HIP JOINT RANGE OF MOTION IMPROVEMENTS USING THREE DIFFERENT INTERVENTIONS

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ABSTRACT

Moreside, JM and McGill, SM. Hip joint range of motion improvements using three different interventions. *J Strength Cond Res* 26(5): 1265–1273, 2012—The purpose of this study was to analyze the effect of 3 different exercise interventions plus a control group on passive hip range of motion (ROM). Previous research studies into the methods of improving passive hip mobility have focused on stretching protocols aimed specifically at the hip joint. The effect of core stabilization, motor training, and myofascial stretching techniques on hip mobility in a selected asymptomatic group with limited hip mobility is unclear. In this study, 24 young men with limited hip mobility (<50th percentile) were randomly assigned to 4 groups: stretching, stretching with motor control exercises for the hip and trunk, core endurance with motor control exercises, and the control group. Six-week home exercise programs were individually prescribed based on the assigned group, hip ROM, movement patterns, and timed core endurance. Two-way analyses of variances were conducted to analyze the effect of group assignment on hip ROM improvements. Both stretching groups demonstrated significant improvements in hip ROM ($p < 0.05$), attaining hip mobility levels at or above the 75th percentile, with rotation improving as much as 56%. The group receiving core endurance and motor control exercises with no stretching also demonstrated a moderate increase in ROM but only significantly so in rotation. Average core endurance holding times improved 38–53%. These results indicate that stretches aimed at the myofascial components of the upper body, in addition to the hip joint, resulted in dramatic increases in hip ROM in a group of young men with limited hip mobility. Hip ROM also improved in the group that did no active stretching, highlighting the potential role of including stabilization or "proximal stiffening training" when rehabilitating the extremities.

KEY WORDS hip mobility, stretching, core stabilization, motor training, myofascial

INTRODUCTION

Limitation of hip joint range of motion (ROM) is known to affect lumbar spine kinematics (20,21,31,38,43) and is a potential precursor to low back pain (LBP) (3,5,7,25,42,44). The obvious intervention to improve hip joint mobility would be a stretching program. But the question arises as to whether it is prudent to embark solely on a series of hip stretches to improve hip ROM, or whether a concurrent program of core stabilization exercises is warranted.

Previous research has emphasized that it may not be enough to simply look at total hip joint ROM as it affects lumbar spine kinematics, but the temporal quality of the hip-spine interaction must also be addressed (10,39,40). During prone hip rotation, people with LBP have been shown to demonstrate greater maximum lumbopelvic rotation angle, as well as earlier onset of lumbopelvic rotation, when compared with a non-LBP group (39). Not only does the LBP group rotate more in their spine at the end of hip rotation but also the spine appears to have less elastic resistance than the hip joint earlier in the activity. Rehabilitation in such a group might warrant focus on spine or "core" stabilization, that is, improving core muscular strength and endurance (22), in addition to motor control and positional awareness of the spine and hips during movement (6). Indeed, numerous authors have documented this link between diminished core stability and lower extremity injuries (11,29,48). Yet information on how core stability may affect lower limb flexibility is lacking. Constraining spine motion, while encouraging active utilization of the hip joints as the axes of rotation during functional activities, might alter the relative elastic equilibrium of these joints, resulting in more of the motion occurring in the hips and less in the spine. The notion of proximal stiffness in the torso enhancing distal mobility was proposed by Kibler et al. (19). This line of logic motivated the question, would a torso stiffening component assist hip stretching to create greater available passive ROM in the hip joints?

This study was approved by the University Office for Research Ethics and conducted at the University of Waterloo.

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Table 1. Percentile data of supine hip extension and prone rotation from a young adult male population (age, 18–35 years).*

	5th	10th	25th	50th	75th	90th	95th
Total rotation	44°	46°	53°	59 (11)°	66°	75°	82°
Internal rotation	12°	15°	20°	26 (8)°	31°	37°	42°
External rotation	19°	23°	28°	34 (9)°	40°	46°	50°
Hip extension	+8°	+6°	−2°	−1.5 (6)	−5°	−8°	−14°

*Hip extension measurements used the modified Thomas test for position, with degrees measured relative to the horizontal. Rotation measurements are relative to the vertical; 50th percentile data represents the mean (*SD*).

The question also arises as to the most effective method of increasing mobility at the hip joint. Traditionally, joint stretches have been aimed directly at the soft tissues surrounding the joint, with research focusing on variables such as stretch duration, limb position, and whether the applied stress was active or passive (2,18,26,32,33,45,46). Recent literature has revealed that myofascial connections transmit forces to adjacent musculotendinous structures in parallel and in series (13,23,30,34,47). Thus, to apply maximum tension to a soft tissue, this evidence suggests that stretch should also be applied to adjacent structures, such that associated myofascial connections are also under tension.

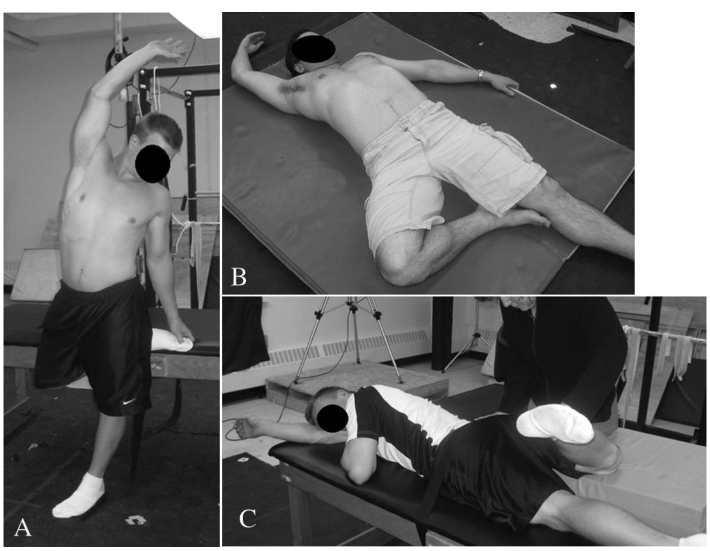

Figure 1. Examples of whole-body stretches incorporating myofascial principles aimed at increasing hip external rotation: A) and B) Self-stretches; C) Manual stretching by the researcher. In each case, the right arm is elevated, and when possible the torso is twisted to the left, and the hip extended to maximize tension in the entire right anterior aspect of the body.

To the best of our knowledge, no literature exists that examines the effect of core stabilization or myofascial stretch techniques on hip joint mobility.

Methods

Experimental Approach to the Problem

The purpose of this study was to analyze the effect of 4 different exercise interventions on passive hip ROM. The aims of the 4 interventions were as follows:

1. Group 1: passive stretches (traditional and myofascial) to improve hip joint rotation and extension
2. Group 2: passive stretches (traditional and myofascial) to improve hip joint rotation and extension, in addition to motor control exercises aimed at improving participants' understanding of an ability to coordinate lower limb movements without significant trunk movement (i.e., hip-spine disassociation exercises)
3. Group 3: improve trunk muscle endurance, in addition to hip-spine disassociation exercises. This group received no stretches
4. Group 4: control (no intervention).

Outcome measures included ROM of hip joint extension, internal rotation (IR), and external rotation (ER). Specific hypotheses being tested were as follows: hypothesis 1: all the 3 intervention groups will demonstrate a significant increase in passive hip extension and rotation, and hypothesis 2: 6 weeks of core endurance exercises (group 3) will result in a significant improvement in core endurance.

Subjects

Participants were selected based on having limited hip mobility. Previous research on populations with limited hip mobility has tended to focus on those with arthritic or neurologic impairments (4,17,21,43). Such conditions may also affect the efficacy of hip mobilizing protocols. Clinically, there also exist pain-free young adults who do not fall into

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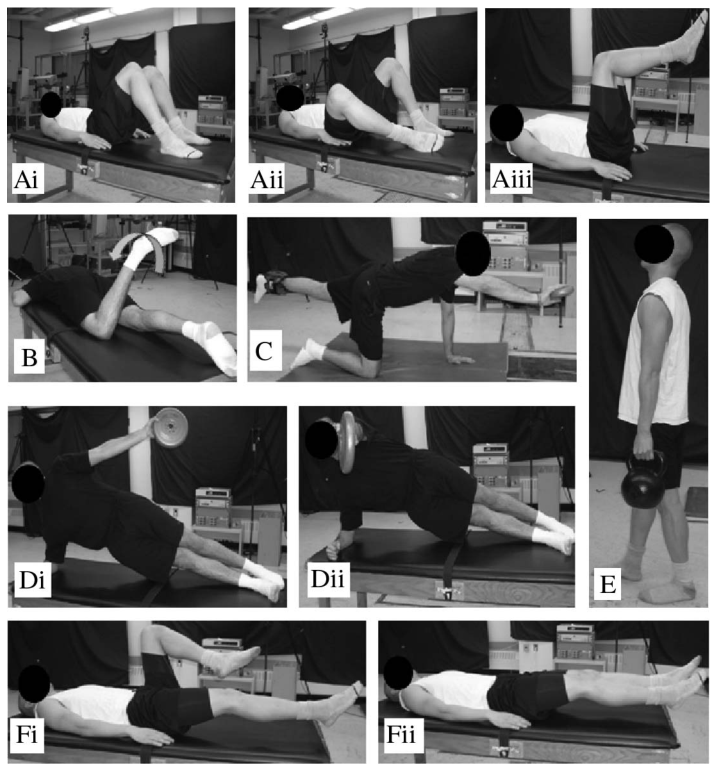

Figure 2. Examples of endurance and motor control exercises. Ai) Supine hip rotation, starting position. Aii) One leg at a time is allowed to rotate out to the side, while pelvic motion is kept to a minimum. Aiii) Progression involves legs being unsupported; weights may be added to ankles to further the challenge. B) Prone lying hip rotation: Internal and external hip rotation, while concurrent pelvis rotation is kept to a minimum. C) Bird-dog exercise: advanced level. Spine is to be kept in a neutral posture, while the opposing arm and leg are raised. Weights have been added to the limbs to increase difficulty. Further challenge would involve abduction and lowering of each limb, before returning to the midline position. Di) Side bridge. Dii) Side bridge with weight. Further progression would involve moving the weight in an anterior and posterior direction, to challenge rotational stability of the spine. E) Unilateral weight carry: 32 kg weight in one hand while maintaining an upright posture. Fi) Unilateral and bilateral abdominal exercises: from a starting position of both hips being flexed (as in Figure Aiii), one leg is slowly lowered to the plinth, then raised back up. Lumbar spine must be maintained in a neutral lordotic position. Fii) Progression involves lowering both legs simultaneously.

a pathological group yet demonstrate limited ROM of hip extension and rotation that may be because of several factors, including chronic exposure to certain activities. Normal and percentile data exist for hip ROM in such a group (Table 1) (27). Using this information, participants were recruited from the university population and surrounding area via posters and word of mouth, who demonstrated hip mobility of less than the 50th percentile, ideally in both directions. In total, approximately 250 men between 19 and 30 years were measured in an attempt to find participants who fit the criteria. Twenty-seven participants were identified with limited hip mobility and took part in the study. Two dropped out because of other commitments, and 1 because of illness, resulting in a total of 24 participants (mean height, 178.3 [7.1] cm; mean weight, 81.2 [15.05] kg). These individuals were randomly assigned to 4 groups for treatment protocol, based on the order of entrance to the study. All subjects were healthy without current hip or back pain or past pathology in these regions. Participants completed a written informed consent document approved by the University Office for Research Ethics of the University of Waterloo.

Procedures

Data Collection. Hip extension measurements were collected in supine lying, using the modified Thomas test (MTT) with the researcher controlling for abduction-adduction and rotation (16). With the participant lying supine, the researcher's hand was placed under the lumbar spine. Both hips were passively flexed until both parties agreed that the lordosis had reduced to a neutral position, indicating posterior rotation of the pelvis in the sagittal plane. The 'researcher's hand was then removed from the low back, and a blood pressure (BP) cuff replaced it (while returning the spine to the same approximate position) with the cuff then being inflated to 60 mm Hg. This pressure was monitored by the BP cuff as one of the participant's legs was lowered passively by the researcher to a position of maximum hip extension without associated changes in pelvic position-pressure. The opposite leg was held passively in a position of hip-knee flexion by the researcher, which maintained the BP cuff at approximately 60 mm Hg. Participants were encouraged to give feedback as to their perception of pelvis position, in an attempt to further minimize pelvic rotation during hip extension.

Hip rotation measurements were obtained with participants in prone lying with a securing strap around the pelvis. Bilateral IR movements were performed simultaneously, as participants were asked to let both lower legs fall out to the side, while maintaining the knees at 90° of flexion. External rotation required the leg of interest to passively rotate across the midline. Pressure was applied on the ipsilateral pelvis by the researcher to ensure that pelvis rotation did not occur. In those cases where large amounts of hip ER were present, the nontested leg was abducted approximately 10° to allow free motion of the tested leg (3).

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Table 2. Exercise progression for groups 2 and 3.†‡

subj #	Rx grp	classic bent-knee fallouts (BKFO)	BKFO with legs unsupported	unsupported BKFO with straight leg	weights added to ankle	prone lying hip rotation	lower abs with unilateral leg lowering	lower abs with sequential leg lowering	lower abs with bilateral leg lowering	lifting head and shoulders added	single leg stance: hip patterns	lunges, etc with stable pelvis	elastic resist hip motion in single leg stance	side bridge	side bridge with weight in upper hand	side-bridge with body rolling to opposite SB	bird dog: diagonal lifts	bird dog: arm/leg "squares"	weights added to ankle or hand	weights placed on back	plank	plank into side bridge	one armed plank	suitcase walk	body-blade
1	2	*	**	**		*	*	**			*	**	**												
6	2	*	**	**		*		*			*	**	**												
9	2	*	**	**				*			*	**	**	*			*								
14	2		*	**							*	**													
32	2	*	**	**							*	**			*							*	**		
4	2		*	**				*			*	**													
29	3	*	**	**	**		*	**	**	**	*	**		*	**		*	**	**	**	*		**	**	
31	3	*	**	**			*							*	**		*	**			*	**			
35	3		*	**	**			*	**		*	**			*		*	**							
34	3		*	**	**	*					*	**			*	**		*	**	**				**	**
37	3		*	**	**	*	*	**	**		*	**	**		*	**		*	**				**	**	
43	3	*	**	**		*			**	**	*	**		*	**			*	**			**			

*Beginning point of exercise regimen.

**An exercise progressed from one that was already in their routine.

†Exercises progress in difficulty as the columns move from left to right within the darker lines. Participants in group 2 were concurrently being given stretches to do at home, whereas those in group 3 only focused on core endurance, thus were generally able to progress to a higher level of difficulty. Criterion for progression of the nonendurance exercises was the ability to complete 20 successful repetitions without losing a neutral spine posture.

‡BKFO = bent knee fallouts; SB = side bridge.

Extension and rotation measurements were obtained using a standard goniometer modified with the addition of 2 spirit levels: one on each of the arms, to improve the accuracy of determining horizontal and vertical positioning (9). These measurement protocols have been previously described and have demonstrated high correlations with measurements obtained using a passive motion capture system (Pearson correlations, 0.94, 0.96, and 0.98 for extension, ER, and IR, respectively) (27). Every participant was positioned passively into hip extension and rotation by a physiotherapist who had more than 30 years of clinical experience. Measurements were obtained and recorded by an assistant without sharing the results with the researcher at the time. The order of measurements was randomized.

Endurance measurements were a timed protocol: the participants were asked to assume the specific posture (described below), and the sliding portion of a caliper was positioned at the body segment that was required to be maintained aloft. For example, during the side bridge, it was placed below the pelvis; for the Biering-Sorensen test, it was placed below the shoulder. When the participant was no longer able to maintain their body position above the caliper, the session ended. Only 1 test was performed for each position, as each was to exhaustion. Approximately 5 minutes rest separated each test.

Intervention Protocol. All the 4 intervention groups attended the initial and final measurement sessions 6 weeks apart, during which hip ROM was measured and endurance was tested in group 3. At the initial session, a home exercise program was individually tailored to each participant, based on his group assignment, current hip flexibility, endurance (group 3), and movement patterns. Groups 1–3 were then scheduled for weekly intervention sessions, which included passive stretching (groups 1 and 2), exercise coaching, and upgrading. Participants were required to exercise at home no less than 4 days per week and were provided with a logbook to assist with keeping track of the exercises. All participants

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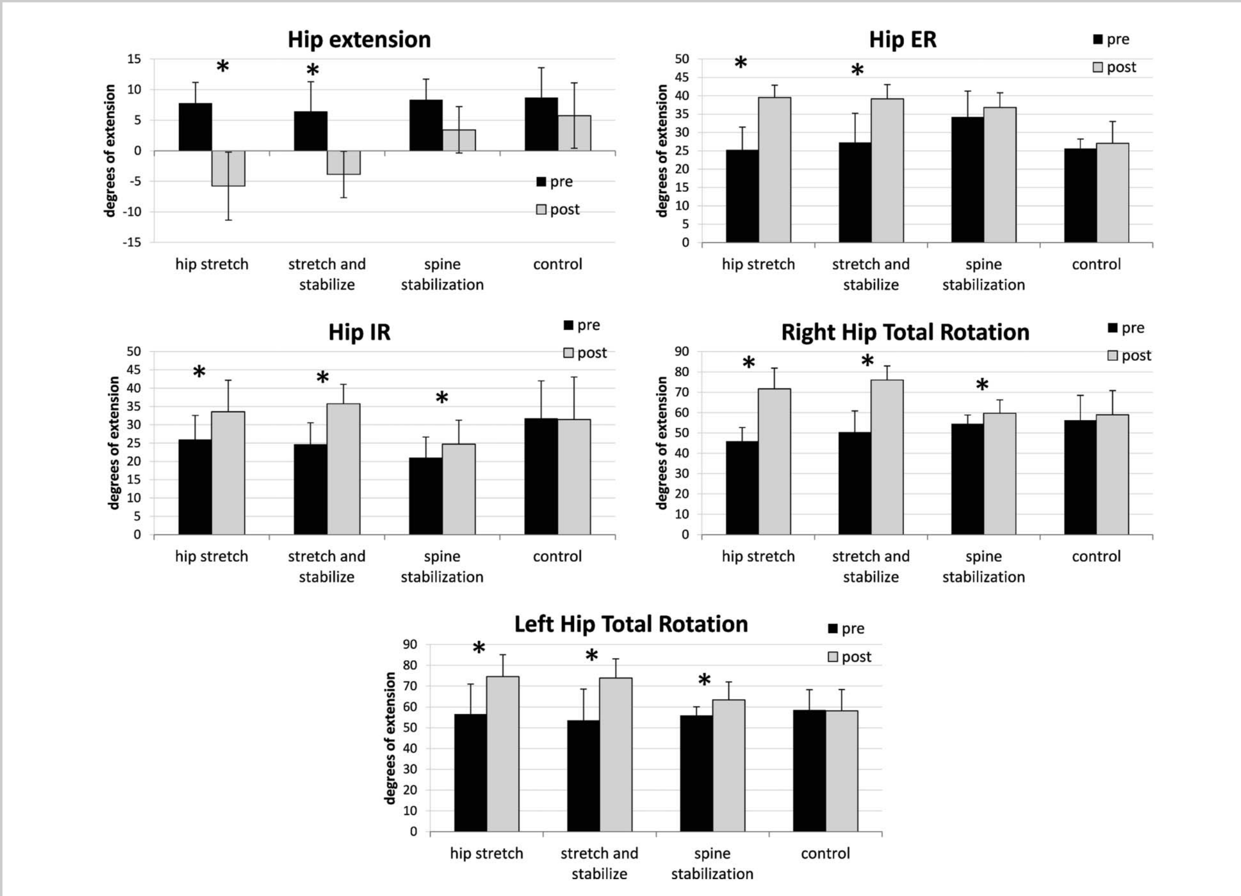

Figure 3. Average range of motion in each of the treatment groups comparing measurements before and after a 6-week treatment protocol. $n = 6$ participants per group (24 total). *Significant difference between the pre and post measurements ($p < 0.05$).

were instructed not to change their normal exercise routine, other than to add in the new protocol.

Group 1. The stretching protocol was based on numerous philosophies: (a) Exercises would be more likely adhered to if they could be completed alone, that is, no additional person was required as an assistant. (b) A more thorough stretch would be obtained if stretching included not only hip joint motion but also the entire side of the body which was under stretch at the hip, thus incorporating some of the principles of myofascial force transmission (12,13,23,30,34). For example, stretching of the right hip IR would also include elevation of the right arm overhead, with extension and left side bending of the torso (Figure 1). (c) Stretches were performed in a position approximating upright posture. Thus, hip rotation stretches involved minimal associated hip flexion. (d) A combination of static stretches (30-second hold) and ballistic stretches might be more beneficial than either one alone (30,36,45). Using these principles as guidance and to mimic clinical reality, participants were given a stretching program with individual modifications to address their patterns of limited mobility. Hip extension stretches were generally performed in the same position as the MTT, or in a lunge position or in both positions. Participants were encouraged to alter their positions if tension to the structures being stretched was increased by moving their arm, twisting their torso, and the like.

Group 2. This group received stretching similar to group 1 but in combination with exercises aimed at improving hip-spine disassociation: maximizing active hip motion while minimizing concurrent spine motion. Generally, most participants began with supine hip rotations (SHR) (Figure 2A), prone lying hip rotations (Figure. 2B) (37), "bird-dog" exercises (Figure 2C) (24), and upright standing unilateral hip motions (flexion-extension, circumduction, abduction-adduction), with instructions and coaching to maximize hip ROM while constraining concurrent spine motion. Exercises were progressed once the participant was able to complete approximately 20 repetitions without losing control of their neutral spine posture (e.g., supported SHR) (Figure. 2Ai) progressed to unsupported (Figure 2Aiii), then repeated with a straight leg, with progression to a weight added to the ankle when they mastered 20 unweighted repetitions).

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TABLE 3. Average hip range of motion measurements in degrees for all the treatment groups before and after the 6-week stretching protocol.*

	Treatment group†	Pretreatment	Posttreatment	Average change	Average % change	p
Extension	1	7.8 (3)	−5.8 (6)	−14.0		<0.001‡
	2	6.4 (5)	−3.9 (4)	−10.3		<0.001‡
	3	8.3 (3)	3.4 (4)	−4.9		0.067
	4	8.7 (5)	5.8 (5)	−2.9		0.264
External rotation	1	25.3 (6)	39.5 (3)	14.2	56.1	<0.001‡
	2	26.8 (8)	39.2 (4)	12.4	46.2	<0.001‡
	3	34.2 (7)	36.8 (4)	2.6	7.6	0.261
	4	25.6 (3)	27.0 (6)	1.4	5.4	0.527
Internal rotation	1	25.9 (7)	33.6 (9)	7.7	29.7	<0.001‡
	2	24.7 (6)	35.8 (5)	11.1	44.9	<0.001‡
	3	21.0 (6)	24.7 (6)	3.7	17.6	0.022‡
	4	31.8 (11)	31.5 (12)	0.3	0.9	0.847
Right total rotation	1	45.8 (7)	71.7 (10)	25.9	56.6	<0.001‡
	2	50.3 (10)	76.0 (7)	25.7	56.1	<0.001‡
	3	54.4 (4)	59.7 (7)	5.3	9.7	0.048‡
	4	56.2 (12)	58.9 (12)	2.7	4.8	0.283
Left total rotation	1	56.5 (14)	74.6 (10)	18.1	32.0	<0.001‡
	2	53.5 (15)	73.8 (9)	20.3	37.4	<0.001‡
	3	55.9 (4)	63.3 (9)	7.4	13.2	0.019‡
	4	58.5 (10)	58.1 (10)	−0.4	−0.6	0.888

*Extension is measured relative to the horizontal, thus a negative number indicates greater range of motion. $n = 6$ participants in each group.

†Treatment groups: 1 = passive stretching; 2 = passive stretching and motor control exercises; 3 = trunk muscle endurance; 4 = control.

‡Significance at the 0.05 value.

Group 3. Core endurance challenges were combined with hip-spine disassociation exercises in this group, with a strong focus on substantial activation of the trunk musculature. They received no instruction or exercises aimed at stretching the hip joint. In their initial treatment session, endurance tests were performed using the following positions: (a) Plank: the torso and legs remaining in a straight line, with bodyweight being borne on the forearms and toes (8,15); (b) Side bridge: torso and legs in a straight line, weight being borne on lower forearm and the side of the feet (uppermost foot in front) (Figure 2D) (1,14) (this was repeated for both right and left sides); (c) Biering-Sorensen position: lower half of body supported on a treatment table, securely held down with a nonelastic strap as well as manual pressure on the calves by an assistant. The upper body was unsupported, being cantilevered over the end of the table. With the arms crossed in front the chest, the participant was to hold the upper body in a line horizontal to the lower body. In addition to the motor control exercises prescribed to group 2, group 3 also received instruction in planks, side bridges, and supine lower abdominal exercises (Figure 2F) (37). Progressions involved adding weights to the moving limbs (arm or leg) (Figure 2Dii), increasing the scope of arm or leg movement (in the bird-dog or side bridge), and in some cases, adding in more intense strengthening exercises such as the unilateral weight carry (Figure 2E) or using the Body-blade in a vertical 2-handed, side to side oscillation pattern (28).

Group 4. This was the control group. Range of motion was measured at the beginning and at the end of 6 weeks, and they were instructed to not change their normal exercise routine during this time.

Statistical Analyses

Initial analyses were performed using SPSS (version 17; SPSS, Inc., Chicago, IL, USA), whereas subsequent post hoc tests on within-subject factors were conducted using SAS (version 9.2, SAS Institute Inc., Cary, NC, USA) (significance level $p \leq 0.05$).

Hip Stretching Outcomes (Hypothesis 1). Paired *t*-tests were used to compare right and left sides for each of the dependant variables (hip extension, IR, ER, and total rotation [TotR], which was a sum of IR and ER) in the preintervention and postintervention conditions. If no significant differences were found, these data were collapsed. Repeated measures analyses of variances were conducted on hip ROM for each of the dependant variables, using a within-subject factor of pretreatment and posttreatment and a between-subject factor

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Table 4. Average endurance times (in seconds) and percent change from participants in group 3, comparing their times before and after a 6-week core endurance protocol.*

Subject number	Pretreatment				Posttreatment				% change			
	RSB	LSB	Plank	Back extension	RSB	LSB	Plank	Back extension	RSB	LSB	Plank	Back extension
29	80	85	85	75	100	125	140	127	25	47	65	69
34	90	92	75	100	105	150	150	120	17	63	100	20
31	80	70	100	115	105	100	95	115	31	43	-5	0
35	90	170	200	135	140	170	260	205	56	0	30	52
37	80	83	100	100	140	200	120	169	75	142	20	69
43	100	125	210		158	152	253		58	22	20	
Average (SD)	87 (8)†	104 (37)	128 (60)	105 (22)	125 (24)	150 (35)	170 (70>)	147 (39)	44 (23)	53 (49)	38 (38)	42 (31)

*RSB = right side bridge; LSB = left side bridge.
†Significant difference between pretesting and posttesting times ($p < 0.0125$).

of treatment group. Tukey's post hoc tests were applied to any significant results.

Endurance Outcomes (Hypothesis 2). Paired *t*-tests were used to compare pretreatment and posttreatment endurance times for the plank, right side bridge, left side bridge, and Biering-Sorensen test. Bonferroni adjustments were applied. Cohen's *d* effect sizes were calculated.

Results

Participants in groups 2 and 3 proceeded through a motor control exercise progression as each step was mastered according to criteria previously described. This progression is outlined in Table 2 together with indicators as to individual progress.

Passive Hip Range of Motion

When collapsed across all the treatment groups, there were no differences between right and left hip extension, IR, or ER ($p = 0.375$, 0.252, or 0.060, respectively). However, the TotR did demonstrate a difference between the sides (right, 52 (9)° and left, 56 (11)°; $p = 0.005$) and thus were analyzed separately.

In groups 1 and 2, passive hip ROM increased significantly for all 5 indicators being analyzed ($p = 0.005$ for extension and $p < 0.001$ for IR, ER, right TotR, and left TotR) (Figure 3, Table 3). Specifically, every participant in the 2 stretching groups improved in each direction, with average rotation increasing between 29.7% and 56.6% and extension increasing to an average of 11.9 (7)° (Table 3). Those in group 3, who received only spine stabilization exercises, increased their ROM significantly in hip IR and both TotRs (averaging 18% and 10%, respectively). The control group demonstrated no significant changes in ROM.

Core Endurance (Group 3)

Trunk muscle endurance improved between 38% and 53% for all the 4 test positions (Table 4), but given the stringent significance level of 0.0125 calculated with the Bonferroni adjustment, it was significantly so only for the right side bridge ($p = 0.006$, 0.039, 0.018, and 0.039 for right side bridge, left side bridge, plank, and back extension, respectively). Cohen's *d* effect sizes were 2.09, 1.26, 0.6, and 1.36 (same order as above), indicating that despite the lack of statistical significance, the effect of the exercise program on endurance was large for all but the plank exercise, which could still be considered moderate.

Discussion

At the end of 6 weeks, substantial improvements were demonstrated in all the intervention groups. Hip stretching (groups 1 and 2) resulted in large increases in passive hip ROM, with average extension increasing from approximately the 8th to the 75th percentile, right TotR from the 15th to the 85th percentile, and left TotR from the 30th to the 85th percentile. Thus, not only did these participants go from being in the "limited hip mobility" group to "average" but also they

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ended having excessive hip mobility. It is not possible to comment on whether the myofascial stretches resulted in greater improvements than stretches aimed specifically at the hip joint would have done. The improvements are similar to the 10–14° described by Winters et al. (45) who compared passive and active stretching in a group of young men (23.6 [5.3] years). Their protocol focused solely on the extension at the hip joint (no rotation), without including the extra torso and upper limb stretch components. However, their population was a LBP group, which may confound a direct comparison of outcomes. Anecdotally, many of the participants in this current study were already involved in a fitness-stretching program of their own and admitted to appreciating that these myofascial stretches were different, potentially targeting tight structures, which had not previously been addressed. Those participants who received only core stabilization exercises (group 3) also demonstrated a small but significant improvement in 3 of the 5 conditions, with their final measurements for TotR averaging between the 55th and 70th percentiles. In that there was no significant improvement in ROM in the control group, it may be surmised that increasing core endurance and hip-spine disassociation resulted in greater passive hip joint rotation. That is, as rotation exercises were performed with greater torso stiffness, the axes of rotation would have been directed more so at the hip joints, resulting in gradual active stretching and ultimately greater ROM. This adds insight into the proximal stability for distal mobility proposition of Kibler et al. (19). Thus, the first hypothesis, that all the 3 protocols will result in improved ROM, can be accepted in all but 2 of the indicators (group 3: hip extension and ER).

Core endurance improvements were moderate and limited; thus, the second hypothesis can only be accepted for the right side bridge condition. In the other conditions, variability was high and participant numbers were low, resulting in low statistical power (0.29–0.47), despite moderate-to-large effect sizes. Based on these numbers, increasing the number of participants to 22 would likely have resulted in statistical significance in all the groups. As it was, more than 250 participants were screened to identify those who fit the admission criteria, thus numbers were limited.

Participants in group 2 progressed through a series of hip-spine disassociation exercises, with increasing difficulty (Table 2). This group is difficult to quantify objectively and is representative more so of the type of education and exercises that are frequently prescribed in a rehabilitation setting (10,12,30). But the improvements in ROM were not significantly different from those found in group 1. Further investigation is warranted to determine if a difference exists between these 2 groups as to their ability to transfer this newfound joint mobility to functional activities.

The investigation was limited to healthy young men to reduce error that may have been introduced because of sex and age differences (17,35,41) and to minimize the possibility of arthritic joint changes. Further research is warranted to determine if women or other age-groups demonstrate similar outcomes. Future research investigating changes in joint flexibility based on diurnal rhythms and daily activity would be of value.

Practical Applications

This study highlighted the large improvements in ROM that are possible in a group of asymptomatic young adult males with limited hip mobility. In that stretching protocols are a key component of most fitness programs, it is important to investigate new methods, in an attempt to explore the "best practice." Thus, this study incorporated hip stretching protocols that include torso and arm positioning, to address the concept of myofascial stretch. Given the large improvements in hip mobility, it appears that these stretches are beneficial and should be considered as another mechanistic choice when recommending a stretching protocol. Of equal interest is the finding that hip rotation ROM improved when participants were given a 6-week program of core endurance exercises, combined with hip-spine disassociation exercises. No hip stretches were given or discussed, yet passive hip rotation improved, highlighting the potential role of including core stabilization or proximal stiffening training when rehabilitating the distal extremities.

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