DOI:10.34084/bshr.1695069 e-ISSN 2587-1641

Journal of Biotechnology and Strategic Health Research

Review / Derleme

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Relationship Between Fetal and Neonatal Bicromial Diameter Measurements and Shoulder Dystocia, A Systematic Review

Fetal ve Neonatal Biacromial Çap Ölçümlerinin Omuz Distosisi ile İlişkisi, Sistematik Review

Elif Terzi[1], **Aytaç Kenar**[2]

[1] Lokman Hekim University, Faculty of Medicine, Department of Obstetry and Gynecology, Ankara, Türkiye

[2] Konya Şehir Hastanesi, Yenidoğan Yoğun Bakım Kliniği, Konya, Türkiye

ORCID ID: Elif Terzi: https://orcid.org/0000-0001-9809-0494, Aytaç Kenar: https://orcid.org/0000-0001-5257-4987

***Sorumlu Yazar / Corresponding Author:** Elif Terzi, **e-posta / e-mail:** elif.terzi@lokmanhekim.edu.tr

Geliş Tarihi / Received : 11-05-2025 **Kabul Tarihi / Accepted:** 01-06-2025 **Yayın Tarihi / Online Published:** 31-08-2025

Terzi E., Kenar A. Fetal ve neonatal biacromial çap ölçümlerinin omuz distosisi ile ilişkisi, sistematik review. J Biotechnol and Strategic Health Res. 2025; 9(2):41-50

Abstract

This article aims to systematically review prior studies on the relationship between fetal and neonatal biacromial diameter measurements and shoulder dystocia and to guide further studies on this subject. The literature was reviewed by searching the keywords 'fetal biacromial', 'fetal bisacromial', 'fetal bis-acromial', 'neonatal biacromial', 'neonatal bisacromial', 'neonatal bis-acromial', 'shoulder dystocia' on the Pubmed, Embase, Cochrane Library search engines with the 'All Fields' option enabled and year ranges left blank. Randomized controlled trials, case-control studies and cohort studies written in English were included. 19 articles were found. Eight of these met the inclusion criteria. Eight articles including a total of 3669 patients were included in the review. It was observed that the articles used no common standardized measurement technique or measurement material to assess fetal and neonatal biacromial distance. The review revealed that the cut off value for fetal biacromial diameter was between 13.8-15.4 mm and that this measurement reliably predicted shoulder dystocia. When the cut off value for neonatal biacromial diameter was 14 mm, a strong positive correlation between this measurement and shoulder dystocia was found. Both fetal and neonatal biacromial diameters are positively correlated with shoulder dystocia. Establishing standardized and easy-to-use measurement methods can make biacromial diameter measurements more useful for obstetricians in predicting shoulder dystocia.

Keywords Shoulder dystocia, anthropometry, prenatal ultrasonography, Newborn

Abstract

Bu makale fetal ve neonatal biacromial çap ölçümlerinin omuz distosisi ile ilişkisini araştıran literatür çalışmalarını sistematik olarak derlemek ve bu konuda yapılacak diğer çalışmalara ışık tutmak amacıyla yazılmıştır. Yıl sınırlaması olmaksızın 'fetal biacromial', 'fetal bisacromial', 'fetal bis-acromial', 'neonatal biacromial', 'neonatal bisacromial', 'neonatal bis-acromial', 'shoulder dystocia' anahtar sözcükleri 'All Fields' seçeneği kullanılarak, Pubmed, Embase, Cochrane Library arama motorları ile literatür tarandı. İngilizce dilinde olanlar ve randomize kontrollu çalışma, vaka kontrol çalışma, kohort çalışması niteliğinde olan çalışmalar dahil edildi. 19 sayıda yayına ulaşıldı. Bunların 8 tanesi seçim kriterlerini karşıladı. 3669 sayıda hastayı içeren 8 yayın derleme kapsamına alındı. Fetal ve neonatal biacromial mesafeyi değerlendirmek için standart bir ölçüm tekniği ve ölçüm materyali olmadığı izlendi. Yayınların incelenmesi sonucunda fetal biacromial ölçümün cut off değerinin 13,8-15,4 arasında olduğu ve bu ölçümün omuz distosisini güvenilir şekilde öngördüğü bulundu. Neonatal biacromial ölçüm için cut off değeri 14 mm alındığında omuz distosisi ile kuvvetli pozitif korelasyon tespit edilmiştir. Sonuç olarak hem fetal hem de neonatal biacromial ölçüm ile omuz distosisi arasında pozitif korelasyon vardır. Ölçüm metodlarının standart ve kolay kullanılabilir olması biacromial çap ölçümünün omuz distosisi prediksiyonu için obstetrisyenler tarafından daha fazla tercih edilmesini sağlayacaktır.

Anahtar Kelimeler *Omuz distosisi, Antropometri, Prenatal ultrasonografi, Yenidoğan*

INTRODUCTION

Shoulder dystocia (SD) refers to the delay and difficulty experienced in the birth of the fetal body after the fetal head in the second stage of labor. Especially with increasing fetal weight, the risk of vaginal births being complicated by SD increases. In general, deteriorating eating habits and increasing both maternal and fetal weight result in a higher risk of SD at birth.[1]

SD is an obstetric emergency that cannot always be foreseen by the clinician before delivery.[2] Its unpredictability and the permanent damage it can cause to the newborn cause physicians to take a defensive approach due to medico-legal concerns and perform more deliveries by cesarean section than before.[3]

The most well-known etiologic factors for SD are macrosomia, maternal diabetes, and a history of SD in previous births.[4] Macrosomia is the most blamed cause for SD. However, despite formulas combining different fetal measurements, fetal weight estimation may be inaccurate in the antenatal period.[5] SD can also occur in non-macrosomic infants.[6,7]

The main concern about SD is the mismatch between fetal biacromial diameter (FBAD) and maternal pelvic outlet.[2-4] Thus, recent studies have focused on the relationship between FBAD measurement methods and SD.[8-11] Biacromial diameter is the distance between the acromial processes of both scapulae. The acromial process connects the clavicle and scapula via a joint. As a whole, both clavicles account for the majority of the biacromial diameter. For this reason, fetal clavicle measurements have also been used to predict SD and for intrauterine assessment of biacromial distance.[11] Ultrasound cannot provide a single cross-section that includes the biacromial diameter of the fetus, especially near term. Therefore, research is being done in order to develop some methods to measure FBAD.[8-11] Prior studies on the correlation of indirect measurements of FBAD in the antenatal period and direct measurements on the newborn evaluate both the accuracy of fetal measurement methods and shed light on the relationship between these measurements and SD.[12-15]

Although the limits and measurement methodology for child and adult biacromial diameter are clear, the limits and measurement methodology for both fetal and neonatal measurements have not yet been defined.[16] Hence, this systematic review aims to examine the relationship between fetal and neonatal biacromial diameter (NBAD) measurements and SD and to draw attention to the terminology of this issue.

METHODS

Studies eligible for this systematic review were identified according to the following criteria (PICOS);
Population (P): women whose offspring underwent biacromial measurement in the fetal and/or neonatal period, and who had a term, singleton pregnancy and vaginal delivery.
Intervention (I): pregnant women who had SD during vaginal delivery.
Comparison (C): pregnant women who did not have SD during vaginal delivery.
Outcomes (O): association of biacromial distance measured in fetal and neonatal period with SD.
Study design (S): studies examining the relationship between biacromial measurement during fetal and/or neonatal period and SD during vaginal delivery.

In the preparation of this review article; the literature was searched with Pubmed, Cochrane Library search engines without any year limitation. The literature search was conducted with the keyword ‘Shoulder dystocia’, 1927 articles were found. Later, in order to examine the articles in which biacromial measurements were made, the search was repeated using the keywords ‘fetal biacromial and shoulder dystocia”, ‘fetal bisacromial and shoulder dystocia”, ‘fetal bis-acromial and shoulder dystocia”, ‘neonatal bisacromial and shoulder dystocia”, ‘neonatal bis-acromial and shoulder dystocia". Studies in English and randomized controlled trials, case-control studies, and cohort studies were included. Case reports, case series, reviews and animal studies were excluded. In the selection of articles, articles in which biacromial measurements were made in the fetal and neonatal period and shoulder dystocia was evaluated with these measurements were included in the study. As a result of the literature review, 19 publications were found. The titles and abstracts of all articles identified by electronic search were reviewed by the authors. After this preliminary review, the full texts were also reviewed by the authors to determine whether the studies met the inclusion criteria. Of the studies, 8 met the inclusion criteria and were included in the study. The flow chart regarding the number of included and excluded articles is given in Figure 1. The articles were examined by both Dr. E.T. and Dr. A.K. separately. Discrepancies regarding the articles were solved by the arbitration of Dr. Turgut

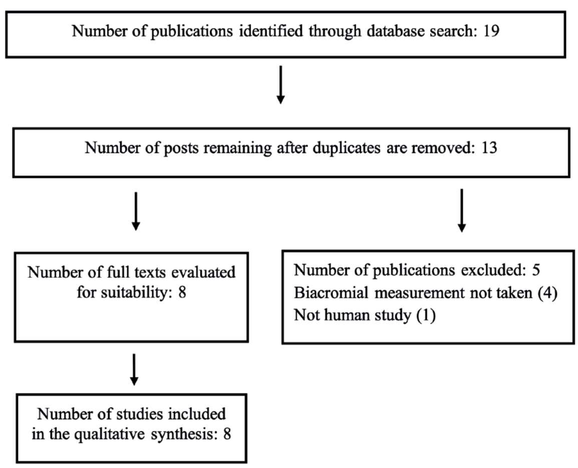

Figure 1. Flow chart depicting the search strategy and study selection process

The two authors independently assessed the risk of bias for each study using criteria outlined in the Cochrane Handbook for Systematic Review of Interventions. Risk of bias of the articles in the review are summarized in Figure 2.[17] Any disagreements were resolved through discussion or by involving a third evaluator. The quality of the articles was assessed using the Critical Appraisal Skills Programme (CASP) checklist. Five articles were of high quality and three articles were of medium quality.

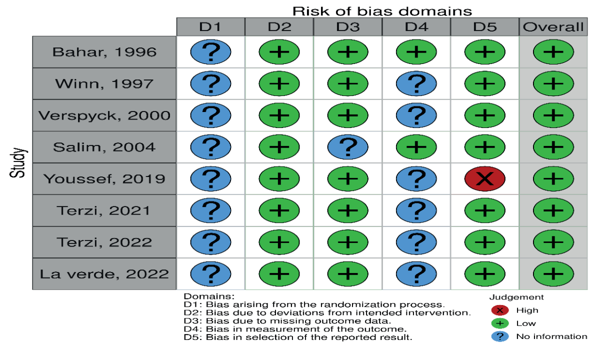

Figure 2. Risk of bias summary: Judgement about each risk of bias item for each included studies

RESULTS

The content of one cohort, one case-control, and six prospective observational studies evaluated in this study were examined according to the following criteria and the results are summarized in Table 1.

A) In studies conducted in the neonatal period;

- Biacromial distance measurement technique in the neonatal period
- Instrument used for measurement in the neonatal period
- Cut off value for SD in NBAD measurements
- Relationship between NBAD measurements and SD

B) In studies conducted during the fetal period;

- Ultrasound technique used in fetal period biacromial assessment
- Cut off value for SD in FBAD measurements
- Relationship between FBAD measurements and SD

FBAD measurement was performed in two studies included in the review, NBAD measurement was performed in five studies, FBAD and NBAD measurements were performed in one study.

Table 1. Comparison of the Reviewed Articles

Author*, Year	Number of participants / Type of study	Measurement Method, Limit, Material and Position	Results
AM Bahar, 1996	227/ Case-control	NBAD: Material: Orthopedic anthropometer Measurement limit: The distance between the outer edge of acromial processes Position: Prone	1. In the group with SD, the mean NBAD was 15.16 cm and HC/NBAD was 2.38, whereas in the control group, NBAD was 14.61 cm and HC/NBAD was 2.46 (p < 0.001). 2. A significant difference was found between the case group and the control group in terms of biacromial diameter measurement and HC/NBAD (p < 0.001).
HN Winn, 1997	54/ Prospective observational	FBAD: Chest circumference: half of the sum of two measurements taken at the bony margin in a cross-section through all four chambers of the heart multiplied by pi Arm circumference: half of the sum of the two measurements taken using the image formed by 90-degree rotation of the probe while the humerus was followed in the longitudinal plane at the mid-arm level multiplied by pi. NBAD: Material? Measurement limit: Distance between acromions Position: Prone	1. In this study, the mean value for NABD was 15.5 cm (min-max: 14-18). 2. The fetal measurements most highly correlated with these neonatal measurements were chest circumference (r = 0.67, p = 0.003) and arm circumference (r = 0.59, p = 0.03). 3. None of the 54 births included in the study had SD.
E Verspyck, 2000	2222/ Cross-sectional	NBAD: Material: Craniometer Measurement limit: The distance between the outer edge of acromial processes Position: Prone	1. The mean NBAD was 12.20 cm +/-0.50. 2. he best cutoff point for prediction of SD was ≥14. 3. NBAD has a low false positive rate (<10%) combined with a high sensitivity rate. 4. This measurement had a low sensitivity of 27.27%, a specificity of 91.82%, a positive predictive value of 4.02% and a negative predictive value of 99.01% for the prediction of SD.
R Salim, 2004	134/ Prospective cohort	NBAD: Material: Tape measure Measurement limit? Position?	1. There was no significant difference in anthropometric measurements between the two groups with and without GDM. 2. The secondary analysis of newborns weighing 4000 g or more at birth revealed no significant differences between anthropometric measurements of the two groups. 3. None of the cases had SD.

AEA Youssef, 2019	600/ Prospective observational	FBAD: "Youssef's formula": Transverse thoracic diameter + 2× mid-arm diameter. NBAD: Material: Orthopedic anthropometer Measurement limit: Distance between acromions Position?	1. There was no statistically significant difference between the recommended FBAD measured by ultrasound and the actual NBAD measured after birth (p = 0.192). 2. As a result of ROC curve analysis, AUC for the prediction of macrosomia at birth based on FBAD and abdominal circumference were 0.987 and 0.989, respectively. 3. When the cutoff value for FBAD was taken as 15.42 cm, the sensitivity for SD prediction was 95%, accuracy was 86.7% and AUC was 0.944.
E Terzi, 2021	181/ Prospective observational	FBAD: In the third trimester, the location of the clavicle was determined and measured when the head was in the occiput transverse position.	1. The median third-trimester clavicle length was 39.5 mm (range: 30.7–43.9) in neonates who did not develop SD. 2. The median third-trimester clavicle length was 42.5 mm (range: 41.4–43.1) in the 3 neonates who developed SD. 3. When the third-trimester clavicle length cut-off SD was calculated as 41.35 mm (sensitivity: 100.00%, specificity: 83.82%, accuracy: 84.5% and AUC was 0.934)
E Terzi, 2022	161/ Prospective observational	NBAD: Material: Tape measure Measurement limit: Distance between acromions Position: Supine	1. The mean NBAD was 12.4±1.0 cm. 2. There was a correlation of 0.373 between SD and NBAD. 3. For a cutoff point for NBAD of ≥14 cm, the sensitivity and specificity for SD were 63.64% and 89.33%, respectively.
M La Verde, 2022	90/ Prospective observational	FBAD: "Youssef's formula": Transverse thoracic diameter + 2× mid-arm diameter.	1. Fetuses with SD had higher FBAD compared to those without SD, p=0.04 (15.04 cm, 95% CI (13.32- 16.76 cm), 13.35 cm, 95% CI (13.01- 13.70), respectively). 2. When the cutoff value for FBAD was 13.83 cm, the AUC for SD was 0.821 (p= 0.001).

*The first author named in the article.
NBAD: neonatal biacromial diameter, FBAD: fetal biacromial diameter, SD: shoulder dystocia, GDM: gestational diabetes mellitus, HC: head circumference AUC: Area Under Curve CI: confidence interval

Fetal Bıacromıal Dıameter Measurement

In two studies, the Youssef formula [Transverse thoracic diameter + 2× mid-arm diameter] was used for biacromial diameter measurement[8,9], while in another study, the biacromial diameter was determined by measuring the clavicle.[11]

In a study that used the Youssef formula for fetal measurement, neonatal measurements were also taken, and a correlation between them was observed (p=0.192). SD developed in a total of 40 patients (14.4%), and the cut off value of FBAD at 15.42 cm showed a sensitivity of 86.7% for SD risk with an Area Under Curve (AUC) of 0.944.[8]

In the other study using Youssef formula, only fetal measurement was performed and SD was observed in a total of 4 patients (4.4%), a significant difference was found between cases that developed SD and those that did not develop SD in terms of FBAD, and the AUC for SD risk of FBAD 13.83 cm cut off value was calculated as 0.821.[9]

In the study that measured fetal clavicle, SD developed in 3 patients (1.65%), and the clavicle length in the complicated group was significantly higher than in the uncomplicated group. The cut off value of 41.35 mm for fetal clavicle showed a sensitivity of 84.5% for SD risk with an AUC of 0.934.[11]

Neonatal Bıacromıal Measurement

In one study, a craniometer was used for biacromial distance measurement[12], in two studies, a tape measure was used[13,14], in two others, an orthopedic anthropometer was utilized[8,15] and in one study, the measurement tool was not specified.[10]

Three studies defined the measurement boundaries as the "Distance between acromions" [8,10,14], two studies as "The distance between the outer edge of acromial processes"[12,15], while one study did not provide a definition for the measurement boundary.[13]

Neonatal measurements were taken in the prone position in three studies[10,12,15], in the supine position in one study[14], not specified in one study[13], and one study described it as: "The diameter was measured by an orthopedic anthropometer while the neonate was lying on its back in the prone position and the arms lying to the sides of the body".[8]

In one study, fetal chest and arm circumference measurements were taken using intrauterine ultrasound, and their correlation with NBAD measurements was evaluated (0.67 and 0.59, respectively), with no SD cases observed. In this study, NBAD ranged between 14-18 cm.[10]

In another study conducted on 2,222 patients, the average NBAD was found to be 12.2±0.50 cm, with SD developing in 22 cases (0.99%). The cut off value for SD risk was calculated as ≥14 cm, with PPV of 4.02% and NPV of 99.01%.12 In another study with 134 patients, an equal number of participants with and without gestational diabetes mellitus (GDM) were included. The average NBAD in the GDM group was 12.20 cm, while it was 11.90 cm in the non-GDM group. No SD cases were observed, and the anthropometric measurements, including NBAD, showed no significant differences between the groups. A secondary analysis was conducted on newborns weighing 4000 g or more at birth, and again, no significant differences in anthropometric measurements were found between the groups.[13]

In another study evaluating 89 patients with SD and 138 control patients, NBAD and head circumference (HC) measurements were made and compared. The average NBAD was 15.16 cm and HC/NBAD was 2.38 in the SD group, while the control group had a NBAD of 14.61 cm and HC/NBAD of 2.46. A significant difference was found between the case and control groups in terms of NBAD and HC/NBAD (p<0.001).[15]

In another study, the mean NBAD was found to be 12.4±1.0 cm. SD occurred in a total of 5 patients (3.1%)

and when the cut off point for NBAD was taken as ≥14 cm, the sensitivity and specificity for SD were 63.64% and 89.33%, respectively, and the correlation rate between SD and NBAD was 0.373.[14]

An expert statistician concluded that the articles were not adequate for meta-analysis due to the small number of articles included in the review and the differences between the analysis methods used in the studies.

DISCUSSION

In the 1997 study of Winn et al. on fetal measurements that can predict biacromial diameter and the comparison of these measurements with the NBAD, the distance between the acromions of newborns was measured when the newborn was in the prone position. The fetal measurements most highly correlated with these neonatal measurements were chest circumference (r = 0.67, p = 0.003) and arm circumference (r = 0.59, p = 0.03). Chest circumference was calculated by multiplying half of the sum of two measurements taken at the bony margin in a cross-section through all four chambers of the heart by pi. Arm circumference was calculated by multiplying half of the sum of the two measurements taken using the image formed by 90-degree rotation of the probe while the humerus was followed in the longitudinal plane at the mid-arm level by pi. In this study, the mean value for NBAD was 15.5 cm (min-max: 14-18 SD: 0.9) and SD occurred in none of the 54 deliveries included in the study.[10]

The clavicle bone constitutes a large part of the biacromial distance. Based on this information, as a result of our study to predict SD with fetal clavicle measurement in 2021, we found a significant relationship between third trimester clavicle length and birth weight and SD. The median third-trimester clavicle length was 39.5 mm (range: 30.7–43.9) in neonates who did not develop SD and 42.5 mm (range: 41.4–43.1) in the 3 neonates who developed SD. The third-trimester clavicle length cut off for SD was calculated as 41.35 mm (sensitivity: 100.00%, specificity: 83.82%, accuracy: 84.5%).[11]

The FBAD measurement method devised by Youssef et al. in 2019, defined as the Youssef's formula [Transverse thoracic diameter + 2× mid-arm diameter], has been used in many subsequent studies. In this method, the mid-arm diameter is measured by a skin-to-skin measurement of the upper arm at the level of the heart, and the transthoracic diameter is measured by a transverse section at right angles to the fetal spine, as circular as possible, obtaining a four-chamber view of the heart. Using this formula, Youssef et al. evaluated fetal and NBAD measurements of 600 participants and concluded that the fetal measurements were consistent with the neonatal measurements (p=0.192). Of the pregnant women included in the study of Youssef et al., 46.2% delivered vaginally and the rate of SD was 14.4%. When the cut off value for FBAD measurement was taken as 15.42 cm, the sensitivity for SD prediction was 95%, accuracy was 86.7% and AUC was 0.944. In this study, NBAD measurement was performed between the acromion with an orthopedic anthropometer. However, the sentence 'The diameter was measured by an orthopedic anthropometer while the neonate was lying on its back in the prone position and the arms lying to the sides of the body' in the article led to confusion regarding the position the measurement was taken in and an e-mail was sent to the responsible author about this issue.[8]

In La Verde et al.'s study using the Youssef formula, 4 patients out of the 90 participants included had SD and it was found that the biacromial diameter measurements of fetuses with SD (150.4 cm; 95% confidence interval (CI) 13.32 cm to 16.76 cm) were higher compared to those without SD (13.35 cm; 95% CI 13.01 cm to 13.70 cm; p = 0.04). As a result of the Receiver Operating Characteristic (ROC) analysis, when the cut off value for biacromial diameter was 13.83 mm, the AUC for SD was found to be 0.821 (p= 0.001).[9]

Measurements made during the neonatal period guide the evaluations that should be made during pregnancy. Verspyck et al. conducted a large observational study examining the biacromial diameter measurements of 2,222 newborns taken in the first 24 hours postpartum and the correlation of these with SD. In this article biacromial diameter and shoulder width are used synonymously and the measurements were taken in the prone position with the inner edges of the arms of the craniometer placed under the acromial process. As a result of the study, the average neonatal shoulder width was found to be 12.20 cm +/- 0.50. When the cut off value for SD prediction was 14 cm, a high sensitivity rate and a low false positive rate (<10%) were achieved. This measurement had a low sensitivity of 27.27%, a specificity of 91.82%, a positive predictive value of 4.02% and a negative predictive value of 99.01% for the prediction of SD.[12]

Similarly, 161 participants were evaluated in our study conducted in 2022 investigating the relationship between biacromial measurements taken in the postnatal period and SD. Measurements were taken with a tape measure at the most prominent point of the acromioclavicular joint when the newborn was in the supine position. The mean biacromial diameter was found to be 12.4±1.0 cm, SD occurred in a total of 5 patients, and when the cut off point for biacromial diameter was ≥14 cm, the sensitivity and specificity for prediction of SD were 63.64% and 89.33%, respectively, and the correlation rate between SD and biacromial diameter was 0.373. In this study, bideltoid breadth was also evaluated. This measurement was taken as the distance between the most prominent points of both deltoid muscles of the newborn lying in the supine position.[14] Bahar et al. also evaluated 89 patients who had SD and 138 control patients in a study conducted in the postnatal period. In this study, the biacromial diameter was interchangeably called shoulder width and the measurement was taken in the prone position by placing the arms of the orthopedic anthropometer under the outer edge of the acromial processes. In the group with SD, the mean biacromial diameter was 15.16 cm and head circumference/ biacromial diameter was 2.38, while in the control group, the biacromial diameter was 14.61 cm and head circumference/ biacromial diameter was 2.46. A significant difference was found between the case group and the control group in terms of biacromial diameter and head circumference/ biacromial diameter (p<0.001).[15]

Salim et al. conducted a study with 134 patients, including an equal number of participants with and without GDM, and found that the mean biacromial diameter was 12.20 cm in the group with GDM and 11.90 cm in the group without GDM. None of the patients had SD and anthropometric measurements including biacromial diameter did not show a significant difference between the groups. A secondary analysis was performed with newborns weighing 4000 g or more at birth and no significant difference was found between the groups in terms of anthropometric measurements. Biacromial diameter measurement was taken with tape measure, but no information about the measurement method was found in the article. An e-mail has been sent to the author to get detailed information.[13]

CONCLUSION

SD is among the most urgent conditions in obstetrics. Since the main concern about SD is the mismatch between FBAD and maternal pelvic outlet, recent studies have focused on the relationship between FBAD measurement methods and SD. According to studies using the available measurement methods, the cut off value for FBAD was taken between 13.8-15.42 and SD prediction was found to be reliable at these values. There were also differences in anthropometric measurements of newborns in births with SD compared to those without SD. When the articles included in this systematic review were evaluated, SD prediction was reliable when the cut off value for NBAD measurement was 14 cm.

As a result of the review, it was observed that there was a correlation between fetal and neonatal biacromial measurements. Due to these correlations, the measurement of biacromial diameter with ultrasonography in the fetal period can be used to predict SD. The development and standardization of approach methods related to intrauterine fetal assessment will facilitate the application.

Biacromial diameter measurement in adults has been standardized in terms of both method and measuring devices used. However, the limits of the measurement to be taken from the newborn, the position of the newborn when taking this measurement (supine or prone) and the ideal measuring devices are not as clearly defined as in adults. The literature review revealed that the terms shoulder width, bideltoid breadth and biacromial diameter were used interchangeably. It is thought that standardizing measurement and evaluation, which is indispensable for scientific studies, for NBAD measurements is a must.

Limitations: The main limitations of this systematic review are the small number of original articles written on the relationship between fetal and neonatal biacromial measurement and SD and the lack of standards regarding measurement techniques.

Peer-review

Externally and internally peer-reviewed.

Authorship Contributions

Concept: E.T., A.K. Design: E.T., A.K., Data Collection or Processing: E.T., A.K., Analysis or Interpretation: E.T., A.K., Literature Search: E.T., A.K., Writing: E.T., A.K.

Conflict of Interest

No conflict of interest was declared by the authors.

Funding

The authors declared that this study received no financial support.

Acknowledgment

We gratefully acknowledge the valuable contributions and support of Prof. Dr. Turgut Var and Prof. Dr. Sevim Demir.

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