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Investigation of Hip Extension and Flexion Muscle Strength in Female Weightlifting Athletes

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Abstract

Objective: It was aimed to investigate hip flexion and extension muscle strength of female weightlifters athletes participating in national and international weightlifting championships.

Methods: Hip extension, hip flexion strength measurements, weightlifting performances and demographic data of female athletes participating in international weightlifting championships (n= 15) and female athletes participating in national weightlifting championships (n= 15) included in our study were determined. Hip flexion/extension muscle strength measurements of the athletes were performed with a Lafayette hand-held dynamometer.

Results: It was observed that hip flexion and extension muscle strength values of female weightlifters who do weightlifting at international level values were higher than the values of female weightlifters who do weightlifting at the national level ($p < .05$). There was a statistically significant difference between right-left hip-flexion values in female weightlifting athletes who do elite weightlifting sports ($p < .05$).

Conclusion: It was determined that hip extension-flexion muscle strength of athletes participating in international championships were higher than hip extension-flexion muscle strength values of athletes participating in national championships. Considering that asymmetrical developments may cause sports injuries, it is thought that it is important to evaluate the asymmetrical development of hip muscle groups in certain periods.

Keywords: Hand-held dynamometry, Hip strength, Muscle strength, Olympic style weightlifting

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Kadın Halter Sporcularında Kalça Ekstansiyon ve Fleksiyon Kas Kuvvetlerinin Araştırılması

Öz

Amaç: Ulusal ve uluslararası düzeyde halter şampiyonalarına katılan kadın halter sporcularının kalça fleksiyon ve ekstansiyon kas kuvvetlerinin araştırılması hedeflenmiştir.

Yöntemler: Çalışmamızda yer alan uluslararası halter şampiyonalarına katılan kadın sporcular (n= 15) ve ulusal halter şampiyonalarına katılan kadın sporcuların (n= 15) kalça ekstansiyon, kalça fleksiyon kuvvet ölçümleri, halter performansları ve demografik verileri belirlendi. Sporcuların kalça fleksiyon/ekstansiyon kas kuvvetleri Lafayette el dinamometresi ile gerçekleştirildi.

Bulgular: Uluslararası düzeyde halter sporu yapan kadın halter sporcularının kalça fleksiyon ve ekstansiyon kas kuvveti değerlerinin ulusal düzeyde halter sporu yapan kadın halter sporcularından daha yüksek olduğu gözlendi ($p < .05$). Elit düzeyde halter sporu yapan kadın halter sporcu gruplarında sağ-sol kalça-fleksiyon değerleri arasında istatistiksel açıdan anlamlı bir farklılık gözlendi ($p < .05$).

Sonuç: Uluslararası düzeyde şampiyonalara katılan sporcuların kalça ekstansiyon-fleksiyon kas kuvvetlerinin ulusal düzeyde şampiyonalara katılan sporcuların kalça ekstansiyon-fleksiyon kas kuvveti değerlerinden daha yüksek olduğu belirlenmiştir. Asimetrik gelişimlerin sportif yaralanmalara sebep olabileceği düşüncesinden hareketle belirli periyotlarda kalça bölgesi kas gruplarının asimetrik gelişimlerinin değerlendirilmesinin önemli olduğu düşünülmektedir.

Anahtar Kelimeler: El Dinamometresi, Kalça kuvveti, Kas kuvveti, Olimpik stil halter.

INTRODUCTION

Weightlifting sport has been called Olympic style weightlifting, since the day it was accepted in Olympic Games. Olympic style weightlifting championships are held in 10 different body weight categories for different age groups of both female and male athletes. Female and male weightlifting athletes participating in the championships compete in snatch and clean and jerk techniques by lifting one-repetitive maximal weight[1].

Many muscles function in the fulfillment of the hip joint functions, which has a structure suitable for movement in three axes. The hip joint formed between the caput osis femoris and the acetabulum is located between the spheroid group joints[2,3]. There are twenty two known muscles that act on the hip joint. Many of these muscles are responsible for movement and dynamic stabilization of the hip joint. The main flexor muscle of the hip joint is the iliopsoas, which consists of the psoas major-minor and iliacus. The psoas major begins at the thoracic XII-lumbar V vertebral bodies and ends at the trochanter minor of the femur. At the level of the inguinal ligament, the psoas major and iliacus muscles combine to form the "iliopsoas" muscle[4]. For the iliopsoas muscle in hip flexion; sartorius, rectus femoris, pectineus and tensor fascia lata muscles have supporting functions. The gluteus maximus, the antagonist of m. iliopsoas, is the strongest extensor muscle of the hip joint. In the hip joint, the biceps femoris, semitendinosus and semimembranosus muscles have supporting functions in the extension of the thigh[3]. The iliopsoas muscle has important functions in flexion of the pelvis, lateral flexion of the lower vertebral column and upright posture of the trunk[5]. The gluteal muscles have important functions in hip extension/abduction and rotation of the hip and are important in stabilizing the knee joint and keeping the trunk in an upright position[6]. In Olympic style weightlifting, where stabilization of the trunk, pelvis and lower extremities is important, the strength parameters of the muscles and muscle groups in these regions are

important in terms of athletic performance[1]. Sports are one of the leading causes of musculoskeletal injuries involving the hip and knee joints[7]. Knowing the hip muscle strength is important in terms of preventing lower extremity injuries due to sports activities. Research shows that decreases in hip muscle strength are associated with lower extremity injuries[8]. It has been stated that hip muscle weakness will impair the coordination of not only the lower extremity but also the trunk and pelvis[9]. In studies conducted in different sports branches, it is known that imbalances in agonist/antagonist strength ratios increase the injury risk factor[10]. Insufficient muscle strength that stabilizes the hip joint also affects knee kinematics negatively[11].

In both female and male weightlifters, a stable trunk on a strong pelvic and hip structure can be obtained with strong and proportional hip muscles. In this way, the athletes can display a high level of weightlifting performance while being protected from the risk of injury[1]. In light of the available information, we hope that knowing the hip flexion and extension muscle strength values of female weightlifters participating in championships at national and international level will contribute to the literature and weightlifting professionals.

From this point of view, in current study, it was aimed to investigate the hip flexion and extension muscle strength of female weightlifters participating in national and international weightlifting championships.

METHODS

Participants

The female weightlifters participating in the research were composed of female weightlifters who participated in the Olympic style weightlifting championships at the national (n=15) and international (n=15) level. Elite level athletes (Elite-W) who participated in international championships were athletes who participated in the Olympic Games, World and European Weightlifting Championships. The athletes participating in the championships at the national level (Non Elite-W) were composed of female athletes who participated in the Turkey Weightlifting Championships and special weightlifting tournaments. Elite-W group was formed from athletes who have been doing regular and active weightlifting sports (at least 6 days a week) for the last 5 years in the Turkish Weightlifting National Teams. The Non Elite-W group was selected from the athletes who have been doing weightlifting (at least 5 days a week) regularly and actively for 4 years. Before the physical measurements of the athletes, the health examinations were made by the medical doctor (BI). The athletes participating in the study were given general information about the study process. Signed consent forms were obtained from all athletes who agreed to participate in the study. The study complies with the Declaration of Helsinki and the ethical approval of the study was obtained from the Clinical Research Ethics Committee of Karamanoğlu Mehmetbey University Faculty of Medicine (approval number; 01-2023/22, dated; 19.01.2023)

Data Collection Tools

The age (years), how long they had been involved in weightlifting (years), weekly training times (weeks) and injury history of all the athletes included in the study were recorded by questioning. Anthropometric characters such as height, body weight, and hip extension and flexion strength values were measured on the days when the athletes did not train and in their own places. The body weights of the athletes were measured with Tanita brand bioimpedance (MC 580), height measurements with Seca brand height meter (213 portable mechanic, Germany), and body mass indexes (BMI) were performed by dividing the body weight value by the square of the height measurement in accordance with the

literature[12,13]. All measurements were performed by the same investigator (KE).

One-repetition maximal (1RM) snatch and clean-and-jerk records for the gained by the weightlifters in World weightlifting championships, European weightlifting championships and international tournaments and weightlifting championships in Turkey were taken from the official web sites of World Weightlifting Federation[14] (https://www.iwf.net/new_bw/results_by_events/), European Weightlifting Federation[15] (http://result.ewfed.com/) and Turkish Weightlifting Federation[16] (https://halter.gov.tr/sonuclar/).

Hip extensor and flexor muscle strengths were evaluated isometrically with a manual hand dynamometer (Model-01165, A.B.D). In the evaluation of isometric muscle strength, while the athlete performs the desired movement with all her strength; the evaluator applied counterforce in the opposite direction of the movement, proportional to the force exerted by the athlete, until the point where the athlete could overcome her strength. Evaluation was done in three repetitions and the average was taken. The obtained values were recorded in kilograms (kg). Between repetitions of the test, a 30-second rest break was given.

Hip extensor isometric muscle strength (Hip-Ext) was evaluated in the prone position. The manual hand dynamometer was placed at the posterior level 5 cm proximal to the medial malleolus, and the athlete was asked to lift her leg upwards with all her strength. Hip flexor muscle strength (Hip-Flex) was evaluated in the sitting position. Athletes were asked to sit with their hips and knees at 90° and cross their arms across their chest. The manual hand dynamometer was placed 5 cm above the midpoint of the patella and the athlete was asked to lift the knee upwards with all her strength[17,18]. In order to determine the lower extremity dominance, the athletes were tested for hitting the ball, stepping on the 20 cm platform and descending from the 20 cm platform. In at least two of these three tests, the extremity used first was determined as the dominant side. Individuals with right foot dominant were included in the study.

The criteria for inclusion in the study were to be between the ages of 18-20, to be active in weightlifting for at least four years, 5 days a week, and to not have had a hip or knee injury in the past year. It was questioned whether the athletes had any sports injuries, a medical condition they were treated for, or whether they had undergone physical therapy with any previous operation. Weightlifting athletes who had hip joint range of motion limitation and pain in both lower extremities during the evaluations were excluded from the study.

Statistical Analyses

Before proceeding to the basic analysis, descriptive statistics of demographic variables were examined. In addition, Skewness and Kurtosis values, histograms and Q-Q plots were examined to examine whether the data set satisfies the normality assumption. The results obtained showed that the data met the normality assumption. In order to evaluate whether the elite and non-elite athlete groups differed significantly in terms of anthropometric, demographic and sportive performance values, t-Test analysis was performed for independent groups. To compare the right-left hip-extension and hip flexion asymmetry values, the t-Test was conducted for the paired groups. The relationships between right-left hip-extension and hip flexion values and anthropometric, demographic and sportive performance values were evaluated with Pearson correlation analysis. The level of significance for the analysis results was determined as $p < .05$. All data for this study were analyzed using SPSS computer software for Windows (IBM Corp. Released 2017. IBM

SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp).

RESULTS

The demographic, anthropometric and training age values of the groups were presented in Table I.

Age values of Elite-W's were observed to be statistically different from the values of Non-Elite-Ws t(28) = 2.856, (p < .01). There was no statistically significant difference between the groups in terms of other parameters.

Table I: Comparison of demographic and anthropometric values of elite and non-elite female weightlifting groups

Parameters	Groups	n	Mean	SD	*t*	*p*
Age (year)	Elite-W	15	19.67	1.23	2.856	.008**
	Non Elite-W	15	18.53	.915		
Height (cm)	Elite-W	15	160.33	7.20	-.441	.663
	Non Elite-W	15	161.40	6.01		
Body weight (kg)	Elite-W	15	67.98	16.66	.070	.945
	Non Elite-W	15	67.57	15.83		
BMI (kg/m^2)	Elite-W	15	26.14	4.61	.245	.808
	Non Elite-W	15	25.72	4.78		
Training age (year)	Elite-W	15	6.93	1.79	1.922	.065
	Non Elite-W	15	5.73	1.62		

*Elite-W: Elite Weightlifters, Non Elite-W: Non-Elite Weightlifters, n: Number of athletes, BMI: Body Mass Index, **p < .01, SD: Standard Deviation*

Maximum snatch, maximum clean and jerk, Right-Left Hip-Ext and Hip-Flex values of the groups included in the study are presented in Table II. It was determined that the maximum snatch, maximum clean and jerk, Right-left Hip-Ext, Right-left Hip-Flex values of Elite-W's were higher than the values of Non Elite-W's (p<.01).

Table II: Weightlifting performance data and hip muscle strength values of athlete groups

Parameters	Grup	n	Mean	SD	*t*	*p*
Maximum snatch (kg)	Elite-W	15	86.67	10.26	**3.399**	**.002****
	Non Elite-W	15	74.47	9.38		
Maximum claen and jerk (kg)	Elite-W	15	112.73	15.67	**3.456**	**.002****
	Non Elite-W	15	94.60	12.94		
Right Hip-Ext (kg)	Elite-W	15	24.77	3.53	**4.731**	**.000****
	Non Elite-W	15	19.19	2.91		
Left Hip-Ext (kg)	Elite-W	15	23.96	3.81	**3.713**	**.001****
	Non Elite-W	15	18.88	3.68		
Right Hip-Flex (kg)	Elite-W	15	22.46	3.42	**3.677**	**.001****
	Non Elite-W	15	17.98	3.24		
Left Hip-Flex (kg)	Elite-W	15	21.59	3.81	**2.967**	**.006****
	Non Elite-W	15	17.87	3.03		

*Elite-W: Elite Weightlifters, Non Elite-W: Non-Elite Weightlifters, Ext: Extension, Flex: Flexion, kg: kilogram, n: Number of athletes, ** p < .01, SD: Standard Deviation*

Right-left Hip-Ext, Right-left Hip-Flex asymmetry comparisons of Elite-W and Non-Elite-W's are presented in Table III. A statistically significant difference was observed between Right-left Hip-Flex values of Elite-W's t (14) = 2,355, p < .05). On the other hand, there was no statistically significant difference between Right-left Hip-Ext, Right-left Hip-Flex strength parameter values of the athletes in the Non Elite-W groups.

Table III: The asymmetry comparison of Right-left Hip-Ext and Right-left Hip-Flex of Olympic style weightlifting athletes

Groups	Right/Left Hip-Ext/Flex (kg)	Mean	SD	*t*	*p*
Elite-W (n=15)	Right Hip-Ext	24.77	3.53	1.685	.114
	Left Hip-Ext	23.96	3.81		
	Right Hip-Flex	22.46	3.42	**2.355**	**.034***
	LeftHip-Flex	21.59	3.81		
Non Elite-W (n=15)	Right Hip-Ext	19.19	2.91	.674	.511
	LeftHip-Ext	18.90	3.68		
	Right Hip-Flex	17.98	3.24	.292	.774
	LeftHip-Flex	17.87	3.03		

*Elite-W: Elite Weightlifters, Non Elite-W: Non-Elite Weightlifters, Ext: Extension, Flex: Flexion, kg: kilogram, n: Number of athletes, * p < .05, SD: Standard Deviation*

The correlations between Right-left Hip-Ext and Right-left Hip-Flex values and anthropometric values, training age and maximal snatch and clean and jerk performances of Elite-W and Non Elite-W athletes are presented in Table IV.

A statistically significant and positive correlation was observed between Right-left Hip Ext, Right-left Hip Flex values and height, body weight and maximal clean and jerk values in Elite-W's. In Elite-Ws; It was determined that body weight was positively correlated with Right-left Hip Ext, Right-left Hip Flex. BMI was significantly positively correlated with Right Hip Ext, Right Hip Flex in Elite-W's. Moreover, Maximum snatch was significantly positively correlated with Left Hip Ext in Elite-W's. On the other hand, it was determined that there was no significant correlation between Right-left Hip Ext, Right-left Hip Flex values and age and training age in Elite-W's.

It was observed that there was no significant correlation between Right-left Hip Ext, Right-left Hip Flex values of age, height, body weight, BMI, training age and weightlifting performances in Non Elite-W's.

Table IV: Correlation between athletes' hip extension and hip flexion strengths and anthropometric variables, training age and weightlifting performance

Variable	Elite-W (n=15)				Non Elite-W (n=15)			
	Right Hip Ext	Left Hip Ext	Right Hip Flex	Left Hip Flex	Right Hip Ext	Left Hip Ext	Right Hip Flex	Left Hip Flex
Age	.203	.174	.278	.325	.172	.058	.102	-.015
Height (cm)	**.611***	**.673****	**.568***	**.643****	-.152	-.159	.188	.224
Body weight (kg)	**.637***	**.572***	**.604***	**.603***	.012	.023	.307	.361
BMI (kg/m^2)	**.558***	.453	**.549***	.508	.051	.073	.296	.357
Training age (year)	.249	.264	.406	.326	.006	-.065	.274	.286
Max snatch (kg)	.460	**.558***	.470	.461	-.180	-.161	.303	.294
Max clean and jerk	**.593***	**.662****	**.595***	**.580***	.045	-.027	.418	.315
Right Hip Ext (kg)	1	.874***	.809***	.854***	1	.887***	.784***	.610*
Left Hip Ex (kg)	.874***	1	.840***	.894***	.887***	1	.777***	.722**
Right Hip Flex (kg)	.809***	.840***	1	.928***	.784***	.777***	1	.886***
Left Hip Flex (kg)	.854***	.894***	.928***	1	.610*	.722**	.886***	1

*Elite-W: Elite Weightlifters, Non Elite-W: Non-Elite Weightlifters, Ext: Extension, Flex: Flexion, kg: kilogram, n: Number of athletes, BMI: Body Mass Index, ** p < .01,* p < .05, *** p < .001*

DISCUSSION

Olympic style weightlifting is an Olympic sports branch in which single repetitive maximal weights are lifted with snatch and clean and jerk techniques[1]. In Olympic style weightlifting, stabilization of the lower and upper extremities and the trunk has an important role in achieving success. In static and dynamic activities such as walking, running, standing upright, bending forward and sideways, and lifting weights, the abdominal posterior wall muscles are responsible for the stabilization of the lumbar spine and hips and the control of the lumbar lordos with these functions[19]. The strength parameters of the muscles in the posterior abdominal wall are of great importance during the dynamic and static loads where the weight is lifted. Because, the strength of the posterior abdominal wall muscles is of great importance in terms of both the sportive success of the athletes and the prevention of sportive injuries[20]. In a study examining the volumes of the posterior abdominal wall muscles of Olympic style weightlifting athletes and the relationship of these muscles with sportive

performance, it has been stated that the 12-week special training applied to the athletes provides an increase in the abdominal posterior wall muscle volumes of the athletes and the increase in the volume observed in these muscles positively affects the maximal weights that the athletes lift. The authors stated that it would be a correct approach to add specific exercises that develop the posterior abdominal wall muscles to the general weightlifting programs at the point of contributing to the athletic success of Olympic weightlifters in national and international competitions[20]. Gluteal muscles have important functions in keeping the trunk upright, stabilizing the hip joint, climbing stairs, fixing the hip and knee joints in weight lifting, sprinting, squatting and climbing a steep hill[21-23]. In a study in which the muscle cross-sectional surface areas of the gluteal muscles of Olympic style weightlifting athletes were determined through magnetic resonance images, it has been explained that the gluteus maximus muscle cross-sectional surface area of the athletes is larger than the gluteus maximus muscle cross-sectional areas of the sedentary individuals, but no statistical difference was observed between the gluteus medius and minimus muscle group cross-sectional areas of the athletes and sedentary groups. The authors stated that there is a positive correlation between muscle strength and muscle cross-sectional area, therefore, adding exercises that develop these muscle groups to weightlifting training programs in order to increase the gluteal muscle cross-sectional area determined in weightlifters can be effective in both sportive performance of the athletes and in preventing sports injuries that may occur in this region[24]. In order for the muscles and joint mobility in the hip region to have correct and balanced biomechanics, force couples and agonist/antagonist force ratios should be at a sufficient level. Imbalances in strength ratios cause various injuries during sports activities[18,25]. Niemuth et al.[18] stated that the losses observed in hip abduction and flexion forces are among the factors that predispose to sports injuries, and also stated that there was a significant correlation between muscle strength weakness observed in the muscles of the hip region and running injuries in runners with sports injuries.

In a study examining the differences between injured and uninjured limbs in terms of tennis players who have a groin injury and do not have this sportive injury, hip strength and jump height, the authors stated that tennis players with groin injured have weaker adductor muscle strength and that this observed adductor muscle weakness is related to groin injury[26]. Although no statistically significant difference was observed between the height, body weight, BMI, and training age values of Elite-W and Non-Elite-W's in our study, significant differences were observed in terms of hip extension and flexion strength parameters. The observed difference may have been caused by the differences in the training, snatch, clean and jerk techniques, and the maximum weight lifted among the athlete groups, as observed in correlation analyses. Adding exercises that develop the hip extension and flexion muscle groups to the weightlifting training of Non Elite-W's may be beneficial. As a result, it is believed that with strong hip muscles, not only the risk of injury can be reduced but also athletic performance can be increased.

Gallo-Salazar et al.[27] stated that they found the hip abductor muscle strength to be higher on the non-dominant side and the adductor muscle strength on the dominant side in their research on the hip region muscle strength evaluation of tennis players. The authors emphasized that the asymmetrical developments observed in the muscle groups are related to the training techniques applied to the athletes and that the evaluation of the muscle strength of the muscles around the hips before the season is important

in terms of preventing asymmetrical developments. In a study in which the muscle group strength of the hip region (flexor, extensor, abductor, adductor, internal rotator, external rotator) of runners with and without sporting injuries was determined, the authors explained that no asymmetric development was observed in the hip strength parameters of non-injured runners. It was stated that they detected asymmetrical developments in the injured runners. It has been reported that adding hip strengthening exercises to training programs would be beneficial in terms of increasing the strength parameters of the muscle groups in the hip region and minimizing the observed asymmetrical developments[18]. In a study in which the gluteal muscles and iliopsoas muscle group volume of professional tennis players, football players and healthy individuals were determined; it was shown that the gluteal muscles of the non-dominant side of tennis players were more hypertrophic than the dominant side. In the same study, it was stated that the gluteal muscles and iliopsoas muscle group volume were more symmetrical in football players and healthy sedentary individuals. The authors declared that the presence of side asymmetry in the extremities may cause sports injury[28]. In a study investigating the relationships between hip abduction and extension strengths and lower extremity injury and low back pain in female and male athletes; it was determined that the strength parameters of the left hip extensors were higher in athletes, and that the right hip abductors were stronger than the left hip abductors. The authors stated that the observed asymmetrical strength differences may be due to the applied training methods and the differences in the sports branch[29]. In a study investigating the adductor-related groin pain of soccer players with chronic sports injuries and soccer players without sports injuries, it has been reported that a statistically significant difference was observed in the dominant-non-dominant ratios of adductor-abductor muscle peak torques of the athletes. In addition, it has been reported that the adductor muscle strength of the athletes with sports injuries is quite low in the affected side. The authors stated that the agonist-antagonist muscle strength ratio imbalances observed in the hip muscle groups of soccer players may cause sports injuries, and it would be beneficial to reorganize the training programs of the athletes in order to eliminate such problems[25]. It has been reported that there is a positive correlation between hip flexors, extensors and abductor muscle strengths, core area endurance and balance tests in basketball player women whose hip strength measurements were performed. In the same study, the authors explained that the hip extensors have an important function in the control of the pelvis and trunk[30]. In a study in which the cross-sectional surface areas of the gluteal muscles of weightlifting athletes and sedentary individuals were determined through magnetic resonance images, it was stated that asymmetrical developments observed in muscle cross-sectional surfaces may also cause asymmetrical developments in muscle strength ratios. Due to the fact that weightlifting is a symmetrical sport, no asymmetrical development was detected in the gluteal muscle groups of the athletes participating in the study, but it was stated that it would be beneficial to prevent asymmetrical developments that may occur by performing radiological imaging of this region at certain periods, considering that asymmetrical developments may cause sports injuries[24]. No asymmetrical development was observed between the right-left Hip Ext and Right-left Hip Flex values of the Non Elite-W's in our study, however, a statistically significant difference was observed between the Right-left Hip Flex values of the Elite-W's. In the jerk section, which is the second phase of the clean and jerk technique, the athletes open their feet forward and backward with the scissoring technique and lift the weight above the ahead,

so at this stage, the loads on the leg and hip region differ depending on the use of the dominant foot. Therefore, we speculate that the difference observed in Elite-W's may be the use of the right foot as the dominant foot in the jerk section, which is the second phase of the clean and jerk technique. Furthermore, in elite weightlifters, the asymmetry of hip muscle strength in our study may be associated with technical problems caused by intense and heavy training.

The main limitation of our study is the use of manual hand dynamometer instead of isokinetic systems during hip extension-flexion muscle strength evaluation. It should be noted that isokinetic systems will provide clearer, more objective and detailed information in muscle strength evaluation. In addition, in isokinetic systems, since it will provide not only isometric but also concentric and eccentric evaluation of muscle strength, it may be a more effective determinant in determining risk factors. However, manual hand dynamometer is frequently preferred during hip evaluations in the clinic because of the high cost of isokinetic systems, the laborious and time-consuming hip evaluation. Therefore, in our study, the manual hand dynamometer, which has more practical and accessible clinical applications, was preferred. Another limitation was that the athletes included in our study were formed from asymptomatic individuals. In future studies, it will be possible to evaluate the strength and power parameters of the muscle groups in the hip region by including the athletes with symptoms in the study.

In conclusion, our research has shown that the hip extension and flexion muscle strengths of Elite-W's are statistically significantly higher than Non-Elite W's. Therefore, considering the positive relationship between strength increase and performance increase, we predict that it may be beneficial to add special exercises that increase the development of hip extensor and flexor muscle strength to the training programs of Non Elite-W's. In addition, although weightlifting is a symmetrical sport, the asymmetric development observed in Elite W's was found to be remarkable. Therefore, based on the thought that asymmetrical developments may cause sports injuries and negatively affect weightlifting performance, we think that it may be useful to evaluate the strength parameters of the lower extremity and hip muscle groups of weightlifters at certain periods.

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Ethics Committee Approval: The study protocols were approved by the Clinical Research Ethics Committee of Karamanoğlu Mehmetbey University Faculty of Medicine (date: 19.01.2023, protocol number: 01-2023/22).

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