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Consanguinity and family history as risk factors for developmental dysplasia of the hip in Omani children

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ABSTRACT

Background: Developmental dysplasia of the hip (DDH) is a multifactorial disorder influenced by genetic and environmental factors, with variation in risk profiles across populations, particularly in regions with high consanguinity rates. This study aimed to evaluate risk factors associated with DDH among Omani children.
Methods: This retrospective hospital-based case-control study included children born at Khoula Hospital between 2009 and 2019. Of 567 screened children, 100 confirmed DDH cases were included. A control group of 200 children was matched for age and sex. Univariable and multivariable logistic regression analyses were performed.
Results: Family history (OR 4.38, 95% CI 1.81–10.55; p=0.001) and consanguinity (OR 2.02, 95% CI 1.19–3.46; p=0.010) were independent predictors of DDH. Other factors were not statistically significant.
Conclusions: Family history and consanguinity are significant independent risk factors for DDH in this population, supporting targeted screening strategies.

Keywords: Developmental dysplasia of the hip, Consanguinity, Genetic predisposition, Pediatric orthopedics

INTRODUCTION

Developmental dysplasia of the hip (DDH) describes a spectrum of abnormalities ranging from acetabular dysplasia and hip instability to subluxation and complete dislocation. It is generally regarded as a multifactorial disorder in which mechanical, environmental, and genetic influences interact.[1] Early diagnosis remains important because delayed recognition is associated with more invasive treatment and poorer long-term hip preservation outcomes.[1,2]

The reported incidence of DDH varies substantially across populations and according to the screening strategy used. In a 2022 systematic review and meta-analysis, early detection rates differed markedly between clinical, selective ultrasonographic, and universal ultrasonographic screening strategies, while late detection and operative treatment rates were not clearly reduced by universal screening.[2] These findings support the continued relevance of selective risk-based screening in many healthcare systems.

Established risk factors for DDH include female sex, breech presentation, positive family history, and primiparity, although the strength of association varies across studies and populations.[3-6] In a 2025 meta-analysis of infants younger than 3 months, breech presentation and family history were the strongest predictors of sonography-verified DDH, followed by oligohydramnios, female sex, and high birth weight.[3]

In addition to mechanical factors, increasing evidence supports a genetic contribution to DDH. Reviews of the molecular and genetic basis of DDH have identified susceptibility pathways involving connective tissue, osteogenesis, and chondrogenesis, including genes such as COL1A1, GDF5, PAPPA2, and others.[1,7] In populations

with high rates of consanguineous marriage, these genetic effects may be more readily expressed.

This issue is particularly relevant in Oman. Population-based studies have shown that consanguineous marriage remains common in Oman, with a substantial proportion of unions occurring between first and second cousins.[8,9] A recent epidemiological study from Khoula Hospital also demonstrated that consanguinity and family history are common among Omani patients managed for DDH.[10] However, there remains limited published evidence specifically quantifying the association between these factors and DDH in an Omani case-control design.

The present study was therefore conducted to evaluate risk factors associated with DDH among Omani children managed at the largest pediatric orthopedic referral unit in the country. We specifically aimed to determine which risk factors were independently associated with DDH in this hospital-based cohort.

METHODS

This retrospective case-control study was conducted at Khoula Hospital, Muscat, Oman, a tertiary referral center with an established pediatric orthopedic service.

The medical records of all children diagnosed with DDH and managed at Khoula Hospital between January 2009 and December 2019 were reviewed. From this group, children who were born at Khoula Hospital during the study period were identified, and their records were examined for diagnosis and potential risk factors. Missing clinical information was supplemented, when necessary, by direct phone interviews with parents using a structured questionnaire.

Cases were defined as Omani children born at Khoula Hospital during the study period who fulfilled at least one of the following diagnostic criteria: Graf ultrasonographic classification IIb or higher, IHDI classification grade 2 or higher, or frank hip dislocation on plain radiographs. Children with neuromuscular disorders, arthrogryposis, teratological dislocation, or syndromic conditions were excluded.

A total of 100 eligible cases were identified. For each case, two controls were selected from children born at Khoula Hospital during the same study period who were not referred for suspected DDH. Controls were matched by sex and year of birth, resulting in a total of 200 controls.

This study should be interpreted as a hospital-based case-control analysis within a referred population. Therefore, the proportion of DDH identified in the screened cohort reflects diagnostic yield among referred suspected cases rather than population incidence.

Data collected included sex, age at first visit, laterality of DDH, order of the child, mode of delivery, breech presentation, consanguinity, family history, sibling history, oligohydramnios, ultrasonographic classification, and treatment modality. All included children had follow-up to at least 24 months of age.

Ethical approval was obtained from the Research and Ethical Review and Approval Committee (RERAC), Centre of Studies and Research, Ministry of Health, Oman. The study was approved prior to data collection.

Given the retrospective design, informed consent was waived; however, verbal consent was obtained for additional data collected via phone interviews. All data were anonymized and handled confidentially. Children were included if they were diagnosed with DDH between January 2009 and December 2019 based on Graf classification IIb or higher, International Hip Dysplasia Institute (IHDI) grade 2 or higher, or radiographic evidence of frank dislocation, and had received treatment at Khoula Hospital. Only Omani children born at Khoula Hospital during the study period were included. Patients were excluded if they were diagnosed outside the study period, were non-Omani, or had DDH associated with neuromuscular disorders, arthrogryposis, teratological dislocation, or syndromic conditions.

Statistical analysis

Continuous variables were summarized as mean and standard deviation or median and interquartile range, as appropriate. Categorical variables were presented as frequencies and percentages.

Comparisons between groups were performed using the Mann-Whitney U test for continuous variables and the Chi-square test or Fisher exact test for categorical variables, as appropriate.

Variables that were statistically significant on univariable analysis were entered into a multivariable binary logistic regression model to identify independent predictors of DDH. Odds ratios with 95% confidence intervals were reported. A $p<0.05$ was considered statistically significant. Statistical analyses were performed using IBM statistical package for the social sciences (SPSS) statistics version 28.0.

RESULTS

A total of 567 newborns were referred with suspected DDH during the study period, of whom 100 children (17.6%; 95% CI: 14.6–21.0) were confirmed to have DDH and met the inclusion criteria. This proportion reflects the diagnostic yield among referred cases rather than population incidence (Figure 1).

Among the DDH cases, 75% were females and 25% were males. The mean age at first orthopedic evaluation was 7.41 months in the DDH group compared to 5.98 weeks in

the control group, with no statistically significant difference in age at first visit (p=0.503).

The majority of referrals originated from the pediatric unit at Khoula Hospital (88%), with the remaining 12% referred from external institutions.

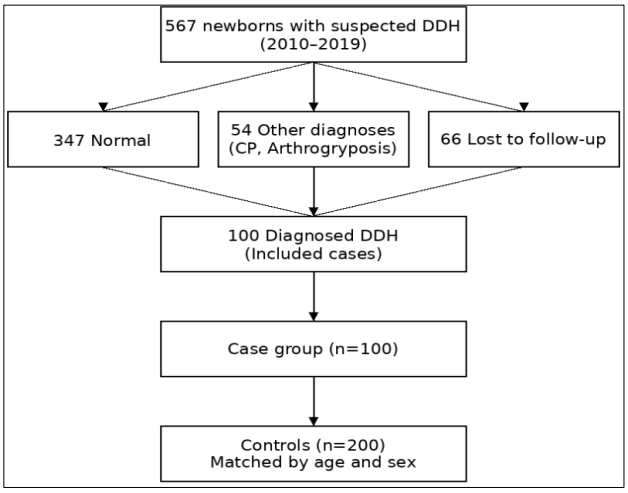

Figure 1: Study flow diagram.

Regarding laterality, left hip involvement was most common, observed in 80% of cases (including unilateral left and bilateral involvement), while isolated right hip involvement was present in 20% of cases. Pavlik harness was the primary treatment modality, used in 77% of patients. The remaining 23% of cases were diagnosed after 6 months of age and required alternative treatment approaches.

Risk factor analysis

Univariate analysis demonstrated that consanguinity (38.0% versus 24.1%, p=0.015), family history (23.0% versus 6.5%, p<0.001), and sibling history (12.0% versus 4.5%, p=0.028) were significantly associated with DDH. No statistically significant associations were observed for sex, birth order, mode of delivery, breech presentation, or oligohydramnios (Table 1).

Multivariate analysis

Multivariate logistic regression identified consanguinity and family history as independent predictors of DDH. Consanguinity was associated with a twofold increased risk (OR 2.02, 95% CI: 1.19–3.46, p=0.010), while family history conferred a fourfold increased risk (OR 4.38, 95% CI: 1.81–10.55, p=0.001). Sibling history was not statistically significant after adjustment (Figure 2).

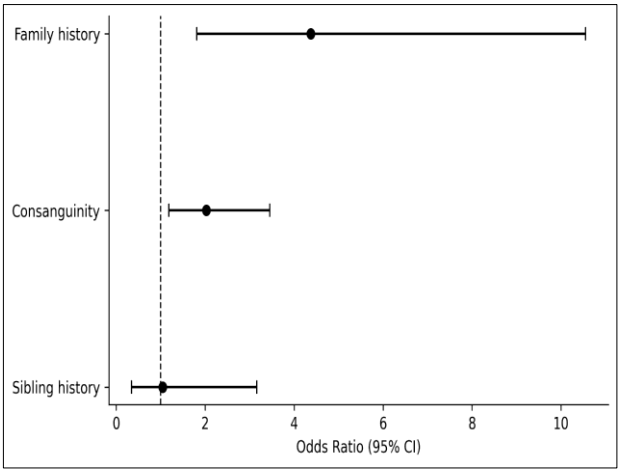

Figure 2: Adjusted odds ratios (OR) with 95% confidence intervals for risk factors associated with developmental dysplasia of the hip (DDH). Family history and consanguinity were identified as independent predictors, while sibling history was not statistically significant.

Table 1: Comparison of demographic and clinical risk factors between DDH cases and control group.

Variables		DDH (n=100) (%)	Control (n=200) (%)	P value
Sex	Male	25 (25.0)	50 (25.0)	1.000
	Female	75 (75.0)	150 (75.0)	—
Birth order	1st	33 (33.0)	77 (38.5)	0.403
	2nd	30 (30.0)	58 (29.0)	—
	3rd	14 (14.0)	36 (18.0)	—
	4th	14 (14.0)	19 (9.5)	—
	>4th	9 (9.0)	10 (5.0)	—
Mode of delivery	Vaginal (SVD)	70 (70.0)	126 (63.0)	0.249
	Cesarean (LSCS)	30 (30.0)	74 (37.0)	—
Breech presentation	Yes	27 (27.0)	57 (28.5)	0.892
	No	73 (73.0)	143 (71.5)	—
Consanguinity		38 (38.0)	48 (24.1)	0.015*
Family history		23 (23.0)	13 (6.5)	<0.001*
Oligohydramnios		8 (8.0)	11 (5.5)	0.453
Sibling history		12 (12.0)	9 (4.5)	0.028*

*Statistically significant.

DISCUSSION

Early identification of DDH remains clinically important because treatment initiated in infancy is generally less invasive and is associated with better radiologic and functional outcomes than treatment begun after delayed presentation.[1,2] In the current series, the mean age at first orthopedic visit in the DDH group was 7.41 months, and nearly one-quarter of patients were diagnosed after 6 months of age, underlining the continued burden of delayed presentation in tertiary practice.

The 17.6% figure observed in this study represents the diagnostic yield among children referred with suspected DDH rather than disease incidence in the general population. This distinction is important. Population-level incidence varies widely according to geography and screening strategy, and a recent meta-analysis demonstrated that detection rates differ substantially between clinical, selective ultrasonographic, and universal ultrasonographic screening programs.[2] Our findings therefore should be interpreted within the context of a referred high-risk cohort rather than the general newborn population.

Female predominance was marked in the present study, with females constituting 75% of cases. This is consistent with the established female susceptibility reported in prior studies and meta-analyses.[3-6] Because the control group was matched for sex, however, sex could not be evaluated as an independent predictor in the current case-control analysis.

The principal finding of this study is that both family history and parental consanguinity were independently associated with DDH. The association with family history is consistent with contemporary literature identifying family history as one of the strongest predictors of sonography-verified DDH.[3,5] Family history has also been associated with more severe forms of DDH and higher likelihood of treatment escalation in recent cohort studies.[5]

The association with consanguinity is particularly relevant in the Omani setting. Consanguineous marriage remains common in Oman, with national studies documenting high rates of first- and second-cousin unions.[8,9] In such a setting, clustering of susceptibility variants within families may increase the expression of genetically mediated musculoskeletal conditions, including DDH.

Current molecular and genetic reviews support the contribution of genes involved in connective tissue architecture, osteogenesis, and chondrogenesis, including COL1A1 and GDF5, to DDH susceptibility.[1,7]

In contrast, breech presentation, mode of delivery, and oligohydramnios were not significant predictors in this cohort. This differs from broader meta-analytic evidence in which breech presentation and family history were the most powerful traditional risk factors, with oligohydramnios also showing increased risk.[3] Several explanations are possible, including the modest sample size of the present study, referral-related selection, incomplete documentation of perinatal variables, and genuine population-specific variation. Accordingly, these negative findings should be interpreted with caution rather than taken as definitive evidence of no association in the wider Omani population. Our results nonetheless support the value of targeted ultrasonographic screening in infants with familial and genetic risk profiles, especially in populations where consanguinity is common. They also suggest that locally derived evidence may refine risk-based screening pathways beyond the direct adoption of data from Western populations.

This study complements the recently published epidemiological report from the same tertiary center, which described the burden and distribution of DDH in Oman and showed that consanguinity and family history are common among affected children.[10] The present case-control design extends those descriptive observations by quantifying the independent association of these factors with DDH in a matched analysis.

Limitations

This study has several limitations. First, its hospital-based design introduces selection bias and limits generalizability to the broader newborn population. Second, the retrospective design resulted in incomplete documentation, and some data were collected by parental phone recall, introducing possible recall bias. Third, several potentially relevant variables, including swaddling practices, birth weight, prematurity, and associated musculoskeletal findings such as torticollis, were not consistently available for analysis. Fourth, this was a single-center study conducted at a tertiary referral institution, and referral patterns may have influenced the case mix. Finally, genetic testing was not performed; therefore, the biologic interpretation of the association with consanguinity remains indirect rather than genotype-based.

CONCLUSION

Family history and consanguinity are significant independent risk factors for DDH in this population, supporting targeted screening strategies.

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