iHOT, international hip outcome tool; MHHS, modified Harris hip score.

Examiners

The interobserver and intraobserver reliabilities of these radiographic parameters were investigated in all blinded patients. For intraobserver reliability, 1 hip surgeon (S.K.) measured each radiograph 3 times, with an interval of at least 1 week between the measurements. For interobserver reliability, 2 hip surgeons with 6 and 12 years of experience (H.U. and S.K.) performed the radiographic review independently and were blinded to the clinical data and details of radiology reports (Table 2). Interclass correlation coefficients (ICCs) and corresponding 95% confidence intervals (CIs) were calculated to quantify interobserver and intraobserver reliabilities for continuous variables. The weighted kappa value was used to determine a broken Shenton line. Based on the standards for the kappa statistic proposed by Landis and Koch, our measurements were in substantial agreement[41] (Table 3).

Hip Range of Motion Measurements

Range of motion measurements were hip flexion, extension, adduction, abduction, internal rotation, and external rotation. Internal and external rotations were measured with the limb at both 0 and 90 degrees of flexion. The pelvis was secured to the examination table with a pelvic strap to minimize confounding pelvic motion or tilt during each measurement. Each side was measured twice, and the mean value was calculated. Examiner reproducibility of measurement performed on 10 healthy people, and was the ICC (1,1): 0.94 to 0.98.

Muscle Strength Assessment

Isometric hip flexor and extensor, and abductor and adductor muscle strength were measured using a handheld dynamometer (μ-TasMF-01; Anima Co. Tokyo).[42] The pelvis was stabilized to the examination table using the aforementioned strap. We measured muscle strength twice and adopted the stronger one as each muscle strength and calculated the body weight ratio. Examiner reproducibility of the measurement was carried out with respect to 10 healthy people, and it was the ICC (1,1): 0.87 to 0.92.

Holding time of the side bridge posture in the involved side to the lower side was measured as the trunk muscle strength.[30] It was measured once after performing sufficient practice. The examiner checked deflection of the pelvis, defined as the inability to retain initial proper position with excursions of at least 50% of pelvic width in the AP and vertical directions any time during the 60-second testing period.

Femoral Anteversion Angle

Following the method of the Craig test, the involved lower limbs were placed in 0-degree hip extension and 90-degrees knee flexion in the prone position. A digital camera from the foot of the examination table determined the hip rotation position, where the greater trochanter was most prominent laterally.[43] Then, the angle between the vertical line and the tibial long axis of the floor was recorded as the femoral anteversion angle using an image analysis software (Image J, National Institutes of Health, USA).

Examiner reproducibility of the measurement carried out with respect to 10 healthy people and was the ICC (1,1): 0.98.

TABLE 3. Interrater and Intrarater Reliability Study

	Interrater Reliability		Intrarater Reliability	
	r	*P*	r	*P*
LCEA	0.696	0.001	0.993	<0.001
Sharp angle	0.485	0.03	0.414	0.07
FNSA	0.717	0.001	0.999	<0.001
Tönnis angle	0.819	<0.001	0.998	<0.001
Alpha angle	0.199	0.652	0.998	<0.001

Interobserver reliability for 1st and 2nd observers and intraobserver reliability for continuous variables (CE angle, Sharp angle, Tönnis angle, alpha angle, FNSA). Data are ICCs for continuous variables.
FNSA, femoral neck shaft angle; LCEA, lateral center edge angle.

TABLE 4. Radiographic Parameters in the Trunk Training Group and the Control Group			
	Control Group (10)	**Trunk Training Group (10)**	**Significance, P**
LCEA (degree)	31.4 (23.0-38.0)	29.3 (26.0-37.0)	0.27
Tönnis angle (degree)	6.4 (1.0-12.0)	8.7 (3.0-18.0)	0.24
Alpha angle (degree)	64.0 (46.0-98.0)	65.0 (46.0-80.0)	0.86
Sharp angle (degree)	41.1 (38.0-46.0)	41.6 (32.0-47.0)	0.77
FNSA (degree)	133.3 (125.0-139.0)	133.0 (121.0-143.0)	0.91

Data are the mean of each parameter. Mann–Whitney U test.
FNSA, femoral neck shaft angle; LCEA, lateral center edge angle.

Statistical Analysis

The differences in each item in the preintervention were evaluated by the unpaired t test. The effect of intervention was evaluated by 2-way analysis of variance before and after the intervention. The main effects of each factor were determined by the multiple comparison method of Bonferroni in all combinations. Analysis was performed using IBM SPSS (version 22; SPSS, Inc, Chicago, Illinois), and the level of significance was set at $P < 0.05$.

RESULTS

Twenty female patients with a mean age of 45.1 ± 8.8 years (range, 29-55 years) and a mean follow-up period of 128.9 ± 82.0 days (range, 71-388 days) formed the substance of this study. There were 2 cases of combined type FAI, 17 cases of isolated cam-type FAI, and 1 case of isolated pincer-type FAI.

There was no significant difference between the respective trunk training group and control group with regard to sex, mean age, height, weight, body mass index, Tegner activity score, femoral anteversion angle, duration from onset pain to the beginning of intervention, MHHS, Vail hip score, and iHOT12 before any intervention, as shown in Table 2. There was a trend toward less duration of pain in the trunk stabilization group ($P = 0.19$).

Radiographic Assessment

The intertester reliability of radiographic parameters ranged from 0.18 to 0.81 (LCEA, 0.69; Tönnis angle, 0.81; alpha angle, 0.18; Sharp angle, 0.48; FNSA, 0.71) (Table 3). The intratester reliability of radiographic parameters ranged from 0.41 to 0.99 (LCEA, 0.99; Tönnis angle, 0.99; alpha angle, 0.99; Sharp angle, 0.41; FNSA, 0.99). There was no significant difference of all radiographic parameters including LCEA, Tönnis angle, alpha angle, Sharp angle, and FNSA between both the groups, as shown in Table 4.

Physical Examination

Physical examination demonstrated a significant improvement in hip flexion in the trunk training group detected as early as 4 weeks after the intervention compared with the control group (Bonferroni post hoc test, $P < 0.05$), whereas there was no significant differences in other hip ROMs between the cohorts (Table 5).

Hip flexor strength significantly improved at 8 weeks after the intervention compared with preintervention in both the groups. In the trunk training group, hip flexor strength significantly improved from 0.74 ± 0.12 N·m/kg to 0.91 ± 0.23 N·m/kg; in control group, it improved from 0.71 ± 0.16 N·m/kg to 0.87 ± 0.14 N·m/kg (Bonferroni post hoc test, $P < 0.05$). Hip abductor strength also significantly improved in the trunk training group from 1.01 ± 0.24 N·m/kg to 1.16 ± 0.22 N·m/kg at 4 weeks after the intervention (Bonferroni post hoc test, $P < 0.05$). Hip extension and adductor strength and postural retention time of the side bridge were not significantly different between the cohorts (Table 6).

Patient-Reported Outcome Scores

Patient-reported outcome scores including iHOT12, Vail hip score, and MHHS were obtained at prerehabilitation and 4 weeks and 8 weeks during the intervention. The mean iHOT12 significantly increased from 49.2 ± 18.4 to 68.0 ± 19.4 at 4 weeks of intervention in the trunk training group (Bonferroni post hoc test, $P < 0.01$) and to 78.7 ± 22.4 at 8 weeks of intervention (Bonferroni post hoc test, $P < 0.05$) in the trunk training group. There was no improvement in the control group (Figure 3). The mean iHOT12 also significantly increased at 4 and 8 weeks of intervention in the trunk training group compared with the control group (at 4 weeks, trunk training group: 68.0 ± 19.4; control group: 52.8 ± 22.7; $P < 0.05$: at 8 weeks, trunk training group: 78.7 ± 22.4; control group: 53.0 ± 22.3; $P < 0.01$) (Figure 3).

TABLE 5. Range of Motion in the Trunk Training Group and the Control Group						
	Control Group			**Trunk Training Group**		
ROM (Degree)	**Preintervention**	**4 wk**	**8 wk**	**Preintervention**	**4 wk**	**8 wk**
Flex	108.8 ± 3.5	109.1 ± 3.6	111.1 ± 6.7	110.0 ± 9.2	112.4 ± 6.4*	113.3 ± 6.0
Abd	36.7 ± 3.4	36.2 ± 5.2	37.3 ± 6.4	34.8 ± 5.4	38.7 ± 5.3	39.9 ± 3.5
Add	19.2 ± 5.4	18.4 ± 4.3	18.2 ± 3.0	19.6 ± 4.5	18.5 ± 3.7	18.3 ± 3.1
ER (90 degree)	40.4 ± 12.2	44.4 ± 6.5	44.2 ± 7.9	42.1 ± 11.9	44.5 ± 10.2	48.1 ± 10.1
IR (90 degree)	39.9 ± 8.8	41.2 ± 9.1	40.0 ± 8.0	40.3 ± 7.9	41.2 ± 9.8	43.6 ± 8.4
Ext	13.7 ± 4.6	14.1 ± 4.8	14.9 ± 3.4	14.1 ± 4.9	15.1 ± 4.4	16.8 ± 4.4
ER	26.2 ± 6.6	26.5 ± 7.8	25.1 ± 6.7	25.1 ± 9.1	26.4 ± 8.5	28.1 ± 7.9
IR	46.5 ± 11.5	42.1 ± 8.5	41.7 ± 10.3	42.7 ± 11.4	43.7 ± 10.0	43.2 ± 9.0

Data are the mean of each direction and SD. Two-way analysis of variance.
*P < 0.05, 2-way analysis of variance, compared with control group at 4 weeks after the intervention.
Abd, abduction; Add, adduction; ER, external rotation; Ext, extension; Flex, flexion; IR, internal rotation; ROM, range of motion.

TABLE 6. Muscle Strength in the Trunk Training Group and the Control Group

Muscle (Nm/kg)	Control Group			Trunk Training Group		
	Preintervention	4 wk	8 wk	Preintervention	4 wk	8 wk
Flexor	0.71 ± 0.16	0.87 ± 0.16	0.87 ± 0.14*	0.74 ± 0.12	0.86 ± 0.15	0.91 ± 0.23†
Extensor	0.77 ± 0.14	0.88 ± 0.22	0.84 ± 0.18	0.87 ± 0.20	0.98 ± 0.26	0.90 ± 0.18
Abductor	0.81 ± 0.21	0.99 ± 0.15	0.95 ± 0.17	1.01 ± 0.24	1.16 ± 0.24‡	1.06 ± 0.13
Adductor	0.77 ± 0.13	0.88 ± 0.08	0.81 ± 0.18	0.91 ± 0.17	1.02 ± 0.20	0.94 ± 0.16
Side Bridge	30.3 ± 17.4	33.1 ± 14.2	32.0 ± 16.4	32.6 ± 19.6	38.6 ± 20.3	43.4 ± 16.6

Data are the mean and SD. Two way analysis of variance.
*P < 0.05, 2-way analysis of variance, compared with preintervention.
† P < 0.05, 2-way analysis of variance, compared with preintervention.
‡ P < 0.05, 2-way analysis of variance, compared with preintervention.

The mean Vail hip score significantly increased from 58.9 ± 12.8 to 73.4 ± 17.4 at 4 weeks of intervention in the trunk training group (Bonferroni post hoc test, $P < 0.01$) to 81.6 ± 18.5 at 8 weeks of intervention (Bonferroni post hoc test, $P < 0.01$) in the trunk training group. The mean Vail hip score in trunk training group was significantly higher than that in the control group at 8 weeks (trunk training group: 81.6 ± 18.5; control group: 61.1 ± 11.6 points; $P < 0.05$) (Figure 4).

The mean MHHS significantly improved from 78.5 ± 13.0 to 90.7 ± 11.1 at 4 weeks (Bonferroni post hoc test, $P < 0.01$) and to 95.0 ± 9.3 points at 8 weeks (Bonferroni post hoc test, $P < 0.01$) in the trunk training group, although there was no statistically significant difference in MHHS between cohorts at 4 and 8 weeks after the intervention. There was no improvement in the control group (Figure 5).

After the intervention, 4 patients of control group and 7 patients of trunk training group were able to return their previous activities without pain. The other 9 patients (3 from trunk training group and 6 from control group) were unable to completely return to sports activities because of residual hip pain. However, 4 (1 from trunk training group, 3 from control group) of these 9 patients had no symptoms with daily life activities after the intervention. Regarding sports activities, these 9 patients continued cessation of any aggravating activities during the intervention and after the intervention because of residual pain.

DISCUSSION

To our knowledge, this is the first report of the effect of trunk training on hip ROM, hip muscle strength, and clinical outcome in female patients with symptomatic FAI. In this study, we demonstrated that trunk muscle exercise, when added to hip and pelvic girdle exercise, significantly improved (1) hip ROM, specifically hip flexion, (2) hip strength in flexion and abduction, and (3) PRO scores (Vail hip score and iHot-12) compared with control group with hip muscle exercise only. These findings support the addition of trunk muscle training exercises to a conservative program for female FAI patients.

A recent systematic review demonstrated that physiotherapy and patient education can be effective for managing symptoms of patients with FAI.[17] In this review, however, there were few studies detailing the specific treatment regimens. In addition, Yazbek et al[28] reported that physical therapy comprising hip and trunk stabilization, correction of hip muscle imbalances, and biomechanical control were effective in 4 cases with FAI and concomitant labral tear, emphasizing the importance of the dynamic stability of the pelvis. In fact, hip pain in those cases significantly decreased in 2 or 3 weeks after dynamic pelvic stabilization exercise and posture guidance, enabling patients to proceed to the next stage of intervention. Similarly, our findings demonstrated
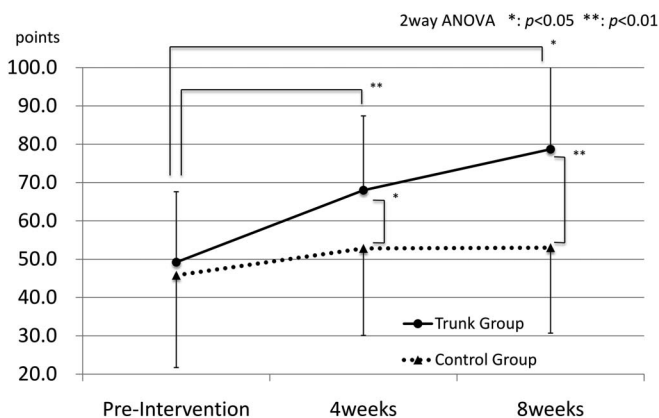
Figure 3. Patient-reported outcome score iHOT12 at preintervention and 4 weeks and 8 weeks after the intervention. Error bur: standard deviation. Two-way analysis of variance and Bonferroni post hoc test, **P < 0.05, **P < 0.01.*
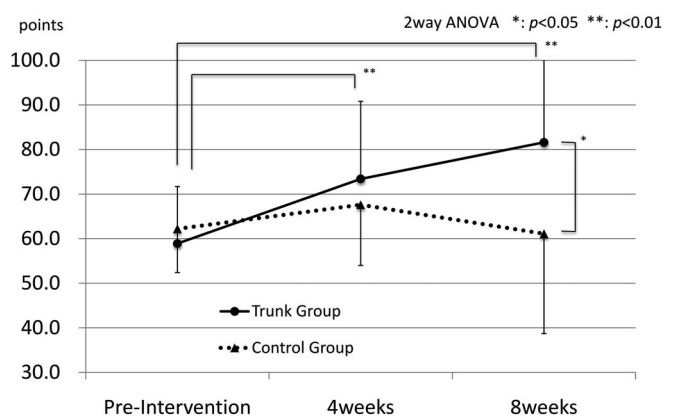
Figure 4. Patient-reported outcome score Vail hip score at preintervention and 4 weeks and 8 weeks after the intervention Error bur: standard deviation. Two-way analysis of variance and Bonferroni post hoc test, **P < 0.05, **P < 0.01.*
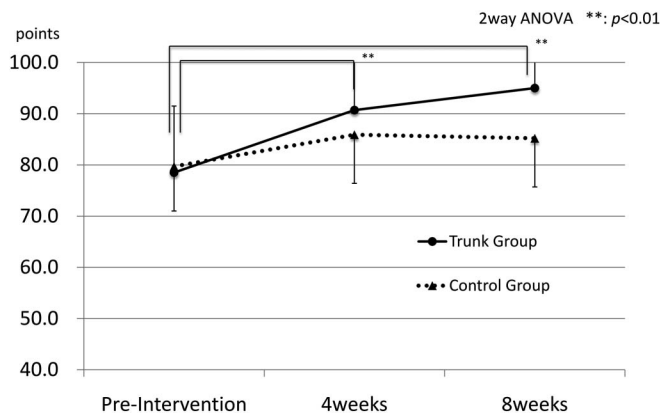
Figure 5. Patient-reported outcome score modified Harris hip score at preintervention and 4 weeks and 8 weeks after the intervention. Error bur: standard deviation. Two-way analysis of variance and Bonferroni post hoc test, **$P < 0.01$.

that PRO scores in patients who were in the trunk training group improved beyond those in the control group. Furthermore, significantly improved PRO scores are recognized as early as 4 weeks in the trunk training group, similar to the report of Yazbek et al.[28]

Among a wide variety of trunk stabilization exercises, rehabilitation of the transverse abdominis muscle has been defined as critical for pelvic stabilization.[44] Okubo et al[45] demonstrated that increased transverse abdominis activity is observed during the plank exercise and bird dog exercise. Thus, we selected plank exercise and bird dog exercise for the trunk stabilization protocol.

On the other hand, the side bridge exercise is also one of the most effective trunk stabilization training exercises.[44,46] Side bridging has been demonstrated to be an effective and reproducible trunk stabilization exercise,[30,44,47] but difficulty in maintaining proper posture because of pain and dysfunction limits its utility. Hence, we opted to not add the side bridge to our trunk stabilization protocol.

Regarding hip ROM, there was significantly more improvement in flexion in the trunk training group compared with the control group as early as the 4-week time point. Moreside and McGill[48] reported that hip ROM improved significantly after the 6-week intervention of motor control exercises for the hip and trunk, such as bird dog and plank, and core endurance exercises compared with the control group. They suggested that the proximal stiffness might affect distal mobility. Hodges and Moseley[49] demonstrated that the deep muscles (eg, transverse abdominis) contribute to important spinopelvic stabilization, whereas superficial muscles (eg, biceps femoris and hip adductors) normally do not. However, if the deep muscles are weak, the superficial muscles play a significant compensatory role. Thus, by strengthening the trunk muscles, the superficial pelvic stabilizing muscles (that were compensating for this weakness in female patients with FAI) may become less spastic and painful compared with the control group. This may have contributed to the improved hip flexion range observed in this study with the addition of trunk stabilization. Hip flexor and abductor strength were also significantly more improved in trunk training group than in the control group.

There were significant differences between the trunk training group and the control group at 4 and 8 weeks after treatment in iHOT12 and at 8 weeks after treatment in Vail hip score. However, there were no differences in MHHS. Although PRO scores are useful in the assessment of pain and function,[50,51] they vary in their ability to detect athletic or more strenuous function. The iHOT12 has been validated as an instrument to measure health-related quality of life in young, active patients with hip disorders.[51] The Vail hip score also assesses hip function in active patients, measuring pain with squatting or during sports activities, or when excessive load is generated in the hip. In contrast, the MHHS assesses primarily sedentary activities of daily living and pain and function during walking, and it has a ceiling effect for more rigorous activities typical of patients with FAI. This may explain our findings of improved iHOT12 and Vail hip scores, which might not have been detected with the MHHS.

We acknowledge that although trunk stabilization significantly benefits short-term clinical outcome in the nonoperative setting, we may not conclude that nonoperative treatment of symptomatic FAI is preferable to surgical treatment. Moreover, the findings of this study may have implications and application beyond nonoperative management. Trunk stabilization may provide incremental improvement to postoperative rehabilitation protocols, which merits further investigation.

There were some limitations for this pilot study including the small number of cases and short-term follow-up. Larger cohorts with longer follow-up may support stronger or different conclusions. Another limitation is that a power analysis was not performed for appropriate sample size. Although this prospective randomized study exhibited no statistically significant differences between cohorts, there was a trend suggesting a shorter duration of pain before the initiation of treatment regimens in the trunk stabilization group. Because the duration of pain in the control group is not a parametric data, the difference in median between the trunk training group (167 days) and the control group (456 days) was evaluated by Mann–Whitney U test. The results were not significant ($P = 0.19$); however, there was a trend toward less duration in the trunk training group, which we consider a study limitation. Male symptomatic FAI patients were also excluded from this study, so the findings of this study cannot be generalized across genders. Regarding trunk muscle strength, a recent cross-sectional study demonstrated that the thickness of the transverse abdominal and internal abdominal muscles in asymptomatic men is significantly greater than those in women.[52] To eliminate a gender influence as a confounding variable, we limited this study to women. Further studies with larger numbers of both men and women are needed to evaluate the effects of trunk training on symptomatic hip FAI.

The activity level as measured by the Tegner activity score in the present study is relatively low: 3.1 to 3.3. Future investigation to evaluate the effect of trunk training for high-level athletes is merited. The MHHS has a significant ceiling effect, limiting its ability to assess athletic performance.[50] However, we used 2 additional PRO scores with less ceiling effect. This study did not investigate the relative benefit of formal physiotherapy versus a home exercise program that incorporates trunk stabilization. Moreover, this study does not compare any treatment, home treatment, or surgical treatment to the exercise regimen included in our

rehabilitation protocol. It also does not show patients to be completely asymptomatic following rehabilitation, comment on the return to their sports and daily activities, nor does it report patients' ultimate decision for or against surgery ≥2 years after the intervention.

CONCLUSIONS

The addition of trunk stabilization to a typical hip rehabilitation protocol improves short-term clinical outcomes and may augment nonoperative and postoperative rehabilitation.

CLINICAL MESSAGES

The addition of trunk stabilization exercises to a typical hip rehabilitation program improved short-term clinical outcomes in conservatively managed female patients with symptomatic unilateral FAI.

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