Research Article

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The Effect of gluteus medius and minimus muscle thickness on developmental hip dysplasia up to three months of age.

Gluteus medius ve minimus kas kalınlığının üç aya kadar gelişimsel kalça displazisi üzerine etkisi.

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Abstract

Purpose: To investigate whether there is a difference in the gluteus medius and minimus muscle thicknesses between the cases with Graf method type IIa and normal subjects.

Material and methods: A total of 200 cases, 1-3 months old infants, who applied to our hospital for developmental hip dysplasia ultrasound scanning between January 2021 and March 2021 were included in our study. The cases were evaluated with a standard coronal plane with a 9-12 Mhz linear array probe according to the Graf method at the level of the triradiate cartilage by the same radiologist. The largest gluteus medius and minimus muscle thickness were measured.

Results: The female to male ratio was 0.9. and the mean age was 45.9±13.7 days. The present study had 159 (79.5%) Graf type I (Group A) and 41 newborns (20.5%) with Graf type IIa (Group B). Demographic and clinical characteristics were similar in both groups (p>0.05). The mean lengths of the gluteus medius and minimus muscles were similar in newborns with Graf type I and IIa (p=0.975 and p=0.069, respectively). A significant difference was found in the mean length of the gluteus minimus muscle between male and female newborns (p=0.001). The muscle length was statistically shorter in the female newborns than the male newborns (3.4±0.5 mm vs. 3.6±0.5 mm).

Conclusion: Since there was no difference in gluteal muscle thickness between mature and immature hips; Gluteal muscle lengths are not a diagnostic landmark in the hip ultrasound scan.

Key words: Developmental dysplasia of hip, hip ultrasound, gluteus medius muscle, gluteus minimus muscle, Graf method.

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Öz

Amaç: Graf yöntemi tip IIa olguları ile normal olgular arasında gluteus medius ve minimus kas kalınlıkları açısından fark olup olmadığını araştırmaktır.

Gereç ve yöntem: Ocak 2021-Mart 2021 tarihleri arasında gelişimsel kalça displazisi ultrason taraması için hastanemize başvuran, yaş aralığı 1-3 aylık arası olan, toplam 200 olgu çalışmamıza dahil edildi. Olgular aynı radyolog tarafından, Graf yöntemine göre 9-12 Mhz lineer array prob ile standart koronal düzlemde triradiat kıkırdak seviyesinde değerlendirildi. En geniş gluteus medius ve minimus kas kalınlığı ölçüldü.

Bulgular: Kadın erkek oranı 0,9'du ve ortalama yaş 45,9±13,7 gündü. Bu çalışmada 159 (%79,5) Graf tip I (Grup A) ve 41 (%20,5) Graf tip IIa (Grup B) yenidoğan vardı. Demografik ve klinik özellikler her iki grupta benzerdi (p>0,05). Graf tip I ve IIa olan yenidoğanlarda gluteus medius ve minimus kaslarının ortalama kalınlıkları benzerdi (sırasıyla p=0,975 ve p=0,069). Erkek ve kız yenidoğanlar arasında gluteus minimus kasının ortalama kalınlığında anlamlı bir fark bulundu (p=0,001). Kas kalınlığı, kız yenidoğanlarda erkek yenidoğanlara göre istatistiksel olarak daha kısaydı (3,4±0,5 mm'ye karşı 3,6±0,5 mm).

Sonuç: Matür ve immatür kalçalar arasında gluteal kas kalınlıkları açısından fark olmadığı için; gluteal kas uzunlukları, kalça ultrason taramasında tanısal bir nirengi noktası değildir.

Anahtar kelimeler: Gelişimsel kalça displazisi, kalça ultrasonu, gluteus medius kası, gluteus minimus kası, Graf metod.

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Introduction

Developmental dysplasia of the hip (DDH) also known as anatomically abnormal development of the femoral head and acetabulum varies in severity from mild dysplasia to complete hip dislocation [1]. DDH includes not only congenital malformations but also disruptions in development.

Developmental hip dysplasia is usually in the early neonatal period with some positive physical examination findings (including the Ortolani test, Barlow maneuvers, and Galeazzi sign) and clinical history (female sex, gestational age, firstborn baby, family history, breech presentation, oligohydramnios, limitation in abduction, foot anomaly) and a definitive diagnosis is made by hip ultrasound in the first 6 months. The Graf method is an ultrasound classification that objectively evaluates hip morphology worldwide, including the alpha and beta angles. This method, described by Graf R. [2] in 1980, is used to distinguish between normal and luxated joints in ultrasound. The neonatal hip is evaluated by measuring two angles formed by three lines drawn from three points, namely the lower limb of the os ilium, the bottom of the acetabulum, and the center of the labrum. As a rule, the angle formed by the acetabular bony roof to the vertical cortex of the iliac bone is the alpha angle, which mainly determines the hip type. The beta angle, also known as cartilaginous roof angle, determines hip subtype.

The incidence of DDH varies from 1.5 to 25 per 1000 live births, although it differs between populations [3]. In studies conducted with neonatal hip ultrasound in Turkey, the incidence was reported to be between 0.5% and 15% [4]. Differences between countries are attributed to genetic, cultural and lifestyle factors.

In Turkey, selective imaging screening of infants with risk factors or physical examination findings (positive or equivocal) is recommended in the first 3-6 weeks of their life by the Ministry of Health. For this purpose, in cases where treatment is required, initiating early and appropriate treatments reduces the number of surgical treatments for hip dislocation and minimizes possible complications [5]. In addition, hip ultrasonography was performed on all infants as a routine screening program at our hospital.

The gluteal muscles are stabilizers of the hip joint and play an important role in knee and pelvic stability [6]. The changes that occur in the gluteus medius-minimus muscles in patients with developmental dysplasia of the hip (DDH) are not fully understood. The aim of our study was to examine whether there is a difference in the gluteus medius and minimus muscle thicknesses between the cases with type IIa developmental dysplasia according to the Graf method and normal cases in the ultrasound imaging performed for screening in the first 3 months.

Material and methods

Infants aged 1-3 months, who were admitted to our hospital for developmental dysplasia ultrasound screening between January 2021 and March 2021, were included in our study. A total of 400 hip assessments were performed in 200 cases. Demographic information of the patients, number of children, family history, type of delivery and birth weight were collected.

The cases were evaluated using ultrasound (Siemens Healthineers, Acuson S3000, Erlangen, Germany) by the same radiologist who has seven years of general ultrasound and hip ultrasound experience. The cases detected as type IIa according to the Graf method were called for ultrasound control one month later.

The cases were evaluated with a standard coronal plane with a 9-12 Mhz linear array probe according to the Graf method. Ultrasound examination was performed in the transverse view with the hip flexed at 90°. Important anatomical structures (center of labrum, lower extremity of iliac bone, bony edge of acetabulum, femoral head, and neck) were identified. Parents were allowed to stay with their babies to calm them down. The alpha (α) and beta (β) angles were calculated according to the Graf method.

The alpha angle greater than 60° and the beta-angle below 55° are classified as normal hip (type I); these patients require no treatment. The alpha-angle 50-60° is classified as an immature hip (type IIa) up to the age of 3 months (13 weeks); these patients require follow-up. The

largest gluteus medius and minimus muscle thicknesses were identified in the coronal plane at the level of the triradiate cartilage (Figure 1).

This study was approved by the Zonguldak Bülent Ecevit University Ethics Committee.

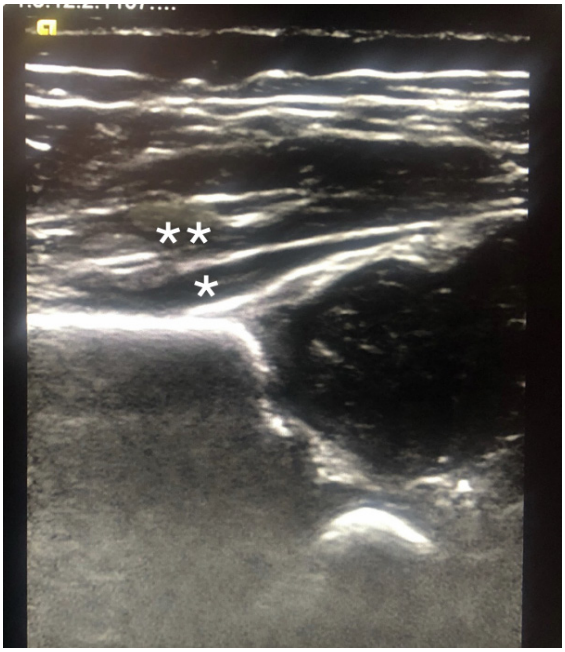

Figure 1. The view of gluteus medius (**) and minimus (*) muscle in hip ultrasound examination at coronal plane

Statistical analysis

Descriptive statistics were given as mean ± standard deviation and median with minimum-maximum values for continuous variables depending on their distribution. Numbers and percentages were used for categorical variables. The normal distribution of the numerical variables was analyzed by the Shapiro-Wilk, Kolmogorov-Smirnov, and Anderson-Darling tests.

The Independent Samples t-test was used in comparing two independent groups where numerical variables had a normal distribution. The power analysis was calculated using G*Power version 3 based on independent two samples (alpha: 0.05, power: 80%). The Mann-Whitney U test was applied for variables without normal distribution.

Pearson Chi-Square and Fisher's Exact tests were used in 2x2 tables to compare the differences between categorical variables.

For statistical analysis, "Jamovi project (2020), Jamovi (Version 1.8.2) [Computer Software] (Retrieved from https://www.jamovi.org) and JASP (Version 0.14.1.0) (Retrieved from https://jasp-stats.org) were used. The significance level (p-value) was set at 0.05 in all statistical analyses.

Results

There were 200 newborns in the study with a female-to-male ratio of 0.9. The mean age at the diagnosis was 43.9±13.7 days. We detected a positive family history in 3.0% of the cases. The demographic and clinical characteristics of the newborns are given in Table 1. In the study group, there were 159 (79.5%) and 41 newborns (20.5%) with Graf types I (Group A) and IIa (Group B). The mean age at the diagnosis was 47.2±13.5 days in Group A and 40.8±13.5 days in Group B. The difference in mean age at the diagnosis was significant (p=0.008). Other demographic and clinical characteristics were similar (p>0.05) (Table 1) (Figure 2, 3).

Calculating each side of the thicknesses separately, the mean length of the gluteus medius and minimus muscles were similar in newborns with Graf type I and IIa (p=0.975 and p=0.069). The mean alpha angle of the hips (each side counted separately) within Group A was 65.9±2.7°. The mean alpha-angle in Group B was 58.4±1.0°. The difference was statistically significant (p<0.001). We also detected a significant difference in the mean beta angle of the hips between the groups (p<0.001) (Table 2).

By calculating each side of the lengths separately, the mean length of the gluteus medius muscle was 4.6±0.8 mm in the male newborns and 4.4±0.8 mm in the female newborns (p=0.089). We detected a significant difference in the mean length of the gluteus minimus muscle between the male and female newborns (p=0.001). The muscle length was statistically shorter in the female newborns than the male newborns (3.4±0.5 mm vs. 3.6±0.5 mm) (Table 3).

Although there was no difference in the mean alpha angle of the hips (each side counted separately) between the male and

Figure 2. A 37-day age-old girl, Graf method type 1 (mature) hip ultrasound image
alpha angle: 67° beta angle: 48°
gluteus medius muscle thickness: 5.7 mm
gluteus minimus muscle thickness: 3.6 mm

Figure 3. A 45-day age-old girl, Graf method type 2a (immature) hip ultrasound image
alpha angle:56° beta angle: 54°
gluteus medius muscle thickness: 4.8 mm
gluteus minimus muscle thickness: 4.6 mm

Table 1. Demographic and clinical characteristics of the newborns with developmental dysplasia of the hip (n=200)

		Graf type		
	Overall	**Group A (Type I) (n=159)**	**Group B (Type IIa) (n=41)**	***p*-value**
Age at the diagnosis (day) †	45.9±13.7	47.2±13.5	40.8±13.5	**0.008***
Sex ‡				
Male	105 (52.5)	85 (53.5)	20 (48.8)	0.719***
Female	95 (47.5)	74 (46.5)	21 (51.2)	
Birth order §	2.0 [1.0-8.0]	2.0 [1.0-8.0]	2.0 [1.0-5.0]	0.997**
Positive family history ‡	6 (3.0)	4 (2.5)	2 (4.9)	0.605***
Birth weight (g) †	3,238.4±431.8	3,244.1±447.2	3,216.0±370.3	0.680*
Birth weight groups ‡				
<4000 g	193 (96.5)	152 (95.6)	41 (100.0)	0.348***
≥4000 g	7 (3.5)	7 (4.4)	0 (0.0)	
Type of delivery ‡				
0 Cesarean section	48 (24.0)	36 (22.6)	12 (29.3)	0.496***
1 Spontaneous vaginal delivery	152 (76.0)	123 (77.4)	29 (70.7)	

†: mean ± standard deviation, ‡: n (%), §: median [min-max]
US: ultrasound
*. Independent samples t-test
**. Mann Whitney U test
***. Pearson Chi-square test / Fisher exact test

Table 2. Morphometric features of the bilateral hips in the newborns with Graf type 1a and 2a

	Graf method type		
	1a (n=159)	**2a (n=41)**	***p*-value**
Length of gluteus medius muscle (mm) †	4.5±0.8	4.5±0.8	0.975
Length of gluteus minimus muscle (mm) †	3.5±0.5	3.6±0.6	0.069
Alpha angle (°) †	65.9±2.7	58.4±1.0	<0.001
Beta angle (°) †	44.5±4.4	47.0±4.9	<0.001

†: mean ± standard deviation
Independent samples t-test

Table 3. Comparison of the morphometric features of the bilateral hips based on the sex distribution

	Bilateral hips		
	Male newborn (n=105)	**Female (n=95)**	***p*-value**
Length of gluteus medius muscle (mm) †	4.6±0.8	4.4±0.8	0.089
Length of gluteus minimus muscle (mm) †	3.6±0.5	3.4±0.5	0.001
Alpha angle (°) †	64.7±4.0	64.1±3.8	0.097
Beta angle (°) †	44.5±4.7	45.7±4.3	0.008

†: mean ± standard deviation
Independent samples t-test

female newborns (p=0.097), the beta angle was significantly lower in the male newborns than the female newborns (44.5±4.7° vs. 45.7±4.3°, p=0.008).

By calculating each side of the lengths separately, we detected no significant difference in the mean lengths of the gluteus medius and minimus muscles between the newborns with ≤42 days and >42 days (p=0.627 and p=0.119) (Table 4).

The mean alpha angle of the hips (each side counted separately) within newborns with ≤42 days was 63.6±3.9°. The mean alpha angle in newborns with >42 days was 65.1±3.8°. The difference was statistically significant (p<0.001) (Table 4). There was no significant difference in the mean beta angle of the hips between the newborns (p=0.065).

Post hoc power analysis was done using G*Power version 3, to interpret the generalization of results. Effect size and power values were determined based on independent two samples t-test (alpha: 0.05, sample sizes 159 and 41). Comparison of length of gluteus minimus muscle has 0.181, 0.06, comparison of alpha angle has 3.683, 1, comparison of beta angle has 0.536, 0.678 as effect size and power values correspondingly.

Table 4. Comparison of the morphometric features of the bilateral hips based on the age of the newborns as ≤42 and >42 days

	Age		
	Newborns with ≤42 days (n=94)	**Newborns with >42 days (n=106)**	**p-value**
Length of gluteus medius muscle (mm) †	4.5±0.8	4.5±0.8	0.607
Length of gluteus minimus muscle (mm) †	3.6±0.5	3.5±0.5	0.119
Alpha angle (°) †	63.6±3.9	65.1±3.8	<0.001
Beta angle (°) †	45.5±4.2	44.6±4.9	0.065

†: mean ± standard deviation
Independent samples t-test

Discussion

The analysis of the data collected demonstrated the mean diameters of the gluteus medius and minimus muscles were similar in newborns with Graf type I and IIa in our study sample. Since there is no similar study in the literature; considering our data, we observed the gluteus muscle lengths are not a diagnostic landmark in the first 3 months of hip ultrasound screening. In a study conducted by Liu et al. [7] in 2012, it was observed that the length of the gluteus medius muscle decreased by 8-11% in a total of 19 adult patients aged 35-61 years with unilateral developmental dysplasia of the hip. The causes of gluteus medius muscle atrophy includes late-stage joint pathology, and the femur is displaced proximally. Unlike our study, the CT diagnostic method was used, and we had an adult patient sample group.

The US is the primary imaging tool for the evaluation of DDH in infants. Some type IIa, immature hips improved to type I during follow-up. Graf type IIa hips often have the potential to mature until 12 weeks of age. However, studies have shown that newborn girls with type IIa immature hips have a higher rate of treatment than boys [8]. In our study, only the cases with the first examination were included in the study; follow-up studies were excluded from the study.

Female gender, normal birth, first birth order, positive family history and birth weight were not found to correlate statistically associated with increased risk of hip immaturity in the present study, in a prospective, randomized study of 15529 newborn infants; There was no statistically significant difference between the two groups all neonates-neonates belonging to the risk groups) in terms of late diagnosis (follow-up period between 6-11 years) [9].

Gluteal muscles originate from the gluteal surface of the ilium. The gluteal muscles provide abduction of the femur and prevent pelvic drop on the opposite side during walking. The gluteal muscles have an important place in lateral hip stability and lower extremity function. The thickness of gluteal muscles can be reliably evaluated using US [10, 11]. In our study, the mean gluteus medius muscle diameter was 4.5±0.8 mm, and the minimus diameter was 3.6-3.5±0.5 mm. Furthermore, gluteus minimus was statistically shorter in female newborns than the male newborns.

Our study had some limitations. Firstly, our study includes a relatively small number of patients (200 cases) and the presence of Graf type II patients whose follow-up information was not available. Some of these immature Graff type II cases highly likely have the potential to mature.

Ultrasound is an operator-dependent imaging method. However, all examinations were evaluated by the same radiologist under similar conditions. The interobserver and intraobserver reproducibility could not be evaluated. One of the limitations was that it was a single-center study. Our results should be supported by multicenter prospective studies with a large patient population.

The strengths of our work; It is the first study in the literature to give average gluteus muscle lengths in infants up to the first 3 months; It also emphasizes that it is not necessary to use the gluteus muscle thickness as a landmark in routine DDH screening program.

In conclusion, this study provides preliminary data on the mean gluteus muscle lengths and the absence of differences in the gluteus medius and minimus muscle thicknesses between mature and immature hips.

Conflict of interest: No conflict of interest was declared by the authors.

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Authors contribuitions

Planning methodology to reach the conclusion: A.A.

Organising and supervising the course of the project or the article and taking the responsibility: A.A. and B.B.

Reviewing the article before submission not only for spelling and grammar but also for its intellectual content: A.A. and B.B.