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ORIGINAL RESEARCH

HIP RANGE OF MOTION IN RECREATIONAL WEIGHT TRAINING PARTICIPANTS: A DESCRIPTIVE REPORT

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ABSTRACT

Background: The surveillance of hip injuries and risk factors have become an emerging focus in sports medicine due to the increased recognition of hip pathologies. Researchers suggest that decreased hip range of motion (ROM) is a risk factor for injury in various athletic activities. One under reported population that has potential for hip injuries is recreational weight training (WT) participants. Currently, no studies have reported hip ROM values in WT participants which creates a knowledge gap in this population.

Purpose: The purpose of this study was to report hip passive ROM values of WT participants to develop reference data for future research on injury patterns and prevention strategies for this population.

Study Design: Descriptive cross sectional study

Methods: Two-hundred healthy recreational adult WT participants (age = 27.18 ± 9.3 years, height = 174.84 ± 9.8 cm, mass = 91.0 ± 17.9 kg, body mass index = 29.6 ± 4.5 kg/m2) were recruited. Bilateral hip passive ROM was assessed for flexion, extension, internal rotation, external rotation, and abduction. Statistical analysis included subject demographics (means and SD) and a two-tailed independent *t*-test to compare mean passive hip ROM values between sexes and hips. Statistical significance was considered $p < .05$.

Results: A total of 400 hundred hips (right + left) were measured for this analysis. When comparing hip ROM values within sexes, men had no significant difference ($p \geq .28$) between the right and left hip for all motions. Women did have a significant difference ($p \leq .05$) between the right and left hip for all motions. The right hip had lower values for all motions than the left hip suggesting a more global decrease in right hip ROM. When comparing hip ROM values between men and women, there was a significant difference ($p \leq .05$) between men and women for all motions. Men had lower ROM values for all hip motions when compared to women.

Conclusion: This is the first investigation to provide a descriptive analysis of hip ROM in healthy recreational WT participants. These data provide a starting point for clinicians and researchers to further study this population for injury prevention.

Evidence Level: 2

Key words: Exercise, hip joint, injury, mobility, prevention

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INTRODUCTION

It has been estimated that approximately 45 million Americans participate in some form of resistance training two or more times a week.[1] From a benefit perspective, resistance training improves both health and fitness attributes. Specifically, researchers suggest that resistance training may have a positive effect on muscle performance, bone mineral density, and function.[2-4] Although the benefits of resistance training have been well documented, participation is not without risk as a significant number of injuries have been reported in the literature.

Approximately 25% of those that participate in weight-training (WT), a form of resistance training, report injuries severe enough for which they sought medical attention.[5] It has been reported that WT participants sustained, on average, 2.4-3.3 injuries per 1000 hours of activity.[6,7] Injuries to the shoulder, low back, and knee are the most reported injuries among this population.[7,8] Recently, injuries to the hip have received more attention due to improved recognition of pathology and the advent of hip arthroscopy.[9] Reports of hip injuries among individuals who weight train are lacking in the literature. Among the available studies, Jonasson et al[10] reported that 31% of WT injuries were hip related in a sample of 21 male weightlifters and Kulund et al[11] reported a 3% hip injury rate among 80 male weightlifters. Unfortunately, the WT population has not been studied in detail to determine the future risk for chronic musculoskeletal condition such as hip osteoarthritis. Nevertheless, many of the occupational risk factors identified for hip Osteoarthritis (OA) seemingly resemble WT activities (e.g. climbing, squatting, lifting).[12]

Of interest to sports medicine professionals, is the association between hip range of motion (ROM) and the potential for injury in the WT population. The connection between hip ROM deficits and injury has been reported for other athletic activities. For baseball, a higher risk of shoulder,[13] elbow,[14] and groin injuries[15] have been found in players with hip ROM deficits. Hip ROM deficits have also been associated with hip, groin, and knee injuries in soccer,[16-19] tennis[20] and ice hockey.[21] These data provide insight into a potential risk factor for hip injury among these athletic activities which may also be a risk factor in the WT population. To date, a paucity of data has been directly reported in the WT population which creates a gap in the knowledge regarding this potential connection.

Furthermore, clinicians must rely on previously published normative data on hip ROM and attempt to apply the values when treating clients who WT.[22] Other sports such as soccer,[19] baseball,[23,24] tennis, [25] dance[26] and golf[27] have published reference ROM values. The WT population lacks adequate reporting of hip ROM values and it is not unreasonable to postulate that a difference may exist when compared to the general population as a result of training patterns. Published studies on individuals who participate in WT have focused on hip motion for specific movements such as the squat,[28,29] lunge[30] or the step down movement.[31] To date, no studies have reported hip ROM values for these individuals. Thus, the purpose of this study was to report passive hip ROM values of WT participants to develop reference data for future research on injury patterns and prevention strategies for this population.

METHODS

This descriptive cross sectional study involved the measurement of passive hip ROM in recreational WT participants. This study was approved by the University of Central Florida institutional review board (IRB # IRB00001138).

Participants

A convenience sample of 200 recreational WT participants (400 hips) 18-59 years were recruited via flyers and word of mouth from the university campus, local health clubs, and gymnasiums (Table 1). The inclusion criteria included: history of WT for at least one year and current participation in recreational WT at least two times per week. Exclusion criteria included: current complaint of hip injury or pain, prior surgery to hip joint, and any medical or musculoskeletal condition that would prevent testing. Additionally, participants were excluded if they were currently participating in competitive sports or had a current or past history of competitive bodybuilding or power-lifting. All participants who qualified received detailed information of the study requirements and were required to speak and read English to complete the university approved consent process prior to participation.

Table 1. *Subject Demographics.*	Age (years)	Height (cm)	Mass (kg)	BMI (kg/m2)	Training Experience (years)	Weekly training (days)
All subjects (N=200) (mean ± SD) (M-139, F-61)	27.2 ± 9.3	174.8 ± 9.8	91.0 ± 17.9	29.6 ± 4.5	6.4 ± 1.6	3.4 ± 1.2
Men (N=139)	27.0 ± 9.1	179.6 ± 6.9	99.1 ± 14.4	30.7 ± 4.7	7.8 ± 1.2	3.6 ± 1.4
Women (N=61)	27.6 ± 9.9	163.9 ± 6.7	72.6 ± 10.1	27.1 ± 4.1	5.9 ± 1.8	3.3 ± 1.1
cm=centimeters; BMI, Body mass index; kg, kilograms						

Instrumentation

Measurement of bilateral passive hip flexion, extension, abduction, internal rotation (IR) and external rotation (ER) ROM was performed and measured with a standard goniometer. Standard goniometry has shown to be a valid and reliable instrument for measuring hip ROM.[32-35]

Pilot Study

Prior to data collection, a pilot study was conducted to determine intersession reliability. Two examiners participated in data collection for this study. The goniometric measurements were performed on 20 independent participants chosen for this portion of the study. The Intraclass Correlation Coefficient (ICC) was used to calculate intersession (ICC model 2, k (95% CI)) reliability.[36] For the reliability analysis, a single measurement of the right and left hip were taken and the mean of the two values were used. For passive hip ROM, there was good intersession reliability for IR ICC = 0.90 (.87-.92), ER ICC = 0.89 (.84-.91), flexion ICC = 0.84 (0.78–0.88), abduction ICC = 0.90 (0.86-0.92), and extension ICC = 0.81 (.75-.85) ROM. The standard error of measurement (SEM) ranged from 3-degrees for abduction, ER, and IR to 4 degrees for flexion and extension. SEM values were rounded to the nearest degree to reflect the smallest unit available on a goniometer.

Procedures

All measurement were performed in a climate controlled environment and performed based on previously described measurement procedures.[37,38] All subjects underwent the same testing procedures by two examiners. Subjects were blinded to the results and from other subjects participating in the study. No practice or warm-up was performed prior to testing. The following procedures for each motion is described below.

Hip Flexion ROM. The subject was positioned supine on an examination table. The examiner passively flexed the subject's hip as far as possible with the opposite leg extended. The goniometer was centered at the greater trochanter, aligning one arm along the center of the thigh and the other arm aligned horizontally as illustrated in Figure 1. The examiner monitored for any aberrant pelvic motion prior to taking measurement.[37]

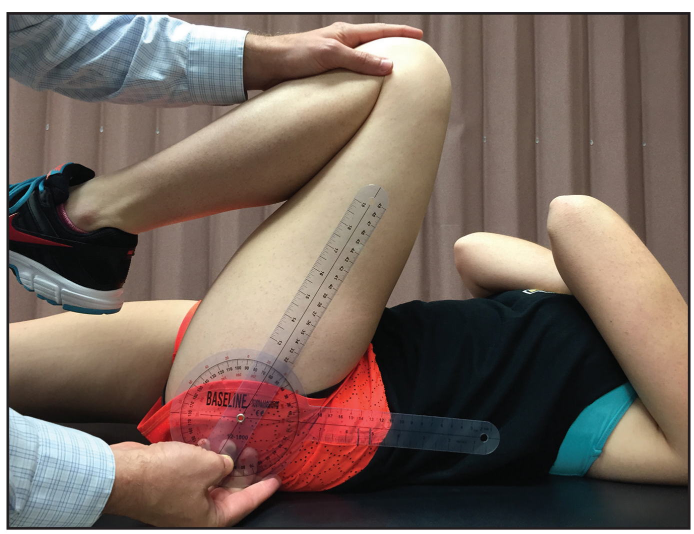

Figure 1. *Goniometric measurement of supine hip flexion.*

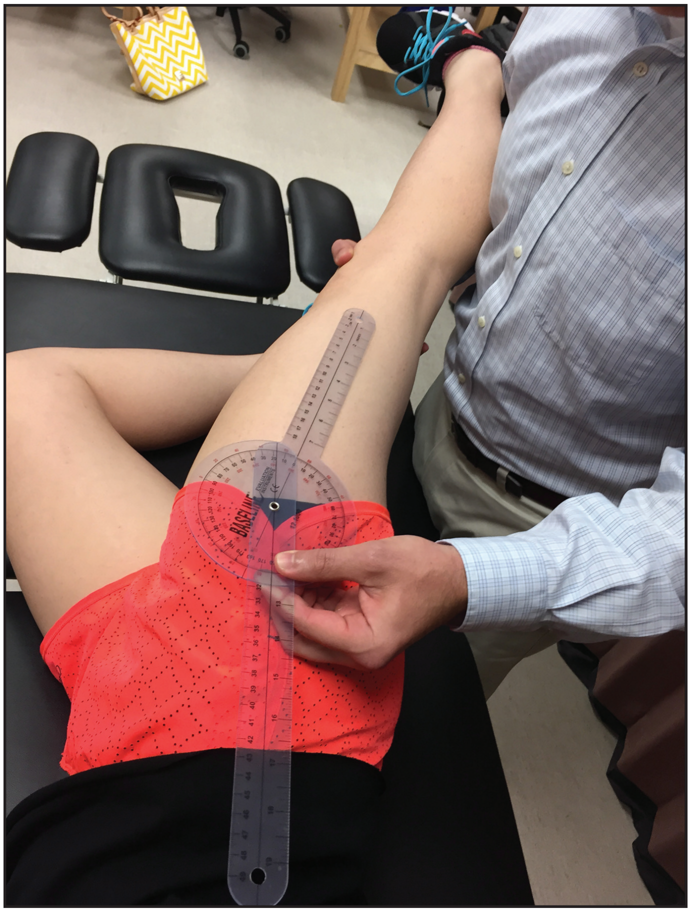

Figure 2. *Goniometric measurement of side lying hip extension.*

Hip Extension ROM. The subject was positioned in the sidelying position on the examination table with the test extremity facing upward. The lowermost extremity was flexed at the hip to 45 degrees and at knee to 90 degrees. The examiner passively extended the hip with knee straight as far as possible. The goniometer was centered at the greater trochanter aligning one arm of goniometer over the center of the thigh and the other arm along a zero-degree position as illustrated in Figure 2. The examiner monitored for any aberrant lumbopelvic motion prior to and during the measurement.[37]

Hip IR ROM. The subject was sitting on an examination table with their knees flexed to 90° and feet unsupported. The examiner stood in front of the test leg and centered the goniometer at the lower border of the patella with the arm of the goniometer aligned along the patellar tendon and the other arm aligned vertically. The examiner passively moved the participant's hip into IR, keeping their leg in neutral, to

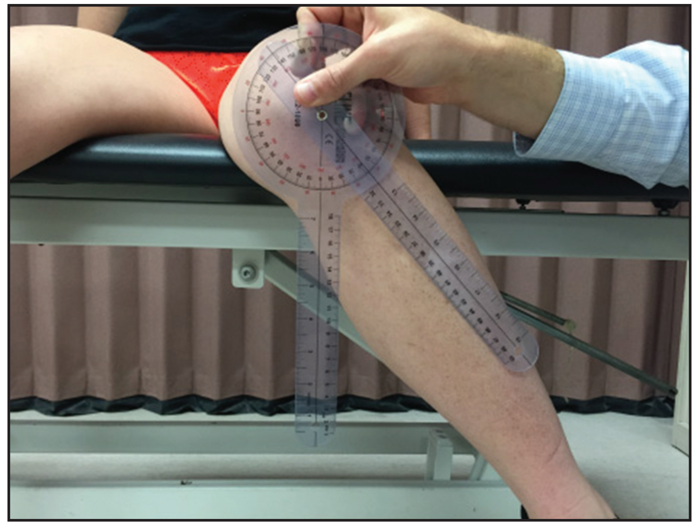

Figure 3. *Goniometric measurement of seated hip internal rotation.*

the end of the available range until an "unyielding" end-feel was felt and then took the measurementas illustrated in Figure 3. [37,38] . The examiner provided verbal cues if the participant compensated in any way to ensure no substitute movements occurred during testing.

Hip ER ROM. The subject was sitting on an examination table with their knees flexed to 90° and feet unsupported. The examiner stood in front of the test leg and centered the goniometer at the lower border of the patella with the arm of the goniometer aligned along the patellar tendon and the other arm aligned vertically. The examiner passively moved the participant's hip into ER, keeping their leg in neutral, to the end of the available range until an "unyielding" end-feel was felt and then took the measurement as illustrated in Figure 4.[37,38] The examiner provided verbal cues if participant compensated in any way to ensure no substitute movements occurred during testing.

Hip Abduction ROM. The subject was positioned supine on the examination table with legs extended. The examiner stood on the side of the test leg. The goniometer was centered midway between the subject's anterior superior iliac spine and pubic symphysis, aligning one arm centrally over their thigh. The examiner passively abducted the subject's leg as far as possible, without causing any aberrant pelvic motion, and then took the measurement as illustrat-

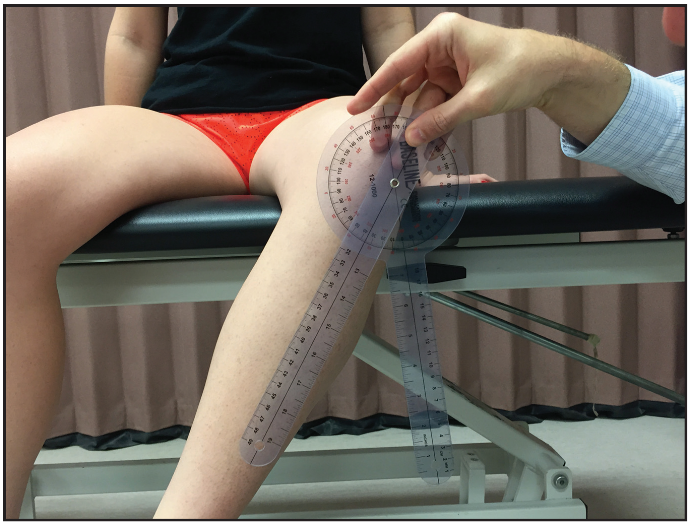

Figure 4. *Goniometric measurement of seated hip external rotation.*

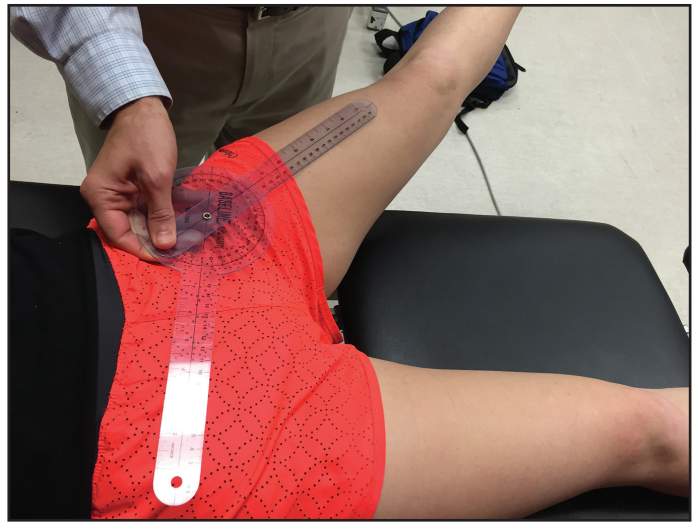

Figure 5. *Goniometric measurement of supine hip abduction.*

ed in Figure 5. [37] The examiner monitored for any aberrant lumbopelvic motion prior to and during the measurement.[37]

Statistical Analysis

Statistical analysis was performed using SPSS version 24.0 (IBM SPSS, Chicago, IL, USA). Participant descriptives were calculated and reported as the mean and standard deviation (SD) for age, height, mass, body mass index, and ROM values. A two-tailed independent *t*-test was used to compare mean passive hip ROM values between the right and left leg to determine asymmetries as well as to compare men and women. Statistical significance was considered as $p < 0.05$. The SEM was calculated for the reliability pilot study using a previously established formula SEM = standard deviation multiplied by the square root of 1-ICC value.[39]

RESULTS

Participant demographic data is presented in Table 1. Both men and women reported participation in WT a mean 3.4 times per week with no significant differences between men and women ($p = .88$). Training experience was reported at a mean of 5.9 years for women and 7.8 years for men. Significant differences for training experience were not found ($p = .22$). Tables 2 and 3 present mean passive ROM values. When comparing hip ROM values among sexes, men had no significant differences ($p \geq .28$) between the right and left hip for all motions. Women did have a significant differences ($p \leq .05$) between the right and left hip for all motions. The right hip had lower values for all motions than the left hip suggesting a more global decrease in right hip PROM (Table 3). When comparing hip ROM values between men and women, there was a significant difference

Table 2. *Hip ROM Values for Recreational Weight Training Participants.*

	Right Hip	Left Hip	p-value
Flexion	120.4 ± 14.5°	121.3 ± 13.8°	.50
Extension	12.6 ± 5.9°	12.6 ± 7.6°	.95
Internal Rotation	36.4 ± 9.5°	36.1 ± 8.7°	.82
External Rotation	32.2 ± 8.7°	32.0 ± 9.4°	.78
Abduction	42.6 ± 11.3°	43.2 ± 12.3°	.64

**= statistically significant difference*

Table 3. *Comparison between Right and Left Hip ROM among Sexes.*

	Men			Women		
	Right	**Left**	**P-value**	**Right**	**Left**	**p-value**
Flexion	117.0 ± 14.9°	118.0 ± 14.4°	.28	118.0 ± 14.4°	128.9 ± 8.2°	<.001*
Extension	11.2 ± 5.4°	10.8 ± 5.5°	.72	10.8 ± 5.5°	16.7 ± 9.9°	<.001*
Internal Rotation	34.6 ± 9.2°	34.4 ± 8.0°	.58	34.4 ± 8.0°	40.1 ± 8.8°	<.001*
External Rotation	30.3 ± 8.5°	29.8 ± 9.1°	.68	29.8 ± 9.1°	37.0 ± 8.1°	<.001*
Abduction	41.9 ± 12.0°	42.1 ± 11.4°	.44	42.1 ± 11.4°	45.8 ± 13.8°	.05*

**= statistically significant difference*

Table 4. *Comparison between Male and Female Recreational Weight Training Participants.*

	Right Hip			Left Hip		
	Men (N=139)	**Women (N=61)**	**P-value**	**Men (N=139)**	**Women (N=61)**	**p-value**
Flexion	117.0 ± 14.9°	127.9 ± 9.9°	.001*	118.0 ± 14.4°	128.9 ± 8.2°	<.001*
Extension	11.2 ± 5.4°	15.7 ± 5.7°	.001*	10.8 ± 5.5°	16.7 ± 9.9°	<.001*
Internal Rotation	34.6 ± 9.2°	40.4 ± 9.1°	.001*	34.4 ± 8.0°	40.1 ± 8.8°	<.001*
External Rotation	30.3 ± 8.5°	36.7 ± 7.7°	.001*	29.8 ± 9.1°	37.0 ± 8.1°	<.001*
Abduction	41.9 ± 12.0°	44.4 ± 9.1°	.05*	42.1 ± 11.4°	45.8 ± 13.8°	.04*

** = statistically significant difference*

($p \leq .05$) between men and women for all motions. Men had lower ROM values for all right and left hip motions when compared to women (Table 4).

DISCUSSION

This is the first investigation to report hip passive ROM values in recreational WT participants. This group has been understudied compared to other athletic groups which leaves a gap in the knowledge regarding hip ROM and the potential risk for injury. These results provide reference hip ROM values that may help to further classify these individuals for future research on injury surveillance and prevention strategies.

The results of the study suggest that among recreational WT participants, women have greater hip ROM in all motions ($p \leq .05$) than men. This is consistent with prior research reporting greater hip ROM values in adult women when compared to adult men.[22,40] However, it is often difficult to make a direct comparison among populations due to the variation in study methodology and the procedure by which ROM may be tested. Currently, there is no standard method for measuring hip ROM since many researchers measure both active and passive ROM in the supine, prone, sidelying, and seated positions.[41,42] With this being stated, the passive ROM findings of this investigation are limited to the specific procedures used. This is a necessary consideration as prone hip ER and IR may have produced different values.

When comparing results from this study to published reference values, only one comparable study was found that used similar methods for measuring passive hip IR and ER in adults.[40] The WT men and women in the current study had lower seated passive hip IR (right +left) (31.1° versus 37.9°) and ER (right + left) (36.2° versus 40.7°) when compared to the published adult values of Kouyoumdjian et al.[40] Potential reasons for the differences reside in measurement technique (e.g. positioning), procedure, and age. In the Kouyoumdjian et al study subjects were older (mean age 39.1 years), measurements were performed in supine and prone, and a digital camera with software was used to quantify ROM.[40]

Injuries to the lower extremities have been reported among elite competitive weightlifters and powerlifters but not in recreational WT participants.[6,8,43] Researchers are just beginning to report injuries specific to the hip among general WT participants. Polesello et al[44] reported on 47 individuals who underwent arthroscopic surgery for hip labral tears and chondral lesions after developing painful symptoms associated with the leg press and squat which are common WT movements. The researchers reported the post-surgical outcomes but did not provide any insight regarding the correlation between the WT movements, hip ROM, and the diagnosed hip injuries. Other researchers have evaluated pre-surgical and post-surgical unilateral and bilateral squat performance in individuals with femoral acetabular impingement (FAI). The researchers observed decreased squat depth, hip internal rotation, and decreased posterior pelvic tilt in individuals with CAM-type FAI.[9,45,46] Researchers have also observed that squat performance improved post-surgically with subjects having a greater squat depth and pelvic motion.[9] Despite these reported finding, the researchers did not discuss if the squat movement was a risk factor for injury which leaves a gap in our understanding of this common exercise.[9,45,46] Future research is necessary to examine the correlation between common WT movements, the required hip ROM, and risk of hip injury.

The data from this study provides a beginning for clinicians to understand common hip ROM values in the WT population. Impaired hip ROM may be a relative factor needing to be considered for injury prevention and athletic performance, thus should be considered for inclusion when prescribing exercises for these individuals.[14,19,23] These data are the first to be reported among WT participants, thus should be considered for clinical practice when managing such patients. WT participants may have different values based upon the types of WT activities, performed, thus general population normative values may not be relevant.

When interpreting differences in ROM values between men and women as well as side-to-side differences it should be recognized that a statistically significant difference does not necessarily mean a clinically important difference nor does it mean error in the measurement is accounted for. Moreover, it is not unreasonable for mean and women to have differences given the potential for training differences as well as body morphology.

One way to determine the error in a measurement is to consider the SEM. The SEM is an index of the expected variation of a score due to measurement error. The SEM is reported in terms of specific value and as a confidence interval around a mean. One SEM value represents 68% of the population. For example, the results of this study suggest that women have statistically greater bilateral hip ROM when compared to men. As an example, when comparing the mean angle of right hip abduction for men (41.9 degrees) to women (44.4 degrees) a difference of 2.5 degrees is present. While this difference is statistically significantly different, the SEM for hip abduction is 3 degrees. This suggests that the angles reported will vary +/- 3 degrees (68% of the time) from the mean for men and women, thus the difference may reflect error.

Limitations

When considering the methodology of this descriptive study, several limitations need to be discussed. First, this investigation reported values in healthy subjects which limits the generalizability of these results to this population. However, no reference data has been reported in this population, thus the information provided may guide practice or be used for reference values. Second, weight-training participants comprise a heterogeneous population and variability within training patterns and styles may indeed influence mobility. The effort to use only recreational participants was an attempt to capture a homogenous subgroup, however, subjects were not grouped according to a specific intensity level of exercise which may have influenced hip ROM values. Perhaps a further classification based on such variables may help guide injury prevention strategies. Third, passive hip IR and ER ROM were measured in the seated position where other investigations have measured hip ROM in different positions.[47-49] This must be considered when interpreting these results or comparing to other values to inform clinical practice. Fourth, hip adduction measurements were omitted which limits the understanding of the complete range of hip mobility in these participants. Lastly, standard goniometry was used in lieu of a digital device, as the standard goniometer is a common tool used in the clinical setting.[32-35]

Future Research

Future research should focus on prospective injury surveillance among recreational WT participants. Given the recent evidence associating hip ROM deficits and athletic injuries, future research in warranted in this population.[13-15,50-52,20,21] Also, attempts to further classify the recreational WT participant according to the type of weight training and level of training may assist in providing a better understating of subgroups based on WT activities. This may provide insight into common mechanisms of injury related to specific weight training activities and help guide injury prevention strategies. Finally, it would be beneficial for future studies to capture hip adduction range of motion and limited mobility in this plane may have consequences in terms of function and sport participation.

CONCLUSION

This study reported passive hip ROM values in recreational WT participants. Women WT participants had asymmetrical passive hip ROM whereas men had symmetrical measurements. With regard to sex, men had lower overall hip ROM compared to women. Implications for these findings may include the use of clinical efforts to increase global ROM in men, whereas women should focus on symmetry. Lastly the right hip had grossly lower ROM values among all participants, which may suggest a participation type dominance which could be addressed with efforts to achieve symmetry. This is the first study to report reference data for recreational WT participants which provides a starting point for future research. Future investigations should focus on injury surveillance and injury prevention strategies in this population.

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