

## ORIGINAL ARTICLE

# Investigation of the relationship between lower extremity muscle strength and hip functions in adult individuals with developmental hip dysplasia

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**Purpose:** Varying degrees of muscle weakness are observed in muscles of individuals with developmental dysplasia around the hip. One of the important parameters that determine functionality for hip joint is the basic movements during daily living activities and requires hip muscles strength. The aim of this study was to investigate whether lower extremity muscle strength is associated with hip functions in developmental dysplasia subjects.

**Method:** Twenty-six female patients (mean age 40.46±2.28 years (range, 20-60 years)) with the developmental dysplasia of hip who haven't undergone total hip arthroplasty were included. Isometric muscle strength of hip flexor, extensor, abductor, adductor, internal rotator, external rotator, quadriceps femoris and hamstring muscles (medial-lateral) was evaluated with hand dynamometer and hip functions was evaluated with Harris Hip Score.

**Results:** There was a significant positive moderate correlation between Harris Hip Score and hip flexors, extensors, abductors, adductors, and lateral hamstring (biceps femoris) muscle strength ( $p<0.05$ ), no relationship was found with internal and external rotators, quadriceps femoris and medial hamstrings ( $p>0.05$ ).

**Conclusion:** There is a close relationship between hip muscle strength and hip function in individuals with developmental dysplasia of hip. This relationship includes hip flexors, abductors, adductors, lateral hamstrings and hip extensors, and as these muscles' strength decreases, hip function decreases. In contrast, hip rotators, quadriceps and medial hamstrings strength are not related to hip function. Therefore, in order to achieve a good functional level in these patients, hip muscle strength should be good and strengthening exercises should be given importance in the treatment.

**Keywords:** Hip dysplasia, Lower extremity, Muscle strength, Function.

## Gelişimsel kalça displazili erişkin bireylerde alt ekstremitte kas kuvveti ile kalça fonksiyonları arasındaki ilişkinin incelenmesi

**Amaç:** Gelişimsel kalça displazili bireylerde kalça çevresi kaslarda değişik derecelerde kas zayıflıkları görülür. Kalça ekleminde fonksiyonelliği belirleyen önemli parametrelerden birisi, günlük yaşam aktiviteleri sırasındaki temel hareketlerdir ve kalça çevresi kaslarının kuvvetini gerektirir. Bu çalışmanın amacı, literatürde gelişimsel kalça displazili bireylerde alt ekstremitte kas kuvvetinin kalça fonksiyonları ile ilişkili olup olmadığını araştırmaktır.

**Yöntem:** Çalışmaya gelişimsel kalça displazisi tanılı ve total kalça artroplastisi uygulanmamış, yaş ortalaması 40,46±2,28 yıl olan (20-60 yaş arası) 26 kadın hasta dahil edildi. Hastaların kalça fleksörleri, ekstansörleri, abduktörleri, addüktörleri, iç ve dış rotatörleri, quadriceps femoris ve hamstring kaslarının (medial ve lateral) izometrik kas kuvvetleri dijital el dinamometresi ile kalça fonksiyonları Harris Kalça Skoru ile değerlendirildi.

**Bulgular:** Harris Skoru ile kalça fleksörleri, ekstansörleri, abduktörleri, addüktörleri ve lateral hamstringlerin (biceps femoris) kas kuvvetleri arasında pozitif yönde orta seviyede bir ilişki bulunurken ( $p<0,05$ ), kalça iç ve dış rotatörleri, quadriceps femoris ve medial hamstringler ile herhangi bir ilişki saptanmadı. ( $p>0,05$ )

**Sonuç:** Gelişimsel kalça displazili bireylerde kalça çevresi kas kuvveti ile kalça fonksiyonları arasında yakın bir ilişki vardır. Bu ilişki, kalça fleksörleri, abduktörleri, addüktörleri, lateral hamstringler ve kalça ekstansörleri için geçerlidir ve bu kasların kuvveti azaldıkça kalça fonksiyonları azalmaktadır. Buna karşılık, kalça rotatörleri, quadriceps ve medial hamstringlerin kas kuvvetleri kalça fonksiyonları ile ilişkili değildir. Bu nedenle bu hastalarda iyi bir fonksiyonel seviyenin elde edilmesi için, kalça çevresi kas kuvvetlerinin iyi olması ve tedavide kuvvetlendirme egzersizlerine önem verilmesi gerekmektedir.

**Anahtar kelimeler:** Kalça displazisi, Alt ekstremitte, Kas kuvveti, Fonksiyon.

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**D**evelopmental dysplasia of the hip (DDH) is a pathological condition in which the constituent parts of the hip are normal during the intrauterine period, but subsequently show structural deterioration due to various reasons.<sup>1,2</sup> According to ethnic and geographical variables the incidence of DDH worldwide is 1-2 per 1000 births. In our country, the incidence of DDH is estimated to be 5-15 per 1000 births.<sup>3</sup>

The importance of early diagnosis and proper intervention in DDH is also well known. The shallow joint of the hip joint, especially in adulthood, requires more serious treatment including major surgical procedures such as total hip arthroplasty (THA).<sup>4</sup>

However, depending on the severity of the pathology, with involvement of the soft tissue, different levels of musculoskeletal problems and functional impairments are seen in individuals with DDH in different ages. Degenerative and mechanical changes, pain, limitation of joint movements and various deformities with compensatory adaptations such as scoliosis, limb length inequalities, pelvic asymmetry are observed from early ages, especially in the hip joint, trunk, spine and lower extremities.<sup>2</sup> Instability or insufficient stability during functional activities, difficulty in walking and in activities of daily living, imbalances in muscle strength and varying levels of balance loss can be seen in individuals with DDH.<sup>4</sup> The functionality of the hip joint, which includes basic hip movements in walking, ascending and descending the stairs, rising up and down from the chair require enough strength of the muscles around the hip. Individuals with DDH have varying degrees of muscle weakness in muscles around the hip as a result of structural and biomechanical changes in the hip joint.

In the literature, quite few studies were performed on muscle strength and hip functions in individuals with DDH who had undergone THA or corrective surgery.<sup>4-7</sup> Muscle strength, pain, and gait were evaluated in fewer studies that includes individuals had not undergone THA and previously received any treatment.<sup>8-10</sup> However, there were no studies that investigate the relationship between hip or lower extremity muscle strength and hip function in pre-operative or post-operative periods in individuals with DDH.

One of the biggest problems in DDH patients is functional deficiency at daily activities and for performing these activities muscle strength plays an important role. Therefore, we thought that an increase in muscle strength may improve functions and functional capacity in DDH patients.

In the light of this information, the aim of this study was to determine whether lower extremity muscle strength is associated with hip functional level in DDH individuals.

## METHODS

This was a cross-sectional study, which evaluate the hip and knee muscle strength and hip functions in developmental dysplasia of the hip (DDH) individuals.

### Participants

Twenty seven female individuals aged between 20 and 60 years old were included in the study. They have been diagnosed as DDH by the same orthopedics and traumatology surgeon from the Ankara University, Faculty of Medicine, Orthopedics and Traumatology Department and have been referred to Hacettepe University, Faculty of Physical Therapy and Rehabilitation, Orthopedic Rehabilitation Unit. Individuals who had undergone total hip or knee arthroplasties or other corrective hip surgeries and the other lower extremity surgeries in the last 5 years and the individuals with disabilities, neurological disease, dementia or cognitive impairment and peripheral nerve injuries at lower extremities were excluded from the study.

An approval was obtained (from the Ankara University, Faculty of Medicine, Ethics Board, 10.12.2018, decision no: 20-1357-18) for this study. Also, we gave an informed consent form about the study to all patients. The study was started after getting patients' approval for participation.

One patient has dropped out from the study due to back pain during the evaluation. The study was conducted with 26 patients. Patients had different levels of hip dysplasia. Their ages, dominant extremities, affected extremities, height and weight values were recorded as demographic information. Their body mass indexes were calculated. Hip and knee muscle

strength and functional level of affected hips were evaluated and recorded.

#### **Assessment of lower extremity muscle strength**

To evaluate isometric muscle strength of the lower limbs of the affected hip side a digital hand dynamometer (Lafayette, 01165, Lafayette Instrument Company, USA) was used. This was a valid and reliable method to measure isometric muscle strength.<sup>11-13</sup>

Each measurement was repeated 3 times with 5 seconds intervals and the average of 3 repeats at room temperature was recorded as Newton. Isometric muscle strength of hip flexors, abductors, adductors, internal and external rotators, extensors, quadriceps muscle, medial hamstrings (semimembranosus and semitendinosus muscles) and lateral hamstrings (biceps femoris muscle) were evaluated. The individuals during evaluation were positioned according to the manual muscle strength test position.

#### **Assessment of hip functions**

Hip functional level on the affected side was evaluated using Harris Hip Score. This score is one of the commonly used clinician-based outcome measure methods applied by a qualified healthcare professional, such as a physician or physiotherapist. It is a reliable and valid outcome measure for determining functional level of various hip pathologies and it has translation, cross cultural adaptation for Turkish version.<sup>14</sup> Harris Hip Score has also been commonly using to evaluate hip functions in adult DDH individuals.<sup>15,16</sup>

It consists of four main sub items as parameters: pain, function, deformity and range of motion. The pain parameter evaluates the severity of pain and its relationship according to level of the activities. The function parameter evaluates functional level of daily living activities (sitting, walking distance, stairs, limping, use of support, wearing shoe & socks, use of public transportation). Hip flexion, adduction, internal rotation and extremity inequality are evaluated in the deformity sub item, while hip flexion, abduction, adduction; internal and external rotation movements are evaluated in the range of motion sub item.<sup>17</sup>

The total score is between 0-100 points. The higher values show the better functional level while lower values show poor functions. Functional levels according to score are

considered as 0-40 points poor, 41-60 moderate, 61-70 good, 71-85 very good, 86-100 excellent.

#### **Statistical analysis**

IBM Statistical package program, version 21 was used for statistical analysis. Data for normal distribution was examined by visual (histogram and probability graphs) and analytical (Shapiro-Wilk Test, Skewness Kurtosis values) methods. While age, hip internal rotation, quadriceps muscle and hamstring muscle medial group muscle strength and Harris Hip Score data provided normal distribution conditions, the other data did not provide. The relationship between the parameters was examined with the Pearson Correlation Coefficient and Spearman Correlation Coefficient Tests when the data provided normal distribution conditions. Mean and standard deviation values were used for descriptive statistics of the data, and type-1 error level was accepted as 0.05 for statistical significance. The correlation coefficient ranges 0.00-0.19 "very weak", 0.20-.0.39 "weak", 0.40-0.59 "moderate" 0.60-0.79 "strong", 0.80-1.0 "very strong" were accepted for correlation level.<sup>18</sup>

## **RESULTS**

26 female individuals diagnosed with developmental dysplasia of the hip (DDH) were included in the study. Age values of individuals were minimum (min): 20 years, maximum (max): 60 years, mean and standard deviation: 40.46±2.28 years and heights were (min): 1.47 m, (max): 1.70 m, average and standard deviation: 1.56±0.052 m, weights were (min): 49 kg, (max): 102.1 kg, average and standard deviation: 61.36±11.46 kg, body mass indexes were (BMI) min: 17.99 kg/m<sup>2</sup>, max: 44 kg/m<sup>2</sup>, average and standard deviation: 26.23±1.09 kg/m<sup>2</sup>. (Table 1)

The right hip in 12 individuals (46.2%) and the left hip in 14 individuals (53.8%) were affected. Dominant extremities were right in 22 individuals (84.6%) and left in 4 individuals (15.4%).

Hip functional levels according to the Harris Hip Score were poor in 2 individuals (7.7%), moderate in 11 individuals (42.3%), while it was good in 3 individuals (11.5%), very good in 9 individuals (34.6%) and perfect in one

individual (3.8%). The mean and standard deviation of muscle strength and Harris Hip Score values of the individuals can be shown in Table 2.

There was a statistically significant positive correlation with moderate level between Harris Hip Score and hip flexors ( $r=0.460$ ) (Figure 1), extensors ( $r=0.412$ ) (Figure 2), abductors ( $r=0.402$ ) (Figure 3), adductors ( $r=0.436$ ) (Figure 4) and biceps femoris ( $r=0.510$ ) (Figure 5) muscle strength ( $p<0.05$ ) whereas there was no significant relationship between the hip rotators, quadriceps and medial hamstrings ( $p>0.05$ ) (Table 3).

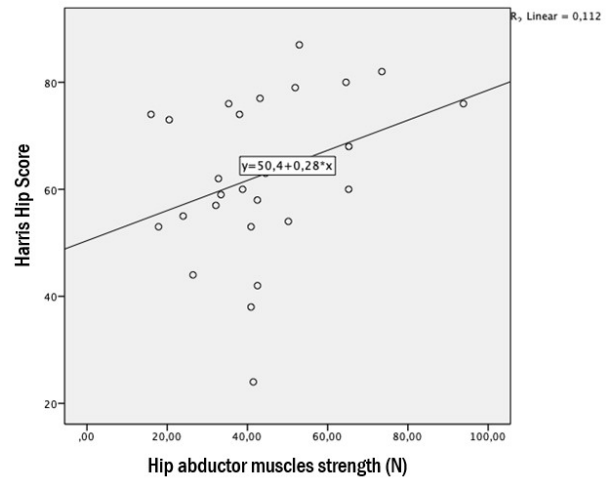


Figure 3. Relationship between hip abductor muscles strength and Harris Hip Score.

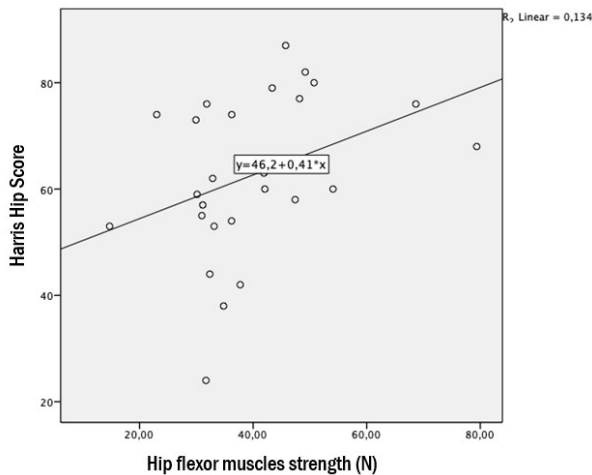


Figure 1. Relationship between hip flexor muscles strength and Harris Hip Score.

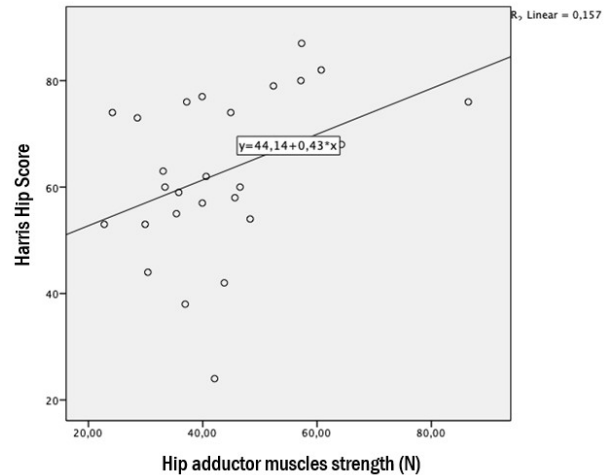


Figure 4. Relationship between adductor muscles strength and Harris Hip Score.

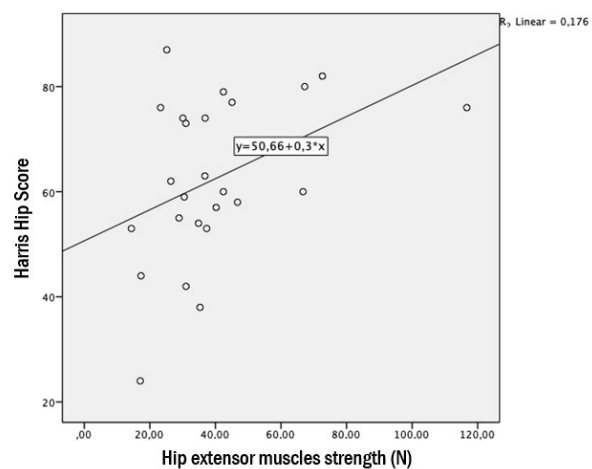


Figure 2. The relationship between hip extensor muscles strength and Harris Hip Score.

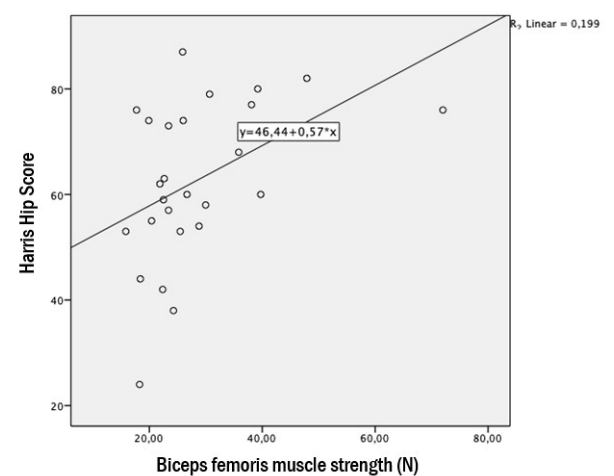


Figure 5. Relationship between biceps femoris muscle strength and Harris Hip Score.

Table 1. Demographic and physical characteristics of the individuals with developmental dysplasia of hip (DDH).

	Mean±SD
Age (year)	40.46±2.28
Height (m)	1.56±0.052
Body weight (kg)	61.36±11.46
Body mass index (kg/m <sup>2</sup> )	26.13±1.09

Table 2. Muscle strength and Harris Hip Score values of individuals with developmental dysplasia of hip.

	Mean±SD
Hip flexors (N)	39.90±2.65
Hip extensors (N)	40.46±4.23
Hip abductors (N)	43.40±3.57
Hip adductors (N)	42.98±2.75
Hip internal rotators (N)	29.45±1.88
Hip external rotators (N)	30.70±1.98
Medial hamstrings (N)	31.16±1.75
Biceps femoris (N)	28.35±2.33
Quadriceps femoris (N)	44.93±2.78
Harris Hip Score (N)	62.62±2.98

N: Newton.

Table 3. Correlations between Harris Hip Scores and lower extremity muscles strength of individuals with DDH.

	Harris Hip Score	
	r	P
Hip flexors	0.460 <sup>a</sup>	0.018*
Hip extensors	0.412 <sup>a</sup>	0.037*
Hip abductors	0.402 <sup>a</sup>	0.042*
Hip adductors	0.436 <sup>a</sup>	0.026*
Biceps femoris	0.510 <sup>a</sup>	0.008*
Hip external rotators	0.122 <sup>a</sup>	0.553
Hip internal rotators	0.146 <sup>b</sup>	0.478
Quadriceps femoris	0.271 <sup>b</sup>	0.180
Medial hamstrings	0.241 <sup>b</sup>	0.235

\*p<0.05. r: Correlation Coefficient Test. a: Spearman Correlation Test. b: Pearson Correlation Test.

## DISCUSSION

In our study, we examined the relationship between lower extremity muscle strength and hip function in individuals with developmental dysplasia of the hip (DDH). Our data showed that there was a relationship between hip functions and the muscle strength of hip flexors, extensors, abductors, adductors and biceps femoris muscle, whereas hip functions have not any relationship with the strength of hip rotators (internal and external rotators), quadriceps femoris and medial hamstrings.

In clinic we see that hip flexor, extensor, abductor and lateral hamstring muscles are often weak and internal rotators and medial hamstring are often strong in DDH patients. When we investigated our results with our clinical experiments, As these muscle groups were similarly strong in individuals with DDH, it was considered that the strength of the rotator and medial hamstrings was not related to functionality in individuals.

In the literature there are some studies, which conducted similar parameters in DDH patients, but there is no study, which investigates the possible relationship between muscle strength and hip functions. There are some studies, which have been taken account the relationship between muscle strength and hip functions were on the individuals with osteoarthritis. Although osteoarthritis and DDH may be considered similar hip degeneration, the effect of skeletal maturation and biomechanical consideration of DDH is different from the hip osteoarthritis. In DDH, the hip has shallow acetabula or dysplasia with nonspheric femoral head as congenital and developmental pathology in early ages, while OA is generally seen in aging or in older ages due to biomechanical problems and /or abnormal load distribution in normally developed hip joint. In the study of Leijendekkers et al., 6 individuals with unilateral DDH who undergone total hip replacement surgery and 8 healthy individuals between the ages of 18-70 years have been compared with the muscle strength and hip functions parameters. They have found that hip abductor and extensor muscle strengths were lower in both hips (operated and non-operated) in DDH compared to healthy individuals. Individuals with DDH had also lower level hip activities and functions than the healthy



subjects. They have claimed that the lower hip functions and activity limitation may be due to weak muscle strength of bilateral, operated and non-operated hip in the DDH patients and, they considered their hypotheses had been supported by poor scores of Harris Hip Score and Oxford Hip Score.<sup>4</sup> Although they did not make correlation between the hip muscle strength and hip functions, their comment seemed to have an indirect relationship between muscle strength and hip functions. In contrary to their study, we did direct correlation between muscle strength and hip functions in DDH who any hip surgery had not, which is also different from their study.

Harris Hip Score assesses hip functional status with the sub items of pain, function, deformity and range of motion. The function has two parameters, walking and activities. Walking parameter includes limping, walking distance and use of support during walking.

The studies related to walking and muscle strength in the OA have showed abnormal walking patterns such as pelvic drop of contralateral side at the frontal plane, decreased hip abductor moment and lateral body limp on the affected side. The authors have found that the abnormal walking pattern was correlated with muscles weakness in hip abductors.<sup>19,20</sup> However they did not make correlation between hip muscle strength and all hip functions as we have used in our study. They have focused the walking patterns (kinetic and kinematic) and the determinant of the gait (walking speed, cadence, stride length, joint angles).

Despite impaired biomechanics and advanced joint degeneration are different, at the end due to hip degeneration the walking pattern in DDH at the frontal plane was observed similar to hip osteoarthritis.<sup>20</sup> In our study as similar to these studies with hip osteoarthritis,<sup>19,20</sup> a moderate relationship was found between hip abductor muscle strength and hip function scores. In one of these studies Hall et al. investigated the relationship between muscle strength and physical function with male and female individuals with OA. The relationship between hip function and isometric muscle strength of hip flexors, extensors, abductors and knee extensors was investigated on 195 symptomatic individuals with OA. In the study, isometric muscle strength was evaluated with digital hand dynamometer and physical functions were evaluated with WOMAC Index

(Osteoarthritis Index of Western Ontario and McMaster Universities), which is different from our study. A significant relationship was found between muscle strength of hip flexors, extensors, knee extensors and physical functions in males, while there was a significant relationship for all evaluated muscles in females. Although it has shown that different muscles strengths were related with hip functions in males and in females, lower extremity muscle strength was generally related with hip functions.<sup>22</sup> Our study included not the males, only the females. Thus, we managed to eliminate gender differences in muscle strength and to give exact results without biomechanical differences dependent upon gender. Our results were generally in accordance with the results of the studies of Hall et al. However, we did not find any relation between the knee extensor muscle strength and the hip functions that was different from their results. We think that this difference is due to the fact that DDH is congenital or developmental pathology while OA a pathology that occurs in later ages with biomechanical changes. Due to these congenital and developmental changes in the hip joint structure and the consequent changing muscle tensile, severe muscle strength weakness are seen mainly in hip muscles in DDH. In the hip OA, degeneration of the hip due to biomechanical disadvantages and altered load distribution can affect all lower extremity. Furthermore, sometimes the main pathology is not originally derived from the hip joint and can be resulted from knee, ankle or back pathology related with abnormal joint mechanics of the lower extremity chain. This can also be seen in DDH by the time, but the main pathology is always in hip joint as congenital and developmental pathology. Therefore, unlike individuals with DDH, knee extension strength was found to be associated with physical function in OA subjects. Besides, Hall et al. have used WOMAC Hip Score in their study and this score includes more functions related with knee joint in addition to hip functions. We used Harris Hip Score which evaluates mostly hip functions and it does not include some related knee functions such as bending to floor, rising from sitting, getting in & out of car and not required knee extensor muscle strength primary during these functions. Therefore, we could not show the possible relationship between the

strength of knee extensors and hip function.

In their study Zeni et al., evaluated the relationship between muscle strength and hip functional level in patients with severe hip osteoarthritis (OA) and they found that weak muscle strength was associated with low scores in performance-based tests, but was not associated with low scores in self-report functional scores. They evaluated the hip functions of the individuals by using the Hip Outcome Score (HOS) based on self-report and the 6-minute Walk Test, Time-Up and Walk Test and Step Test for performance, and they measured isometric muscle strength of the hip abductors and knee extensors by Hand Dynamometer. The results of the study showed that the performance-based test results were related to hip abductor strength and knee extensor strength.<sup>23</sup>

Activity parameter, which is another sub item of Harris Hip Score, includes ability the using of stairs, putting shoes and socks, sitting and public transportation. Muscle strength of hip flexors and extensors are important for performing these activities. Although in the literature effect of hip flexor and extensors muscles on hip functions has not been studied in DDH individuals, there are some studies examining the effect of these muscle groups on functions for OA and pathologies with joint degeneration.<sup>20,24</sup> Nepple et al. studied with 50 individuals (32 males and 18 females) with unilateral femora acetabular impingement syndrome planned for arthroscopic surgery and they found that the decrease in hip functions was associated with hip flexor muscle weakness in the affected extremities.<sup>24</sup>

In our study, we found similar results as a decrease in hip flexor muscle strength and a low hip function score in patients with DDH.

Holstege et al. evaluated lower extremity muscle strength and functional performances of 55 individuals with advanced OA planned to undergone THA in preoperative and postoperative periods in their study.<sup>24</sup> In this study, isometric muscle strength of hip flexors, extensors, abductors and adductors, knee flexors and extensors of the individuals were measured by digital hand dynamometer as similar to our study. Functional results were evaluated by performance tests such as Time-Walk-Walk Test, 6-min Walk Test, and WOMAC Index based on self-report. The researchers

concluded that only preoperative knee extensor (quadriceps muscle) muscle strength was correlated with functional outcomes after surgery. Therefore they recommended that quadriceps muscle strength could be used as a parameter in predicting postoperative functionality. In our study, we didn't find any relation between quadriceps muscle strength and hip functions. When we compare our study with that of the Holstege et al., different assessment methods have been used for the evaluation of the hip functionality. Holstege et al. have included OA individuals with severe degeneration planned for THA whereas we recruited the individuals with DDH not planned THA.<sup>25</sup> Even if the same assessment methods would have been used, in our study, we think that the relationship between muscle strength and functionality may not be same due to the different levels of hip degeneration and features of the pathology.

#### **Limitations**

Although our main aim was to investigate possible relationship between hip functions and hip muscle strength, we could use scoring system for knee functions in addition to Harris Hip Score. We evaluated hip muscle strength together with knee muscle strength and made a correlation with hip score, which mainly evaluates hip functions, not knee functions. If we would have use knee scoring system, we could give detailed comments for the knee functionality.

#### **Conclusion**

Muscle strength of hip muscles effects hip functional levels of individuals with DDH. In order to achieve a higher functional level, especially in basic activities in daily life, hip flexors, extensors, abductors and adductors should be strong. These results are important in terms of guiding the practices related to increasing functional level of individuals with DDH and should be taken consideration in planning of physiotherapy and rehabilitation program.

In the future studies, there may be useful to use WOMAC Hip and Knee Score to show the possible relationship for knee extensor muscles and functions in DDH individuals.

Furthermore, functional evaluations using hip scoring systems may be supported by performance-based tests and self-reported scale in determining hip functions in DDH patients.

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**Conflict of Interest:** *Yok*

**Ethical Approval:** The protocol of the present study was approved by Ankara University, Faculty of Medicine, Ethics Board (issue: 20-1357-18 date: 10.12.2018).

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