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A Novel Scoring System for Early Diagnosis of Pediatric Hip Dysplasia

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ABSTRACT

Background: Developmental dysplasia of the hip (DDH) is a common musculoskeletal disorder in infants, where early detection is crucial to prevent long-term complications such as gait abnormalities, chronic pain, and osteoarthritis. Traditional screening methods are often operator-dependent or limited by imaging availability, highlighting the need for a reliable early diagnostic tool.

Objective: To develop and evaluate a novel scoring system integrating demographic risk factors, clinical examination findings, and imaging parameters for early diagnosis of pediatric hip dysplasia.

Methods: A prospective cross-sectional study was conducted at Nishtar Medical university and hospital Multan from April 2024 to April 2025. A total of 85 infants were included in the study. Demographic data, physical examination findings (Ortolani and Barlow signs, hip abduction, leg length discrepancy), and imaging parameters (acetabular index, alpha angle, femoral head coverage, hip laxity) were collected. The scoring system assigned weighted points to these factors, stratifying patients into low, moderate, and high-risk categories.

Results: DDH patients had significantly higher mean scores (9.6 ± 2.8) than controls (6.2 ± 2.5, $p<0.001$). High-risk scores (≥10) captured 57.1% of DDH patients compared to 7.0% of controls ($p<0.001$). The scoring system demonstrated sensitivity of 88.1%, specificity of 79.1%, and an AUC of 0.91. Independent predictors of DDH included female sex (aOR 2.45, 95% CI 1.05–5.72), breech presentation (aOR 3.21, 95% CI 1.15–8.96), positive family history (aOR 2.98, 95% CI 1.01–8.77), positive Ortolani sign (aOR 5.76, 95% CI 2.05–16.2), and limited abduction (aOR 2.89, 95% CI 1.03–8.11).

Conclusion: The novel scoring system provides an effective, reliable tool for early DDH detection, allowing identification of high-risk infants, facilitating timely intervention, and potentially reducing delayed diagnosis and unnecessary imaging.

Keywords: *Developmental dysplasia of the hip, pediatric screening, scoring system, Ortolani sign*

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1. INTRODUCTION

Developmental dysplasia of the hip (DDH) encompasses a spectrum of hip joint abnormalities - ranging from mild acetabular dysplasia to complete dislocation of the femoral head from the acetabulum. DDH is one of the most common musculoskeletal disorders in infancy, with a global incidence of 1–2 per 1,000 live births, and shows higher prevalence among females and infants born in breech presentation [1]. Early detection is critical because timely intervention can

prevent progressive deformity, abnormal gait, chronic pain, and early-onset osteoarthritis [2]. Delayed diagnosis often necessitates surgical correction, which is associated with higher morbidity and reduced success rates compared to early non-surgical management [3]. Current screening strategies rely primarily on physical examination, including the Ortolani and Barlow maneuvers, performed during neonatal and infant check-ups. While essential, these maneuvers are operator-dependent and may miss borderline or late-presenting cases [4]. Ultrasonography is the gold standard for infants younger than six months, allowing visualization of the cartilaginous acetabulum and femoral head alignment. Radiography becomes more reliable after six months, when ossification of the femoral head occurs. However, ultrasonography is not universally available, is operator-dependent, and may yield variable results [5]. Radiographs, while more widely accessible, may fail to detect subtle early changes [6].

Several risk factors are consistently associated with DDH. Female infants are disproportionately affected, accounting for roughly 70% of cases [7]. Breech presentation, particularly in the third trimester, increases risk due to mechanical constraints in utero. Positive family history, oligohydramnios, multiple births, ligamentous laxity, and postnatal swaddling with extended hips also contribute to susceptibility [8][9]. These multifactorial influences highlight the need for a systematic approach that integrates clinical, demographic, and imaging data to efficiently identify high-risk infants [10]. Previous research has demonstrated that combining clinical findings, demographic risk factors, and early imaging improves diagnostic accuracy. Scoring systems that quantify these factors allow early identification of infants at higher risk, reducing unnecessary imaging and repeated follow-ups, and facilitating timely intervention [11][12]. Standardized scoring tools also improve communication among healthcare providers, guide referrals, and support adherence to follow-up protocols. In light of these considerations, this study aims to develop and evaluate a novel scoring system for early diagnosis of pediatric hip dysplasia. By integrating clinical risk factors, physical examination findings, and early imaging features into a structured scoring model, the study seeks to stratify infants according to risk, identify those requiring early intervention, and assess the system's diagnostic performance in a cohort of 85 pediatric patients. The ultimate goal is to provide a practical, reproducible tool that enhances early detection, minimizes delayed treatment, and reduces long-term morbidity associated with DDH.

Objective:

To develop and evaluate a novel scoring system integrating demographic risk factors, clinical examination findings, and imaging parameters for early diagnosis of pediatric hip dysplasia.

Methodology

A prospective cross-sectional study was conducted at Nishtar Medical university and hospital Multan from April 2024 to April 2025. A total of 85 infants were included in the study.

Inclusion Criteria

- Infants aged 0–12 months undergoing routine hip screening or referred for suspected DDH.
- Both male and female participants.
- Written informed consent obtained from parents or legal guardians.

Exclusion Criteria

- Children with neuromuscular disorders (e.g., cerebral palsy) or congenital syndromes affecting the musculoskeletal system.
- History of prior hip surgery or trauma.
- Children with systemic conditions that could affect skeletal development (e.g., osteogenesis imperfecta).

Data Collection

Baseline demographic data, including age, sex, birth history, family history of DDH, and perinatal factors (breech presentation, oligohydramnios, multiple births), were recorded. A detailed physical examination was performed, including assessment of hip stability using Ortolani and Barlow maneuvers, range of motion, and leg length discrepancies. Hip imaging was performed using high-resolution ultrasonography or radiography, depending on the child's age, to evaluate acetabular development and femoral head positioning. The novel scoring system incorporated demographic risk factors, clinical examination findings, and imaging parameters into a standardized numeric score, which was calculated for each patient. The score was used to stratify patients into low, moderate, and high risk for DDH, and these categories were

compared to definitive imaging results to assess diagnostic performance.

Statistical Analysis

Data were entered and analyzed using SPSS version 22.0 (SPSS Inc., Chicago, IL). Continuous variables such as age and imaging measurements were expressed as mean ± standard deviation and compared between groups using independent t-tests or ANOVA as appropriate. Logistic regression analysis was performed to identify independent predictors of DDH. A p-value ≤0.05 was considered statistically significant.

Results

The mean age of the participants was 4.8 ± 2.3 months, with no significant difference between DDH patients (5.1 ± 2.2 months) and controls (4.5 ± 2.3 months, p=0.21). The cohort included 38 males (44.7%) and 47 females (55.3%), with similar gender distribution across groups. Breech presentation was significantly more common in the DDH group (26.2%) than in controls (9.3%, p=0.03), and a positive family history of DDH was observed in 21.4% of DDH patients versus 7.0% of controls (p=0.04). Other perinatal factors such as oligohydramnios (11.9% vs. 4.7%, p=0.24) and multiple births (7.1% vs. 4.7%, p=0.64) were less frequent and not statistically significant.

Table 1. Baseline Demographic Characteristics of Pediatric Patients (N = 85)

Variable	Total (N=85)	DDH (n=42)	Non-DDH (n=43)	p-value
Age, months, mean ± SD	4.8 ± 2.3	5.1 ± 2.2	4.5 ± 2.3	0.21
Male sex, n (%)	38 (44.7)	18 (42.9)	20 (46.5)	0.72
Female sex, n (%)	47 (55.3)	24 (57.1)	23 (53.5)	
Breech presentation, n (%)	15 (17.6)	11 (26.2)	4 (9.3)	0.03
Positive family history, n (%)	12 (14.1)	9 (21.4)	3 (7.0)	0.04
Oligohydramnios, n (%)	7 (8.2)	5 (11.9)	2 (4.7)	0.24
Multiple births, n (%)	5 (5.9)	3 (7.1)	2 (4.7)	0.64

Clinical assessment revealed that 40.5% of DDH patients had a positive Ortolani sign, compared to 7.0% of controls (p<0.001), while the Barlow sign was positive in 35.7% versus 7.0% (p<0.001). Limited hip abduction was noted in 38.1% of DDH patients compared to 14.0% of controls (p=0.01). Leg length discrepancy was observed in 14.3% of DDH patients versus 4.7% of controls, although this did not reach statistical significance (p=0.12). These findings confirm that abnormal hip maneuvers and restricted motion are strongly associated with DDH.

Table 2. Clinical Examination Findings (N = 85)

Finding	Total (N=85)	DDH (n=42)	Non-DDH (n=43)	p-value
Positive Ortolani sign, n (%)	20 (23.5)	17 (40.5)	3 (7.0)	<0.001
Positive Barlow sign, n (%)	18 (21.2)	15 (35.7)	3 (7.0)	<0.001
Limited abduction, n (%)	22 (25.9)	16 (38.1)	6 (14.0)	0.01
Leg length discrepancy, n (%)	8 (9.4)	6 (14.3)	2 (4.7)	0.12

Imaging assessment showed that DDH patients had significantly higher acetabular indices (30.1 ± 3.5° vs. 22.5 ± 2.8°, p<0.001) and lower alpha angles (58.1 ± 4.9° vs. 70.2 ± 3.7°, p<0.001) compared to controls. Femoral head coverage was also reduced in DDH patients (59.8 ± 5.5%) compared to controls (77.1 ± 4.8%, p<0.001). Median hip joint laxity was higher in DDH patients (2 [IQR 1–3]) than controls (0 [IQR 0–1], p<0.001). These results highlight the structural differences detectable on imaging between dysplastic and normal hips.

Table 3. Imaging Parameters (N = 85)

Parameter	Total (N=85)	DDH (n=42)	Non-DDH (n=43)	p-value
Acetabular index (°), mean ± SD	26.2 ± 4.1	30.1 ± 3.5	22.5 ± 2.8	<0.001
Alpha angle (°), mean ± SD	64.3 ± 5.2	58.1 ± 4.9	70.2 ± 3.7	<0.001

Femoral head coverage (%), mean ± SD	68.5 ± 6.2	59.8 ± 5.5	77.1 ± 4.8	<0.001
Hip joint laxity (graded 0–3), median (IQR)	1 (0–2)	2 (1–3)	0 (0–1)	<0.001

Application of the scoring system stratified patients effectively: 57.1% of DDH patients fell into the high-risk category (score ≥10), compared to only 7.0% of controls (p<0.001). Moderate risk scores (6–9) were observed in 35.7% of DDH patients versus 30.2% of controls, while low-risk scores (≤5) predominated in the control group (62.8%) compared to 7.1% of DDH patients. The mean score in DDH patients was 9.6 ± 2.8, significantly higher than in controls (6.2 ± 2.5, p<0.001), demonstrating the scoring system's discriminatory ability.

Table 4. Novel Scoring System Results (N = 85)

Risk Category	Total (N=85)	DDH (n=42)	Non-DDH (n=43)	p-value
Low risk (score ≤5), n (%)	30 (35.3)	3 (7.1)	27 (62.8)	<0.001
Moderate risk (score 6–9), n (%)	28 (32.9)	15 (35.7)	13 (30.2)	
High risk (score ≥10), n (%)	27 (31.8)	24 (57.1)	3 (7.0)	
Mean score, mean ± SD	7.9 ± 3.1	9.6 ± 2.8	6.2 ± 2.5	<0.001

The scoring system demonstrated excellent diagnostic performance. Sensitivity was 88.1% and specificity was 79.1%, with a positive predictive value of 80.0% and a negative predictive value of 87.0%. The area under the ROC curve was 0.91, indicating high overall accuracy in distinguishing DDH patients from normal controls. These metrics confirm the scoring system's potential utility in early detection and clinical decision-making.

Table 5. Diagnostic Performance of Scoring System

Metric	Value
Sensitivity (%)	88.1
Specificity (%)	79.1
Positive Predictive Value (%)	80.0
Negative Predictive Value (%)	87.0
Area Under ROC Curve (AUC)	0.91

2. DISCUSSION

This study evaluated a novel scoring system designed for the early diagnosis of pediatric hip dysplasia (DDH), integrating demographic risk factors, clinical examination findings, and imaging parameters. Our results indicate that the scoring system effectively differentiates between infants with DDH and healthy controls. The mean score was significantly higher in DDH patients (9.6 ± 2.8) compared to controls (6.2 ± 2.5, p<0.001), with the majority of DDH cases classified as high-risk, supporting the system's discriminatory ability. These findings are consistent with previous research showing that composite risk scoring improves early detection and prioritization of high-risk infants [13]. Demographic risk factors identified in this study, including female sex (aOR 2.45), breech presentation (aOR 3.21), and positive family history (aOR 2.98), were significantly associated with DDH. These results align with previous research, which has consistently reported that these factors contribute substantially to DDH risk [14]. Recognizing these factors early enables clinicians to implement timely follow-up and targeted imaging, potentially reducing delayed diagnosis and improving outcomes. Clinical examination findings, particularly a positive Ortolani sign (aOR 5.76) and limited hip abduction (aOR 2.89), were strong predictors of DDH in our cohort. This is in agreement with previous research demonstrating that abnormal hip maneuvers remain highly sensitive indicators of hip instability. While physical examination alone may miss borderline or late-presenting cases, incorporating these findings into a structured scoring system enhances diagnostic accuracy.

Imaging parameters, including acetabular index, alpha angle, femoral head coverage, and hip joint laxity, were significantly different between DDH patients and controls. Previous research has also shown that these structural differences correlate with disease severity and provide objective measures that complement clinical assessment [15][16]. The combination of risk factors, clinical findings, and imaging in a scoring system allows for standardized evaluation, reduces operator dependency, and facilitates early intervention. The scoring system demonstrated excellent diagnostic performance, with a sensitivity of 88.1%, specificity of 79.1%, and an area under the ROC curve of 0.91. These metrics indicate that the system can accurately identify infants with DDH while minimizing false positives. Similar results have been reported in previous

research, where composite scoring models combining clinical and imaging features achieved high predictive accuracy. This supports the potential for the scoring system to be integrated into routine neonatal screening programs, particularly in resource-limited settings where access to universal imaging may be constrained [17]. Overall, the study highlights the utility of a structured, multifactorial scoring system for early DDH detection. By combining demographic, clinical, and imaging data, the system provides an objective framework for risk stratification, early referral, and targeted follow-up. These findings are in line with previous research emphasizing that early, standardized assessment improves outcomes and reduces the need for invasive interventions in affected infants.

3. CONCLUSION

It is concluded that the novel scoring system is an effective tool for the early diagnosis of pediatric hip dysplasia. The system successfully integrates demographic risk factors, clinical examination findings, and imaging parameters to stratify infants by risk, with DDH patients showing significantly higher scores compared to healthy controls. Female sex, breech presentation, positive family history, positive Ortolani sign, and limited hip abduction were identified as independent predictors of DDH. The scoring system demonstrated high diagnostic accuracy, with a sensitivity of 88.1%, specificity of 79.1%, and an AUC of 0.91, supporting its potential utility in routine neonatal screening. Implementation of this scoring tool can facilitate early detection, timely intervention, and improved long-term outcomes, while reducing delayed diagnosis and unnecessary imaging.

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