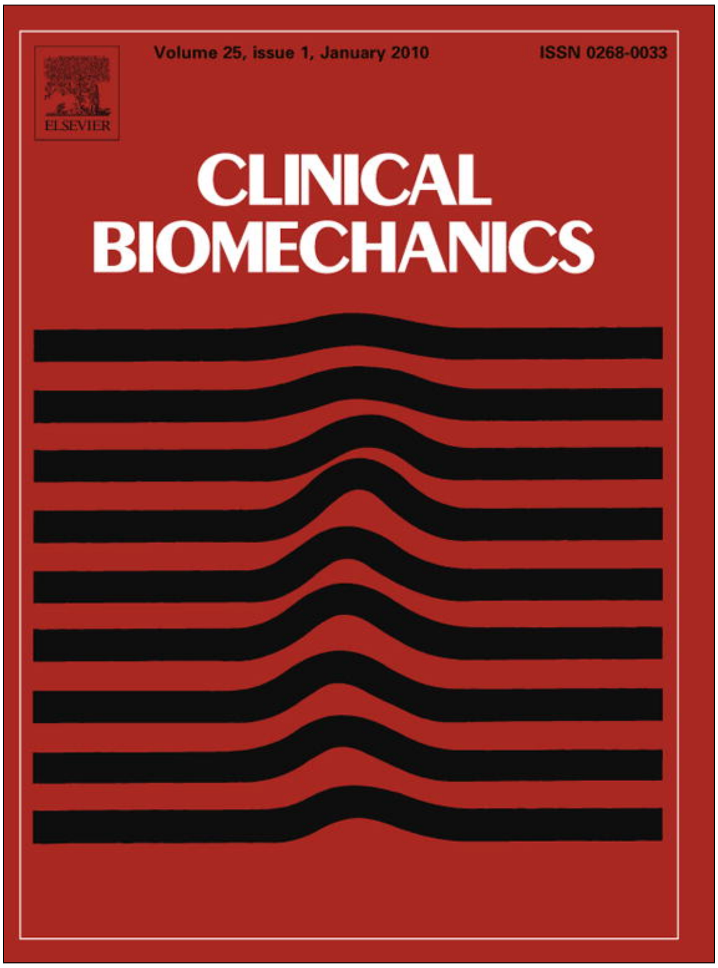
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Symmetrical and asymmetrical hip rotation and its relationship to hip rotator muscle strength

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ABSTRACT

Background: Joint motion studies suggest that adults have symmetrical hip rotation range of motion. Asymmetries in hip rotation are often related to lower extremity musculoskeletal conditions. The purpose of this study was to determine if muscle strength differences occur in subjects with symmetrical vs. asymmetrical hip rotation. We hypothesize that those with asymmetrical hip rotation will have less strength in the standard 0° test position when compared to a position where the joint is in its center or mid-position.

Methods: Sixty-four subjects participated. Muscle strength was measured in the standard 0° and mid-range hip positions. Subjects were divided into three groups depending on hip rotation, symmetrical, internal rotation greater than external rotation and external rotation greater than internal rotation. Data were analyzed using a 3 (Classification Group: Symmetrical vs. greater external rotation vs. greater internal rotation) × 2 (Muscle: External Rotator vs. Internal Rotator) × 2 (Position: Standard 0° vs. Center or Off-mid) ANOVA with the last two factors treated as repeated measures.

Findings: Measures of left and right side yielded significant effects for Muscle, Classification Group - Muscle, Classification Group × Position, Muscle Group × Position, and Classification Group × Muscle × Position.

Interpretation: The results suggest that difference in muscle strength of the hip rotators is dependent upon the position that the hip rotator muscle is tested and the type of hip rotation symmetry or asymmetry present. Before muscle testing or strengthening the hip rotator muscles the presence of joint rotation asymmetries and the effect of joint positioning must be considered.

1. Introduction

Studies have shown that adults usually have symmetrical motion when comparing hip internal rotation to external rotation for a particular side (Staheli et al., 1985; Svenningsen et al., 1989; Roach and Miles, 1991; Roaas and Andersson, 1982; Haas et al., 1973; Ellison et al., 1990; Boone and Azen, 1979). There has been a growing number of studies that suggest that asymmetry in hip rotation, where external rotation (ER) exceeds internal rotation (IR) or where IR exceeds ER are related to a number of different lower extremity musculoskeletal problems that clinicians often see (Chesworth et al., 1994; Ellison et al., 1990; Cibulka et al., 1998; Staheli et al., 1985; Gelberman et al., 1987; Staheli, 1994; Swanson et al., 1963; Svenningsen et al., 1990; Pitkow, 1975). Previous studies have shown that asymmetry in hip rotation is often associated with osteoarthritis of the hip, low back pain, sacroiliac joint dysfunction, femoral neck anteversion and retroversion, as well as patellofemoral pain (Chesworth et al., 1994; Ellison et al., 1990; Cibulka et al., 1998; Staheli et al., 1985; Gelberman et al., 1987; Staheli, 1994; Swanson et al., 1963; Svenningsen et al., 1990; Pitkow, 1975). We have noticed that subjects with asymmetrical hip rotation usually also have hip muscle weakness, usually when more than a 15° difference in motion is found between hip internal and external rotation on a particular side. For example in those with greater hip ER we often find weakness of the hip

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internal rotator muscles, whereas those with greater hip IR internal rotation often have weakness of the hip external rotator muscles. Because hip muscle strengthening exercises is a common treatment program in many of these different conditions we believe it is important to determine if subjects with hip rotation asymmetry really do have muscle strength differences when compared to those subjects who have symmetrical hip rotation.

The purpose of this study was to investigate if a difference exists in the amount of muscle force production of the hip rotator muscles in those with symmetrical hip rotation when compared to those who have asymmetrical hip joint rotation. Specifically we examined if subjects who have asymmetrical hip rotation would have less strength (force production) in the standard manual muscle testing position (standard 0° test position) when compared to testing in their mid-range of motion (center test position). We determined the mid-range joint position by determining the average of the total range of hip rotation from our joint motion measures. Our hypothesis was that subjects who have a symmetrical pattern of hip rotation (where hip internal vs. external rotation is equal or nearly equal) will be strongest at the standard 0° test position and weaker in any other test position, whereas those with asymmetrical hip range of motion (where hip IR exceeds ER, or hip ER exceeds hip IR) will be weaker at the standard 0° test position and stronger in their center test position (mid-range of motion).

2. Methods

2.1. Subjects

Subjects included a convenience sample of sixty-four persons (46 females, 18 males) between 18 and 60 years of age with a mean age of 27.1 years (SD = 10.6). Participants were excluded from this research study if they had a previous recent history of hip, low back or lower extremity pain, intolerance to lying prone, or had surgery or injury of the trunk, hip or lower extremity within the past year. Subjects were volunteers from students, staff and associates of Maryville University, St. Louis, MO. We obtained informed consent from all subjects before entering into the study. The study was approved by the Internal Review Board of Maryville University, St. Louis, MO, USA.

A standard 12-in. plastic round universal goniometer was used to measure passive hip rotation range of motion and a *Microfet* (Hoggan Health Industries, West Jordan, Utah, USA 84088) hand-held dynamometer was used to measure muscle strength. Intra-tester reliability for our purpose was established beforehand. Two of the authors (NW and CW) and an additional examiner performed intra-observer variability tests to establish the reliability for our hip rotation measurements. Given that only one person performed all the goniometric measurements and another person performed all of the manual muscle testing, only intra-rater reliability was established for both range of motion and manual muscle testing for the two testers who performed the specific tests.

Intra-rater reliability for goniometric measurement of passive hip rotation was established on the first 14 subjects. When measuring hip rotation, subjects were placed in the prone position on a firmly padded treatment table. They wore non-restricting clothing. The hip being measured was placed in 0° of abduction and the contralateral hip was placed in about 30° of abduction. The knee was flexed to 90°, and the leg was passively moved to produce hip rotation. Care was taken not to produce tibio–femoral motion (e.g. abduction/valgus or adduction/varus at the knee) that would exaggerate the amount of hip motion (Harris-Hayes et al., 2007). Stabilization of the pelvis was accomplished by using a mobilization strap firmly tightened over the sacrum to prevent pelvic rotation. The rater stopped the leg at the end of passive joint RoM when a firm end-feel was noted. The movement arm of the goniometer was aligned vertically along the shaft of the tibia. The rater was blind to the amount of movement measured by the goniometer; measurements were read and recorded by a different examiner. Two trials for each motion were performed with a rest of approximately 1 min between each trial. An intra-class correlation coefficient (ICC) (3, 1) was used to estimate intra-rater reliability. Results demonstrated a high level of absolute agreement within raters when measuring the range of hip internal and external rotation (Table 1). The standard error of the measure for hip internal rotation was 1.87° and for external rotation 2.0°.

Previous studies have shown the *Microfet* is a reliable and valid tool to measure muscle strength (Bohannon, 1986a,b, 1997, 1988; Sullivan et al., 1988). Intra-rater reliability was established for the *Microfet* hand-held dynamometer from the first 14 subjects. The subjects were positioned as for goniometric measures in the prone position on a firmly padded treatment table. Although Kendall (Kendall et al., 1993) describes the sitting method we chose the prone position over sitting because we could stabilize the pelvis better and it was a more functional test position. The hip that was measured was placed in 0° of abduction and the contralateral hip was placed in about 30° of abduction. The knee was flexed to 90° and the leg was placed in the vertical or standard 0° test position. Stabilization of the pelvis was accomplished by using a mobilization strap firmly tightened over the sacrum to prevent any pelvic rotation. The contact point for the *Microfet* was 2 in. proximal to the medial and lateral malleolli. The subject was asked to "push" into the padded *Microfet* dynamometer for duration of 5 s as hard as they could. Thus we used a "make" not a "break" test as described previously (Bohannon, 1988). Strength (force) measures were obtained for the left and right hip IR and ER muscles. The examiner was blind to all of the force readings from the *Microfet*. After a rest of about 2 min the manual muscle tests were again repeated in the same manner. To estimate absolute agreement for intra-rater reliability we used the ICC (3, 1) (Shrout and Fleiss, 1979). There were high levels of reliability for all muscle test measures; the ICC's are shown in Table 2. The standard error of the measure for hip internal rotator muscle force was .66 kilograms (1.4 lb) and the standard error of the measure for the external rotators muscle force was .74 kilograms (1.6 lb). We also determined the minimal detectable change in muscle force using a minimal detectable change of 90% (MDC_{90}). The 90% confidence interval for hip IR and ER muscles using the formula $MDC_{90} = 1.645 * SD_1 * \sqrt{(2*1\text{-ICC})}$. The MDC_{90} for the hip IR was 1.4 and the ER 1.3 kg.

2.2. Classification of groups and data collection

Data were collected in two different stages (Fig. 1). The first stage included RoM measurements for hip internal and external

Table 1
Intra-class correlation coefficient for hip rotation with means in degrees (SD) for initial (mean 1) and repeat tests (mean 2).

Hip Rotation RoM	ICC	Mean 1 (SD)	Mean 2 (SD)	95% CI
Left hip internal rotation	.98	51.3 (12.2)	52.1 (11.8)	[.96–.99]
Right hip internal rotation	.96	53.5 (6.7)	54.8 (13.7)	[.93–.99]
Right hip external rotation	.94	53.3 (6.7)	54.3 (6.3)	[.89–.97]

Table 2
Intra-class correlation coefficient for hip muscle strength with means in kilograms (SD) for initial (mean 1) and repeat tests (mean 2).

Manual muscle test	ICC	Mean 1 (SD)	Mean 2 (SD)	95% CI
Left hip internal rotators	.96	9.0 (3.0)	9.3 (3.0)	[.92-.99]
Left hip external rotators	.91	11.1 (2.8)	11.9 (2.9)	[.71-.97]
Right hip internal rotators	.95	9.1 (3.1)	9.6 (2.8)	[.92-.98]
Right hip external rotators	.96	11.4 (3.3)	11.5 (4.2)	[.89-.99]

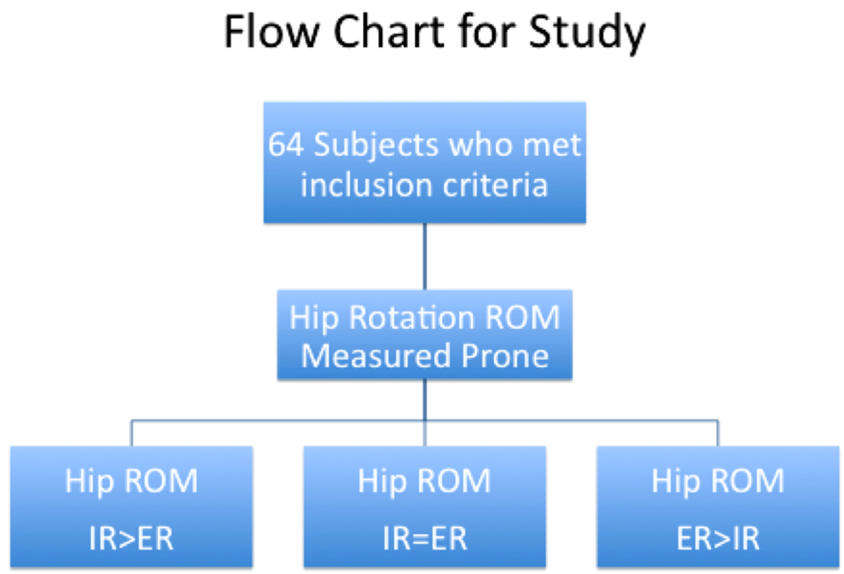

Fig. 1. Flow chart for the study.

rotation on both legs using the goniometric methods described above.

Strength measures in the second stage of the study were defined as the greatest force generated by the subject against a hand-held Microfet dynamometer. Strength measures were determined for the internal and external rotators at the standard testing position (0°) and at a new calculated midpoint, we defined as the center test position, for subjects with more than a 15° difference between hip IR and ER RoM (ER > IR and IR > ER groups). A difference of 15° or more between passive hip internal and external rotation was used for operationally defining the hip rotation groups. Studies examining normal hip range of motion show that differences between hip internal rotation and external rotation range between 0° and 10° (Svenningsen et al., 1989; Cibulka et al., 1998; Roaas and Andersson, 1982; Ellison et al., 1990; Fairbank et al., 1984; Boone and Azen, 1979). We added an extra 5° onto the maximum difference to account for any additional measurement error; 5° represents the minimal detectable change or change outside of error when examining passive hip rotation when determining reliability. Ellison et al. showed that a 10° cutoff was clinically meaningful in a study that examined subjects with differences in hip internal and external rotation who had low back pain (Ellison et al., 1990). Thus we believed that a 15° cutoff could be used to define subjects who had differences between hip internal and external rotation. The center test position was defined as the midpoint in degrees between maximal internal and external hip rotation. The center test position was determined by taking the total range of hip rotation for one side of the hip, for example 45° of left hip internal rotation and 45° of left hip external rotation, which equals 90°. The total range of motion divided by two equals 45°. Forty-five degrees was then subtracted from the greater of the two hip rotation measures, in this example they were equal so 45–45 results in a centered position. Determining the test position when range of hip rotation was asymmetrical was performed in the same manner. For example with 20° of left hip internal rotation and 70° of left hip external rotation, which equals 90° of total left hip range. To find the "center" point for left hip rotation the total range of left hip rotation was then divided by 2, which yielded 45°. Forty-five degrees was then subtracted from the greater of the two hip rotation measures, in this example that would be 70° of external rotation. The resultant, 25° of external rotation from the standard 0° test position, was defined as the standard test position (Fig. 2). A randomly chosen "off-center" test position was used for those with less than a 15° difference between hip IR and ER RoM (IR = ER group) to reduce examiner bias when performing the strength measurements. We randomly placed subjects in the symmetrical group in varying amounts of either internal or external rotation somewhere between approximately 20–30° of internal or external rotation.

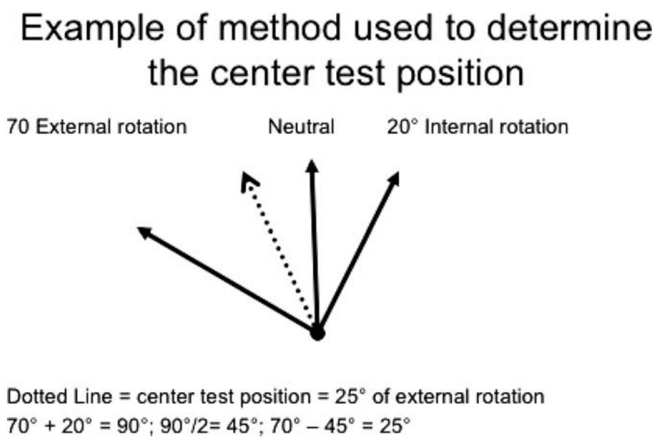

Fig. 2. Example of the method used to calculate the center test position.

After each subject's hip range of motion was measured left and right hips were classified into one of three groups according to hip rotation symmetry or asymmetry (IR = ER, IR > ER, ER > IR) (Table 3). Individual hips were also examined by gender because previous research has shown that males create significantly more muscle force than females with a hand-held muscle dynamometer (Andrews et al., 1996). Ten males and 38 female hips were in the

Table 3
Classification of subjects ($N = 64$) according to hip rotation pattern per side.

Left side	Right side symmetrical	Asymmetrical (ER > IR)	Asymmetrical (IR > ER)
Symmetrical	5	13	4
Asymmetrical (ER > IR)	8	21	1
Asymmetrical (IR > ER)	2	2	8

IR = ER group, 3 males and 13 female hips in the IR > ER group and 23 males and 41 female hips in the ER > IR group. A flow chart for the study is illustrated (Fig. 2).

Confidentiality was maintained during data analysis through the assignment of participant numbers without identifiable names. All personal information of the participants including their name, participant number, and data and testing results was kept anonymous.

2.3. Measurement procedure

After reviewing and signing the informed consent, the testing procedures were explained to the subject. The patient was then instructed to lie prone on a hi-low treatment table with their feet hanging off of the edge. The prone position was chosen for this study because in this position the pelvis could be stabilized better compared to the sitting position. Subjects were strapped to the table using a stabilizing belt across the posterior superior iliac spine of the pelvis to stabilize the pelvis during RoM and strength testing. Once stabilized, one researcher took the subject through passive hip internal and external RoM on each leg using the landmarks previously marked. The joint was moved through its full range of motion one time before being tested. No other warm up besides this was given. The subject was only moved passively to where a firm end-feel was first noted and not beyond.

Another therapist then measured RoM using a hand-held 12-in. universal goniometer. Another researcher recorded the RoM measures on the data sheet. Measurements of hip internal and external rotation were performed three times by the same examiner and then averaged. Once completed, if hip joint asymmetry was found (the difference in the amount of hip internal and external rotation was greater than 15°), the center point was determined by identifying a value halfway between the values of maximal internal and external RoM. This midpoint was recorded and used as a reference (center test position) when testing for strength.

All subjects performed four strength measures per leg. First, internal and external rotator strength was measured in the standard 0° test position (leg vertical). Next, the subject's extremity of the same leg was placed in the new calculated center test position if RoM was deemed asymmetrical or in an "off-center point" position if the subject was symmetrical. Measurements alternated between internal and external strength test to allow the subject some rest between strength tests. Rest periods lasted for about thirty seconds between manual muscle tests. Strength measures were then conducted on the opposite leg using the same procedure. A second therapist recorded the strength measurements on the data sheet.

2.4. Data analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 14.0 (Chicago, IL). Descriptive statistics including mean, confidence intervals, and standard deviations were computed for the strength data for each group. Measures collected from the right and left sides were analyzed separately. An analysis of between group differences in muscle strength was not assessed because of the unequal gender differences that exist between the three different groups. Although such a comparison is possible we could not do this with our data set because of sample size limitations. Each set of measures was analyzed using a 3 (Classification Group: Symmetrical vs. IR > ER vs. ER > IR) × 2 (Muscle: External Rotator vs. Internal Rotator) × 2 (Position: Standard 0° vs. Off-Centered or Centered) analysis of variance with the last two factors treated as repeated measures. Although a single analysis including measures from both sides is possible, separate analyses for each side were deemed necessary because not all combinations of cross-classification for the two sides yielded sufficient numbers of subjects (Table 3). Bonferroni corrections were applied whenever multiple comparisons were made.

3. Results

3.1. Left side

Analysis of strength measures collected on the left side yielded significant effects for Muscle, Classification Group × Muscle, Classification Group × Position, Muscle × Position, and Classification Group × Muscle Group × Position (all Fs > 5.17, ps < .008). Our hypothesis predicted a Classification Group × Muscle × Position interaction, which is displayed in Fig. 3. Bonferroni-corrected follow-up comparisons were made within each classification group and muscle group to determine if differences between the standard 0° test position and the center or off-center test position (center for asymmetrical groups and off-center for the symmetrical group) were significant. The results indicated that position differences within the following combinations were statistically significant (P < .05): ER > IR group and IR muscles; ER > IR group and ER muscles; IR > ER group and ER muscles; symmetrical group and ER muscles. This pattern indicates that the predicted results were found for the ER > IR group for the internal rotator muscles but

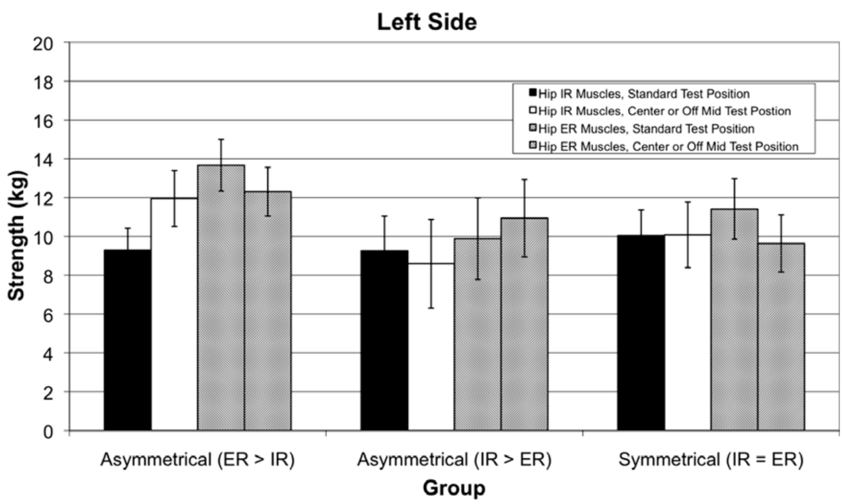

Fig. 3. Left side mean strength (kg) as a function of classification group, muscle group, and position (error bars represent 95% confidence intervals).

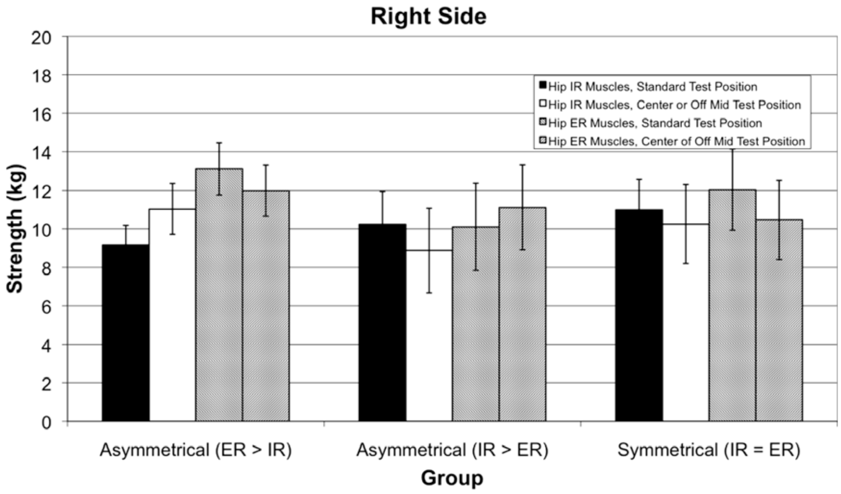

Fig. 4. Right side mean strength (kg) as a function of classification group, muscle group, and position (error bars represent 95% confidence intervals).

not the external rotator muscles. In fact, the opposite pattern was found for the external rotators, they were stronger in the standard 0° position. For the IR > ER group, support for the hypothesis was limited to the external rotator muscles. For the symmetrical group, the difference found for the hip external rotator muscles supported the hypothesis.

3.2. Right side

Analysis of strength measures collected on the right side yielded significant effects for Muscle Group, Classification Group - Muscle Group × Position, Classification Group × Position, and Classification Group × Muscle Group × Position (all Fs > 3.58, ps < . 034). The three-way interaction is displayed in Fig. 4. Bonferroni-corrected follow-up comparisons indicated that position differences within the following combinations were statistically significant ($P < .05$): ER > IR group and internal rotator muscles; ER > IR group and ER muscles; IR > ER group and internal rotator muscles; IR > ER group and external rotator muscles; symmetrical group and external rotator muscles. These comparisons on the right duplicate those for the left side. They indicate that the predicted results were found for the ER > IR group for the internal rotator muscles but not for the external rotator muscles. For the IR > ER group, support for the hypothesis was limited to the external rotator muscles. Results opposite to those predicted were found for the internal rotator muscles. For the symmetrical group, the difference found for the external rotator muscles supported the hypothesis; results for the internal rotator muscles were in the predicted direction but were not statistically significant.

4. Discussion

Only a few studies have previously examined how hip rotation affects hip rotator muscle strength. Haley found no correlation between hip joint range of motion and hip rotator muscle torques when examining 50 females with the hip flexed to 90° (Haley, 1953). May examined the muscle strength of 10 males with the hip flexed to 90° and found greater muscle force of the hip rotators as they moved from a shortened to a lengthened muscle length position (May, 1966). Jarvis examined hip rotator muscle force in both the hip extended and flexed position and found no difference in muscle force between the hip rotators muscles when comparing a mid point position to an end range joint position (Jarvis, 1952). In both Haley and May hip muscles were tested in the 90° hip flexion position, a non functional position and one where the hip rotator muscles act differently than when in hip extension. Thus previous literature was inconclusive in determining if changes in hip rotation affect hip rotator muscle strength.

The results of our study show that in subjects who have symmetrical hip rotation, where the range of hip internal rotation was equal or nearly equal to hip external rotation, the greatest force produced by the ER muscles was in the standard 0° testing position with less force produced when the hip was moved away from the standard 0° test position (off-center). Thus the results show that the external rotator muscles produce their greatest force in the mid-range position. This finding is consistent with the classic length-tension curve, which states that the maximum tension or force a muscle can produce is around its mid-length position while producing less force when moved away from mid-length position (Gordon et al., 1966). The observations held true for both left and right sides, which lends support to our hypothesis. The IR muscles on the right showed the same trend of decreased muscle force when tested in a position away from the standard 0° test position (the off-center position) but the two positions were not significantly different, while the left side showed no difference in force or trend between the two testing positions.

When looking at the two asymmetrical groups, where external rotation range is greater than internal rotation range the internal rotator muscles in the group where external rotation range exceeded internal rotation range and the external rotator muscles in the group where internal rotation range exceeded external rotation were both weaker when tested at the 0° or standard position yet stronger in their center test position (Figs. 3 and 4). This finding held true for both the left and the right sides. These results support our hypothesis. A possible explanation for why the internal rotator muscles in the group where external rotation range exceeded internal rotation and the external rotator ER muscles in the group where internal rotation range exceeded external rotation were stronger at the center test position is that these muscles were tested in a more favorable length-tension position. In subjects where external rotation range exceeded internal rotation the internal rotator muscles are likely lengthened while in the group where internal rotation range exceeded external rotation the external rotator muscles are likely shortened. Williams and Goldspink showed in animals that an elongated muscle would increase its length by adding sarcomeres that would shift the length-tension curve to the right (Williams and Goldspink, 1978). Placing a lengthened muscle in a shortened position would likely put the internal rotator muscles in the group, where external rotation range exceeded internal rotation and the external rotator muscles in the group where internal rotation range exceeded external rotation, in the weakest part of the length-tension curve. When placed in the new mid or centered position both the IR muscles had greater force beyond the MDC_{90}, which suggests that the difference in muscle force was outside measurement error and therefore different. External rotator ER muscle force in the group where internal rotation range exceeded external rotation, although showing a significant increase in strength beyond chance when centered, did not show a muscle force increase beyond the MDC_{90} . This was likely due to the limited number of subjects in the group internal rotation exceeded external rotation range. Regardless, the data shows that when muscles are elongated in subjects with hip asymmetry, the length-tension curve shifts to the right where the elongated muscles are likely to be in a more favorable test position. This finding is in agreement with Williams and Goldspink's classic article on length tension (Williams and Goldspink, 1978).

While the internal rotator muscles in the group where external rotation exceeds internal rotation and the external rotator muscles in the group where internal rotation exceeds external rotation showed an increase in force when moving from 0° to the center test position the external rotator muscles in the group where external rotation exceeded internal rotation and the internal rotator muscles the group where internal rotation exceeds external rotation unexpectedly and against our hypothesis showed opposite effects for both the left and right sides. With hip rotation asymmetry the external rotator muscles in the group where external rotation exceeds internal rotation and the internal rotator muscles in the group where internal rotation exceeds external rotation are likely shortened. Williams and Goldspink showed in animals that a shortened muscle would decrease its length by losing sarcomeres that would shift the length-tension curve to the left (Williams and Goldspink, 1978). In this study both the ER and the IR muscles generated more force at the standard 0° position and less in the center test position (Figs. 3 and 4). This finding suggests that the "shortened" ER and IR muscles in the group where external rotation exceeds internal rotation and in the group where internal rotation exceeds external rotation were weaker when placed in a lengthened position. This finding suggests that the "shortened" ER and IR muscles in both groups with asymmetrical hip rotation respectively were weaker when placed in a lengthened position. These data support the concept that when muscle is shortened the length-tension curve shifts to the left.

The results of our study suggest that the force that hip rotator muscles can exert depends not only on test position but also on the type of symmetry or asymmetry of hip rotation present. Gossman et al. suggested that the phenomenon of stretch-weakness is dependent on where in the range of motion an elongated muscle is tested, however no data were given to support this statement (Gossman et al., 1982). In our study we noted that muscles that were elongated in the asymmetrical group had less force when tested in their shortened range but not through out the full range of motion. The results raise the question as to whether we should use the term "stretch-weakness"? Our data suggests that weakness found in asymmetrical muscle groups are likely from a shift in a muscles length-tension curve and not from muscle weakness. More studies are needed with a larger population to confirm this notion.

The results of our study may have considerable implications on how and where we strengthen "weak" muscles that are "stretched or elongated" or "shortened". Gossman earlier proposed that corrective exercises should be aimed at restoring normal length and developing tension at the appropriate point in the range rather than just strengthening the muscle per se (Gossman et al., 1982). From a clinical viewpoint, if a muscle is found to be weak because of "stretch" or "short" weakness, clinicians may have to work on a program aimed at restoring normal length and also developing tension at the point in the range of motion where the weakness is found. Thus an important treatment goal would likely include restoring symmetry between hip internal and external rotation. Further studies are needed to examine these concepts in greater detail.

An important finding from this study that was not part of our original hypothesis is that asymmetry in hip rotation is much more prevalent than previously expected in a normal population. According to our operational definition of hip rotation symmetry only 5 of 64 subjects were symmetrical in both the left and right hips, while 13 had symmetrical left hip rotation but had ER > IR on the right side (Table 3). On the left side 42 of 64 subjects had hip rotation asymmetry while on the right side 49 of 64 subjects had hip rotation asymmetry (Table 3). This data suggests that we should probably be more aware of hip rotation asymmetry when assessing hip range of motion. This is important to clinicians because hip rotation asymmetry is often found in many different musculoskeletal conditions that affect the low back, hip, and knee (Chesworth et al., 1994; Ellison et al., 1990; Gelberman et al., 1987, 1986; Pitkow, 1975; Staheli, 1983, 1980, 1987; Staheli et al., 1985; Svenningsen et al., 1990; Tonnis and Heinecke, 1999b). Other studies suggest that asymmetrical hip rotation may be related to low back pain, patellofemoral pain, sacroiliac dysfunction, and to numerous hip conditions (Cibulka and Threlkeld-Watkins, 2005; Cibulka et al., 1998; Chesworth et al., 1994; Ellison et al., 1990; Tonnis and Heinecke, 1999a; Swanson et al., 1963; Pitkow, 1975; Staheli, 1980, 1987). Those with femoral neck anteversion and retroversion have asymmetrical hip rotation range of motion (Svenningsen et al., 1990; Staheli et al., 1985; Gelberman et al., 1987; Kozic et al., 1997). Ellison et al. demonstrated a relationship between patients with low back pain and hip rotation asymmetry (Ellison et al., 1990). Cibulka et al. also examined patterns of range of motion in the hip in patients with low back pain from sacroiliac joint dysfunction (Cibulka et al., 1998). The results of our study lend further support to the importance of assessing hip rotation asymmetry when treating patients with low back, hip, or knee pain.

The purpose of the study was to examine the consequence of hip RoM differences and its effect on muscle force in different parts of the range of motion; we did not explore the cause of the hip RoM difference in this study. Previous studies have suggested that habitual extreme hip rotation postural patterns assumed during sitting or standing may be related to hip rotation asymmetry as well as to femoral torsion (Haike, 1965). Published reports (Crane, 1959; Alvik, 1962; Pitkow, 1975; Staheli, 1980) have suggested that habitual sleeping or sitting postures, where the hip is held at or near the end range of internal or external rotation, may produce changes in hip rotator muscle length. Extreme postures often produce an increase in hip rotation in one direction, with a corresponding decrease in hip motion in the opposite direction. Such changes in hip motion would also likely shift the mid-length position in the direction of the hip that has greater range of motion.

5. Conclusion

The results of this study suggests that in subjects with hip rotation asymmetry muscle force is dependant upon the position that the muscle is tested in, the type of hip rotation symmetry or when any of the three different asymmetries present (IR = ER, IR > ER, ER > IR), and the specific hip rotator muscle group (IR or ER muscles) that is tested. The result showed that muscles that were elongated tested weaker when placed in a shortened position and muscles that were shorter tested weaker in a lengthened position. These findings suggest it is important to examine the hip joint for symmetry in hip rotation before muscle testing the rotator muscles of the hip. Clinicians should also consider where in the range a weak muscle should be strengthened when planning an exercise program. Finally, the results of this study cast doubt on the classic concept of "stretch-weakness" suggesting that so-called stretch-weakness may be a consequence of placing an elongated muscle in a disadvantageous position rather than from muscle weakness itself.

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