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# Screening for Developmental Dysplasia of the Hip in Infants in Tibet Identifies Increased Prevalence Associated with Altitude

Authors' Contribution:

Study Design A  
Data Collection B  
Statistical Analysis C  
Data Interpretation D  
Manuscript Preparation E  
Literature Search F  
Funds Collection G

ABCEFG 1 **Lihua Zhao\***  
BCEF 1 **Qichao Ma\***  
BCEF 2 **Xiang Feng**  
BCE 1 **Lingyan Fan**  
CD 1 **Qin Jiao**  
BC 1 **Sun Wang**  
ACDG 1 **Hao Ying**  
ABCDEG 1 **Xiaodong Yang**

1 Department of Orthopedics, Shanghai Children's Hospital, Shanghai Jiao Tong University, Shanghai, P.R. China

2 Department of Orthopedics, Shigatse Developmental Dysplasia of the Hip Clinic Center, Shigatse Peoples' Hospital, Shigatse, Tibet Autonomous Region, P.R. China

\* Lihua Zhao and Qichao Ma contributed equally to this study

**Corresponding Author:** Xiaodong Yang, e-mail: [yangxd@shchildren.com.cn](mailto:yangxd@shchildren.com.cn)

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**Background:** Developmental dysplasia of the hip (DDH), also known as congenital hip dislocation or congenital hip dysplasia is usually diagnosed at birth. Studies on DDH at high-altitude are rare. Tibetans live mainly at altitudes above 3,500 m, and the prevalence of DDH in this population is not currently known. This cross-sectional epidemiological study aimed to identify the prevalence and associated risk factors for DDH in Tibet.

**Material/Methods:** Between 1<sup>st</sup> June 2015 and 30 June 2016, infants in Tibet aged between 0–6 months and from ten districts at different altitudes in Shigatse, Tibet were referred to our hospital for the assessment of DDH. All the infants underwent clinical evaluation for DDH and ultrasound testing using the Graf method.

**Results:** There were 606 infants who met the study inclusion criteria, including 253 female infants and 353 male infants, of which 106 infants had DDH. The prevalence of DDH in Shigatse, Tibet was approximately 174.9/1000 infants (106/606). Altitude was strongly associated with increased risk of DDH in Tibet ( $r=0.82$ ,  $P=0.004$ ).

**Conclusions:** This is the first epidemiological study of DDH in the Tibetan population. The results showed that DDH is prevalent among native Tibetan people in Shigatse, and there was a significant correlation between altitude and the prevalence of DDH. Further studies are needed to investigate the mechanism of the association between altitude and the increased incidence of DDH in infants.

**MeSH Keywords:** **Bone Diseases, Developmental • Epidemiology • Risk Factors • Tibet**

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## Background

Developmental dysplasia of the hip (DDH) is also known as congenital hip dislocation or congenital hip dysplasia and is usually diagnosed at birth. DDH includes a spectrum of anatomical abnormalities from dysplasia of the acetabulum, subluxation of the hip, to complete dislocation of the hip [1–3]. The associations or risk factors for DDH include female gender, a first birth order infant, a history of breech positioning *in utero*, oligohydramnios, a family history of DDH, postural deformities, and deformities of the foot [4–7]. Woodacre and colleagues recently identified a reduced risk of DDH associated with prematurity [8]. However, risk factors for late diagnosis include birth in a rural area and second birth order infants, possibly due to less vigilance for DDH in these infants [9]. An external risk factor for DDH is swaddling the infant's hips in an extended and adducted position [10–12].

Studies that compared the use of ultrasound screening for DDH with clinical examination alone showed that when ultrasound was used, the rate of detection and treatment increased with no significant difference in late detection or surgery [13]. Currently, screening for DDH remains controversial as most screening programs do not meet the main criteria for an effective screening program as recommended by the World Health Organisation (WHO) [14]. However, late diagnosis of DDH when the infant is more than 3 months old, leads to an increased risk of surgical treatment and long-term complications [15]. Early diagnosis, within the first six weeks of life, and timely treatment of DDH is critical to improving the outcome and reduces the need for corrective surgical treatment [16].

The incidence of DDH has been reported in developed countries by epidemiological studies based on maternal and pediatric public health and screening records, and the reported prevalence of DDH in infants ranges from 1.5–78.1 per 1,000 live births, and varies with ethnicity and geographic location [5,17–19]. The overall incidence of DDH in the Chinese population ranges from 0.9–28 per 1,000 live births, but there is no universal screening program for DDH in infants in some remote areas, such as Tibet. Also, because China has a vast geographical area and includes a variety of ethnic groups, it is difficult to determine the prevalence of DDH. Worldwide, the reported incidence of DDH has increased significantly due to advances in clinical and ultrasound screening. In China, due to variations in regional development, a selective high-risk DDH screening program is performed earlier in developed areas such as Tianjin, Beijing, and Shanghai, but it is difficult to launch such a program in some remote areas such as Tibet that are located in regions of high-altitude where primary healthcare may be lacking. Shigatse is the second largest city in Tibet, located in the southern part of Tibet, with an average altitude of 3,500 m above sea level. The native residents

in Shigatse are Tibetans, and 70% of the population live in rural communities.

Therefore, because studies on the prevalence of DDH at high-altitude are rare and Tibetans live mainly at high altitudes, this study aimed to identify the prevalence and associated risk factors for DDH in infants between 0–6 months in Tibet.

## Material and Methods

### Patients and selection of regions

Infants aged between 0–6 months were randomly recruited for screening for developmental dysplasia of the hip (DDH) from ten regions in Shigatse, Tibet. All infants were assessed clinically (by LHZ and QCM) and by ultrasound (by XF) using the method described by Graf [20,21]. The ten regions of Shigatse included in the study were Yadong, Shigatse, Gyangzê, Sa'gya, Lhazê, Ngamring, Namling, Bailang, Xaitongmoin, and Tingri, with different altitudes. To increase the validity of the results, regions were excluded that had a screening population of fewer than 50 infants.

The Ethics Committee of Shanghai Childrens' Hospital and Shigatse Peoples' Hospital approved this cross-sectional epidemiological study. All parents gave written informed consent before data collection.

### Screening diagnosis of developmental dysplasia of the hip (DDH) and the use of clinical questionnaires

The diagnosis of DDH in the screening program was made clinically and by ultrasound of the hip joints performed in all infants in the study who were 0–6 months of age. The clinical and demographic data for the infants included the source and reason for the clinical referral, gender, age, clinical findings, and ultrasound findings, which were recorded in Microsoft Excel version 2016 at the examination center of Shigatse Peoples' Hospital. Each parent was asked to complete a standard epidemiological questionnaire that included information on gender, age, the altitude of residence, delivery conditions, hereditary disease, and the use of hip swaddling. The questionnaire was created and the answers collected by pediatric trainees from Shigatse Peoples' Hospital.

### Inclusion criteria

The inclusion criteria were all infants from 0–6 months of age referred to our screening center between 1 June 2015 and 30 June 2016. Exclusion criteria included neurological, neuromuscular, or syndromic skeletal dysplasia. The referred babies do not have any symptom of asphyxia. Shigatse is the second largest city of Tibet, with a population of 0.75 million inhabitants

**Table 1.** Distribution of the prevalence of developmental dysplasia of the hip (DDH) in male and female infants.

Gender	Positive	Negative	Total	$\chi^2$	P-value
Male	31 (9%)	322 (91%)	353	44.45	<0.01
Female	75 (30%)	178 (70%)	253		

$\chi^2$  – chi-squared.

and the birth rate of Shigatse during the period of the study was recorded as approximately 15.75%. There were 136,285 births in Shigatse and 2,215 infants referred to the Shigatse Peoples' Hospital, and 606 infants met the inclusion criteria.

### Clinical and ultrasound diagnosis of DDH

The Ortolani and Barlow test, the Galeazzi test and movement tests of the hips were clinically conducted for the referred infants. A negative Ortolani and Barlow test result, normal movement of the hips, and equal leg lengths were defined as clinically normal [4,22]. The modified Graf static ultrasound method and the Harcke dynamic ultrasound method were performed using a 7.5 MHz M-Turbo linear array ultrasound transducer (Sonosite, Bothell, WA, USA) [22]. DDH was defined on hip ultrasound as Graf type III (alpha angle <43 degrees) or Graf type IV (alpha angle <43 degrees, and dislocated) [22,23].

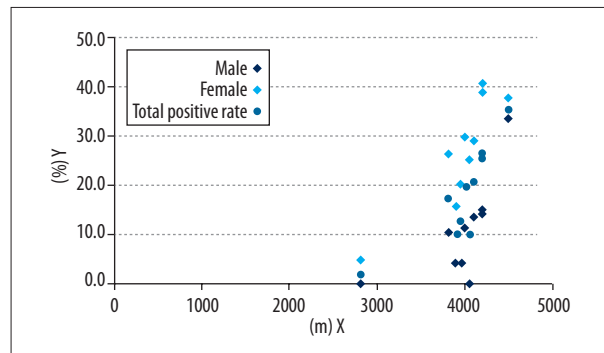
### Statistical analysis

Data were analyzed using SPSS version 18.0 software (SPSS Inc., Chicago, IL, USA). Pearson's correlation coefficient was used to analyze the relationship between altitude and the prevalence of DDH. The chi-squared ( $\chi^2$ ) test was used to evaluate the correlation between the detection rate of DDH and the use and style of swaddling. Calculations of data were performed using 2x2 contingency tables (Microsoft Excel, 2016). P<0.05 indicated statistical significance.

## Results

### Prevalence of developmental dysplasia of the hip (DDH) in Shigatse, Tibet

This study included 606 infants from ten regions of Shigatse in Tibet, who were randomly screened for developmental dysplasia of the hip (DDH). There were 106 infants who were identified to have DDH, with a prevalence of 17.5%. Of the 106 infants with DDH, 75 were female and 31 were male, with a mean age of 5.69±2.54 months. The prevalence of DDH was significantly different between the genders, with a male: female ratio of 1: 2.4 (P<0.001) (Table1). The prevalence of DDH in male infants was 5.1% (31/606) and the prevalence of DDH in female infants was 12.4% (75/606).



**Figure 1.** Relationship between altitude (X) and the prevalence of developmental dysplasia of the hip (DDH) (Y). The p-value of the relationship was 0.004.

### Correlation between the prevalence of DDH and altitude of the region of residence

There was a significant linear correlation between altitude and prevalence of DDH (r=0.819, P=0.004). The prevalence of DDH in male and female infants was significantly correlation with altitude (male: r=0.668, P=0.035; female: r=0.858, P=0.001) (Figure 1, Table 2).

### Correlation between the prevalence of DDH and infant swaddling

All cases of DDH had been swaddled by bundling of both the lower limbs for more than two months. Analysis of the data using the chi-squared ( $\chi^2$ ) test showed a significant association between DDH and swaddling with hip extension (P<0.001).

## Discussion

To the authors' knowledge, this was the first study of screening for developmental dysplasia of the hip (DDH) in high-altitude areas of Tibet. The prevalence and related epidemiological factors associated with DDH in infants and children are difficult to determine in Tibet due to its size and varied geography, the varied definition and clinical criteria for the diagnosis of DDH, type of examination methods used, and experience of the clinicians. Worldwide, some of these same problems exist regarding the effective screening of infants for DDH and are challenges that pediatric orthopedic surgeons wish to resolve.

**Table 2.** Relationship between the prevalence of developmental dysplasia of the hip (DDH) from ten districts and altitude in Shigatse, Tibet.

District (County)	Altitude (m)	Prevalence in male infants (%)	Prevalence in female infants (%)	Total (%)
Yadong	2800	0.0	4.8	2.0
Shigatse City	3800	10.3	26.2	17.4
Gyangzê	3900	4.2	15.7	10.1
Sa'gya	3950	4.1	20.0	12.5
Lhazê	4000	11.3	29.6	19.8
Ngamring	4050	0.0	25.0	10.0
Namling	4100	13.5	28.9	20.7
Bailang	4200	14.8	38.8	26.2
Xaitongmoin	4200	14.1	40.4	25.2
Tingri	4500	33.3	37.5	35.2

Tibet is often called 'the roof of the world,' and is the world's largest and highest plateau with most of its altitude being between 4,600–4,900 m, with an average altitude of 4,000 m [24,25]. Due to Tibet's poor economy and poorly developed regional medical systems, the Tibetan population lags behind many other countries in awareness of screening for DDH for their children compared with the mainland Chinese population [24,26,27]. Therefore, the incidence of late diagnosis of DDH in Tibet is much higher than that of other provinces of China, as this study has shown. Children with a delayed diagnosis of DDH are more likely to need more invasive surgical treatments to maintain hip function.

To investigate the incidence of DDH in Tibet and to better understand the reason why so many patients with DDH in Tibet have a late diagnosis, this cross-sectional epidemiological survey was conducted in infants between 0–6 months of age in different regions of Shigatse. This study showed that the prevalence of DDH was 17.5% in Tibetan infants aged 0–6 months. Therefore, this high prevalence of DDH is a serious concern for the health of the Tibetan population, and more attention should be given to the importance of screening for DDH to reduce the rate of late diagnosis.

The findings of the present study also showed a significant association between altitude and the prevalence of DDH in Tibet, and the Tibetan population who live at higher altitudes have a higher incidence of DDH. Therefore, the findings from this study support that high altitude might be a risk factor for DDH, but the reason and mechanism for this association require further study. Chronic oxygen deprivation is experienced by the Tibetan population who live on the high-altitude

plateaus, which might have a role in the increased incidence of DDH. Several studies have shown that oxygen is a key regulatory signal in tissue development and homeostasis, and chronic hypoxia might influence bone development of the hip joint [28–30]. However, this association has yet to be established and requires further study.

There is a broad clinical consensus that early diagnosis and treatment of DDH are essential for a good outcome. The early detection and treatment of DDH, within the first three months, has been shown to improve outcome and is associated with the need for less invasive treatments [31]. Also, early diagnosis is associated with an increased likelihood of successful treatment, with better bone remodeling leading to fewer secondary procedures. The acknowledgment of the benefits of early diagnosis and treatment is the basis of screening and surveillance programs for DDH. According to the findings of the present study, recommendations should be directed at the government level to ensure that measures are taken to establish screening for DDH in infants who are at increased risk. This is the first study to present data demonstrating the high prevalence and associated risk factors in a Tibetan population living in high altitude areas. The present study has important implications in developing local policies on the prevention and control of DDH.

The present study has several limitations. Firstly, the study did not include all the identified risk factors that may also have had an influence on the high prevalence of DDH in the Tibetan population. Secondly, the data were cross-sectional and not longitudinal. Thirdly, the timing of the screening performed might have influenced the outcome, as Graf suggested

that screening at two different ages, within the first two neonatal weeks and in the sixth to the eighth week should be recommended.

## Conclusions

The results of this cross-sectional epidemiological study confirmed the high prevalence of developmental dysplasia of the hip (DDH) in Tibetan infants from 0–6 months. The results also

showed that there was a significant correlation between altitude and the prevalence of DDH in the inhabitants of Tibet. Further efforts to screen for DDH in other areas of Tibet is warranted and further research is needed to determine the mechanisms for the association between high altitude and DDH, with the effects of chronic hypoxia being a key area for future research.

## Conflict of interest

None.

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