END OF DEGREE PROJECT

BACHELOR'S DEGREE IN MEDICINE



A STUDY OF RISK FACTORS FOR DEVELOPING HIP DYSPLASIA IN NEONATES FROM THE TRAUMA AND ORTHOPEDIC SURGERY DEPARTMENT AT QUIRÓNSALUD MADRID UNIVERSITY HOSPITAL BETWEEN 2021-2023

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1. Abstract and keywords

Introduction: Hip dysplasia is one of the most frequent orthopedic pathologies in pediatrics. There are known risk factors that predispose individuals to the condition, such as female sex, positive family history, breech presentation, firstborn status, oligohydramnios, postural deformities, among others. During the first weeks of life, a child should undergo a physical examination with the Ortolani and Barlow maneuvers and a hip ultrasound. Early diagnosis is key to initiating early treatment, usually with the Pavlik harness, to prevent irreversible complications in adulthood such as degenerative osteoarthritis of the hip joint.

Main objective: Study the relationship between having at least 2 risk factors and developing hip dysplasia.

Methodology: Observational, analytical, retrospective and cross-sectional study. Patients are neonates from Quirónsalud Madrid University Hospital between 2021-2023, from a pseudonymized database. The Chi-Squared/Fisher's exact test, absolute and relative frequencies were used to measure associations to test the main and secondary objectives.

Results: There was a statistically significant difference when studying the association between having at least 2 risk factors and developing hip dysplasia ($p<0.001$). Not all risk factors evaluated turned out to be risk factors in the sample population. The only ones with a statistical difference were family history, breech presentation, firstborn and term delivery. The most prevalent risk factor was firstborn. Most patients had only 2 risk factors. Patients with hip dysplasia had a median of 2 risk factors (IQR 1-3). Having a minimum of 2 risk factors was not associated with developing a more severe form of hip dysplasia (Type III or IV) ($p=0.195$).

Conclusion: There is an association between having a minimum of 2 risk factors and developing hip dysplasia.

Keywords: DDH; developmental dysplasia of the hip; hip dysplasia; risk factors; prevention; Pavlik harness

2. Resumen y palabras claves

Introducción: La displasia de cadera es una de las patologías más frecuentes en la edad pediátrica. Existen factores de riesgo conocidos como sexo femenino, antecedentes familiares, presentación podálica, primiparidad, oligohidramnios, deformidades posturales, entre otros. Durante las primeras semanas de vida, los neonatos deben ser explorados con las maniobras de Ortolani y Barlow y una ecografía de cadera. Un diagnóstico precoz es la clave para un tratamiento temprano, usualmente con el arnés de Pavlik, para prevenir complicaciones irreversibles en la edad adulta como una coxartrosis.

Objetivo principal: Estudiar la relación que existe entre tener al menos 2 factores de riesgo y desarrollar displasia de cadera**.**

Metodología: Observacional, analítico, retrospectivo y transversal. Los pacientes fueron neonatos del Hospital Universitario Quirónsalud Madrid entre los años 2021-2023, de una base de datos seudonimizada. Fueron utilizados el Chi-cuadrado/Test exacto de Fisher y las frecuencias absolutas y relativas para probar el objetivo principal y los secundarios.

Resultados: Hubo una diferencia estadísticamente significativa al estudiar la asociación entre presentar mínimo 2 factores de riesgo y desarrollar displasia de cadera ($p<0.001$). No todos los factores de riesgo estudiados fueron factores de riesgo en la muestra poblacional, los únicos factores que tuvieron una diferencia estadísticamente significativa fueron antecedentes familiares, presentación podálica, primogénito y parto a término. El factor de riesgo más prevalente fue ser primogénito. La mayoría de los pacientes tuvieron 2 factores de riesgo. Los pacientes con displasia de cadera tuvieron una mediana de 2 factores de riesgo (RIQ 1-3). Tener un mínimo de 2 factores de riesgo no fue asociado a un mayor riesgo de desarrollar una displasia de cadera más severa (Tipo III o IV) ($p=0.195$).

Conclusión: Existe una asociación entre tener al menos 2 factores de riesgo y desarrollar displasia de cadera.

Palabras clave: DDC; displasia del desarrollo de la cadera; displasia de cadera; factores de riesgo; prevención; arnés de Pavlik

3. Introduction

The developmental dysplasia of the hip (DDH) is one of the most frequent orthopedic pathologies in pediatrics. Its incidence is approximately 1-10 cases per 1,000 births (1). The term "dysplasia" refers to a developmental anomaly of the femoral head and/or the acetabulum. This pathology affects the acetabulofemoral joint and includes: teratological or non-dislocated hip, subluxation, dislocatable hip and acetabular dysplasia (2,3). A hip subluxation occurs when there is a partial contact between the femoral head and the acetabulum. A dislocated hip occurs when there is loss of contact between both articular surfaces. Acetabular dysplasia occurs when either the femoral head or the acetabulum have not developed adequately, affecting the mechanics of the joint (4). The DDH is one of the main causes of hip instability and limp in children. Therefore, early diagnosis and treatment are crucial. The main objective is to detect this anomaly during the early stages of life to ensure that the child has a clinically stable hip by the end of their skeletal development. If not detected early, approximately 50% of cases of degenerative osteoarthritis in adulthood are a consequence of undetected DDH during childhood, which may eventually require a total hip arthroplasty (2,3,5,6).

The acetabulofemoral joint begins forming around the 7th week of pregnancy from the embryonic mesoderm. Around the 12th week, the lower extremities undergo a medial rotation, a crucial developmental milestone. A defect in rotation can lead to a loss of joint congruity and a more severe dislocation if it occurs earlier in pregnancy. A defect in the development of the muscles responsible for stabilizing the hip between the 12th and 18th week results in a "teratological hip dislocation". This entity is present in about 2% of DDH cases and is often irreducible and associated with neural tube defects. In contrast, "hip dysplasia" is used when it occurs during birth or the first months after birth, representing 98% of DDH cases. The etiopathogenesis is still uncertain. However, most hypotheses postulate that the development of DDH involves intrinsic patient factors, characteristics of the pregnancy, and environmental factors that influence hip joint formation (2,7).

During the neonatal period, all newborns in Spain are screened for DDH with a physical examination. The Barlow maneuver detects a dislocated hip indicating DDH. In contrast, the Ortolani maneuver detects if a dislocated hip is reducible, indicating a more severe DDH. These maneuvers have 100% specificity and 60% sensitivity, which could consequently lead to the overtreatment of a false positive or undertreatment of a false negative. Furthermore, in 60% of cases the Barlow maneuver becomes negative spontaneously during the first two weeks of life, which is why these maneuvers are performed during the first 7 days after birth (3,8). There are other recommended maneuvers/signs that point to DDH, such as the Galeazzi sign, Trendelenburg sign and skinfold asymmetry (9).

Along with the physical examination, known risk factors should be considered when evaluating a patient. There is controversy as to whether risk factors can predict if an infant develops hip dysplasia. According to some literature, only 10-27% of children with DDH presented risk factors. This implies that not all risk factors have the same influence on the genesis of this pathology and that risk factors alone are not enough to develop hip dysplasia. Major risk factors include family history, female sex and breech presentation. Minor risk factors include primiparity, oligohydramnios, postural deformities, multiple gestation, musculoskeletal deformities, cephalopelvic disproportion, swaddling, among others (2,3,10,11). It seems that the female sex is associated with DDH because the female fetus's hormones contribute to the loosening of the hip ligaments as well as the maternal hormones that also increase the ligamentous laxity. The breech presentation forces the hips into misalignment, therefore predisposing to DDH after birth, especially in extended breech presentation. Also, being firstborn increases the risk of DDH due to the mother's anatomy with an unstretched uterus and with a tighter abdominal wall since it has never been expanded to that extent before by a previous pregnancy (12,13).

In contrast, other studies have shown that presenting at least 2 risk factors is enough to develop DDH since all their participants with DDH presented a minimum of 2 risk factors (14,15). The Spanish Association of Pediatrics in Primary Care even recommends close follow-up for infants with more than 3 risk factors since they have a greater predisposition to develop DDH (16). There is controversy regarding how many risk factors are needed to develop hip dysplasia; some studies suggest 2-4 risk factors while others support the idea that DDH is multifactorial without a specific threshold. Nevertheless, results vary between studies, since some of them state that the majority of patients in their sample did not present risk factors (17). Based on studies, ultrasonography is recommended for infants with 2 or more risk factors and/or those who present an abnormal physical examination with the Ortolani and Barlow maneuvers. It is also accepted to directly perform an ultrasound on infants with family history or who were in breech presentation during the third trimester, regardless of the findings with the maneuvers (9). Spanish medical experts recommend ultrasound screening for all neonates during the first weeks of life. Many of these neonates present a normal physical examination and appear clinically healthy despite having undetected DDH. However, the screening remains controversial since most unstable hips heal spontaneously without intervention (14,18).

Since 1980, ultrasound has revolutionized the way physicians diagnose and treat developmental dysplasia of the hip. It is a non-invasive tool with a favorable cost-benefit ratio, without ionizing radiation exposure to patients (19). Furthermore, it has a sensitivity of approximately 100%, which allows patients to be classified according to the severity of their dysplasia in the Graf Classification (Type I, II, III or IV). This

tool allows the exploration of joint stability and acetabular morphology and is also useful for clinical follow-up and therapeutic control. It is still debated whether it should be used on all infants or just in those with risk factors and an abnormal physical examination (3). In any case, ultrasonography leads to an increased rate of treatment with harnesses and rigid hip braces (20,21). Studies state that a universal neonatal ultrasound screening can benefit the individual through early diagnosis and treatment to avoid preventable surgical interventions (22,23).

If DDH is not detected during the neonatal period or up to 6 months after birth, treating the patient with conservative management will no longer be an option. According to prospective cohort studies, the Pavlik harness demonstrated effectiveness in treating infants younger than 6 months of age (9). The Pavlik harness is the most commonly used technique, and the patient must use it for a minimum of 3-4 weeks on average. The harness holds the hip in 90 degrees of flexion with a neutral abduction position, reorienting the femoral head towards the acetabulum. This technique allows reduction of 80% of hip dislocations and 95% of acetabular dysplasia and subluxations. Patients should be examined periodically every 2-4 weeks to assess for complications. The most important complication is the avascular necrosis of the femoral head, which can be avoided by performing an ultrasound periodically and making any harness adjustments during the treatment. In the remaining percentage of cases in which the Pavlik harness was not effective, a rigid hip brace in abduction is indicated (24).

Early diagnosis of hip dysplasia is crucial, and it can prevent the development of chronic hip conditions, such as early-onset osteoarthritis. Later in life, this complication can lead to irreversible degeneration of the hip joint cartilage. The result is limited movement, chronic pain and limping (25). Given that several studies have been conducted on the risk factors for hip dysplasia, physicians have the advantage of knowing when a diagnosis of DDH is likely in a child. Anticipating this condition in an unborn child can benefit their health by preventing potentially chronic and irreversible complications. A doctor's role is not limited to treating diseases but also knowing when to prevent them. This is especially relevant when risk factors play an important role in disease development. Most risk factors for DDH are non-modifiable, which makes doctors responsible for correctly evaluating a neonate and treating them early when necessary. To summarize, neonates with a minimum of 2 risk factors should be evaluated for potentially developing hip dysplasia.

This study was aligned with the United Nations Sustainable Development Goal of "good health and well-being" by providing relevant information on a relatively common orthopedic problem in pediatrics, since early diagnosis and treatment can prevent permanent disability in adulthood.

4. Hypothesis and objectives

HYPOTHESIS: There is a relationship between having at least 2 risk factors and developing hip dysplasia (14).

OBJECTIVES:

Main objective: Study the relationship between having at least 2 risk factors and developing hip dysplasia in neonates from Quirónsalud Madrid University Hospital between 2021-2023.

Secondary objectives:

1. Determine if each risk factor known from existing literature (female sex, breech presentation, family history, firstborn, etc.), and possible risk factors not confirmed with previous studies (vaginal birth and term delivery) are risk factors to develop hip dysplasia in the sample population for this study.
2. Describe the distribution of risk factors and determine the most prevalent risk factor among the patients presenting hip dysplasia from the sample population.
3. Describe the number of patients from the sample population who present a certain number of risk factors (1, 2, 3, 4…) and determine what the maximum value of risk factors within a single patient with hip dysplasia is.
4. Analyze the relationship between having at least 2 risk factors and developing a hip dysplasia Type II or Type III/IV from the Graf Classification.

5. Methodology

5.1. Study design

This was an observational, analytical, retrospective, cross-sectional study, with a longitudinal data collection.

5.2. Setting and subjects of the study

Neonate patients between 2021-2023 from Quirónsalud Madrid University Hospital followed-up in the Trauma and Orthopedic Surgery Department.

5.2.1. Inclusion criteria

Patients included in the study were neonate patients with and without hip dysplasia followed-up in this hospital during this period, and whose medical record contained all relevant information regarding this study. The result of developing hip dysplasia must have been collected in the patients' medical record. Hip dysplasia was defined as an abnormal physical examination with the Ortolani and Barlow maneuvers and/or a Graf angle <60 degrees.

5.2.2. Exclusion criteria

Patients excluded from this study were neonate patients with neuromuscular pathologies, genetic syndromes, congenital malformations or teratological hip dislocation.

5.2.3. Sample size calculation

For this study, 2 groups of patients were chosen: one group consisting of patients with hip dysplasia and another group of patients without hip dysplasia. The sample size was calculated with the program GRANMO (version 8.0) with the tool "two independent proportions". Reference literature was used to determine the number of risk factors needed to develop hip dysplasia. In that study, a total of 3720 patients were included, out of which 3010 presented at least 2 risk factors (14). Out of the 3010 patients, 420 developed hip dysplasia and 2590 did not. This means that 100% of patients with dysplasia (420 out of 420) presented at least 2 risk factors, and that 86.05% of patients without hip dysplasia (2590 of 3300) also presented at least 2 risk factors.

Both percentages were used to calculate the sample size. Since having hip dysplasia is less frequent than not having it, the size ratio between both groups was 2. Additionally, the expected replacement rate was 10% in case certain patients needed to be excluded from the study or could not be taken into consideration. The program calculated that at least 63 patients needed to be included in the study (21 patients for the hip dysplasia group and 42 patients for the group without hip dysplasia). With this sample size, statistically significant differences between having at least 2 risk factors and developing hip dysplasia could be detected with a power of 80% and a 95% confidence level. A drop-out rate of 0% was anticipated.

The study ended up including 142 patients. These were all patients who attended the hospital during 2021-2023 and had a consultation and follow-up in the Trauma and Orthopedic Surgery Department. There were 87 patients with hip dysplasia and 55 patients without hip dysplasia. Only 4 patients were ineligible for the study because they met the exclusion criteria.

5.3. Variables

Table A 1 containing all variables is in the annexes section. The variables used for this study were separated into two groups: main variables and secondary variables. The main variables are described below:

- **Qualitative variables:**
    - Hip dysplasia: YES / NO (outcome variable)
    - Number of risk factors (≥ 2 risk factors): YES / NO (grouping variable)

The secondary variables were grouped by qualitative or quantitative variables. The only quantitative variable, the Alpha angle, was only used to group neonates in the hip dysplasia group and determine the type of dysplasia, but was not used to analyze any of the objectives of this study. The secondary variables are described below:

- **Qualitative variables:**
    - Sex: Male / Female
    - Firstborn: YES / NO
    - Family history: YES / NO
    - Multiple gestation: YES / NO
    - Fetal presentation: Cephalic / Breech
    - Oligohydramnios: YES / NO
    - Lower extremities deformities: YES / NO
    - Congenital torticollis: YES / NO
    - Neuromuscular pathology: YES / NO
    - Gestational age: Preterm delivery / Term delivery
    - Type of birth: Vaginal birth / Cesarean section
    - Type of hip dysplasia: Type I, II, III, IV
- **Quantitative variables:**
    - Alpha angle: 1, 2, 3, … degrees

5.4. Data collection

The data were collected by the clinical tutor. The clinical tutor collected the data retrospectively by entering patients' medical records and selecting neonate patients with and without hip dysplasia between 2021-2023 from Quirónsalud Madrid University Hospital. The patients chosen either had the diagnosis or were suspected to have the condition, which is why they were evaluated at the hospital. Patients were selected from the Trauma and Orthopedic Surgery department and the following variables were collected: gestational age, sex, family history of hip dysplasia, firstborn status, type of birth, multiple gestation, presentation, oligohydramnios, lower extremities deformities, congenital torticollis, neuromuscular pathology and the Alpha angle from the Graf Classification. Data collection was longitudinal: some variables were collected during the first hospital visit, while others required an extra evaluation during the patient's first month of life. The tutor created a pseudonymized database in which he only included patients' information relevant to this study. Only the tutor had custody of the real database with personal information about the patients and their identification number. The student only had access to another database with only the variables needed and each patient's identification number, without any other information that could compromise the patients' privacy. The student did not have any contact with patients or their medical records. All information for this study was provided by the tutor in a pseudonymized database. The use of data complied with the EU legislation on personal data (see ethical and legal considerations). The database was subject to the hospital's control system and was not stored on external mobile devices.

5.5. Statistical analysis

5.5.1. Descriptive analysis

For the descriptive analysis of qualitative variables, the absolute frequency (n) and the relative frequency were calculated. For quantitative variables the median and interquartile range were used, since they followed a non-normal distribution.

5.5.2. Bivariate analysis

To determine the association between qualitative variables, two proportions were compared using the Chi-Squared test. When a cell contained fewer than 4 patients, the Fisher's exact test was used instead. Also, the Mann-Whitney U test was used to assess the relationship between quantitative variables that followed a non-normal distribution.

GENERAL CONSIDERATIONS:

Normality: To assess the normality of the data, the Kolmogorov-Smirnov test was used. Also, the distribution was evaluated through graphical representations with histograms and Q-Q Plot.

Evaluation of the statistical significance: To evaluate the statistical significance, it was considered that a p-value<0.05 was statistically significant for all tests.

Software: The statistical analysis was performed using the Jamovi Software version 2.6.2.0.

5.6. Ethical and legal considerations

5.6.1. Use of Artificial Intelligence (AI) tools

No Artificial Intelligence (AI) tools like ChatGPT were used for the writing of this document. All content and ideas reflected in this document are the author's own (Declaración sobre el uso de ChatGPT y herramientas de IA).

5.6.2. Ethics Committee approval

This research project was approved by the Comité de Ética de la Investigación (CEI) del Hospital Universitario Fundación Jiménez Díaz, following the current regulations. The approval resolution is attached as an annex in this document (Approval resolution from CEIm or Commission).

5.6.3. Data protection and management

El proyecto se realizó respetando las normativas en materia de bioética según la declaración de Helsinki, el informe de Belmont, el convenio de Oviedo sobre los derechos humanos y la biomedicina y la ley 14/2007, de 3 de julio, de investigación biomédica.

El proyecto se realizó conforme a la legislación de la UE sobre datos personales, en concreto la Ley Orgánica 3/2018, de 5 de diciembre, de Protección de Datos Personales y garantía de los derechos digitales, el Real Decreto 1720/2007, la Ley 41/2002, de 14 de noviembre, básica reguladora de la autonomía del paciente y de derechos y obligaciones en materia de información y documentación clínica.

Legislación vigente/Current legislation:

Ley 41/2002, de 14 de noviembre, básica reguladora de la autonomía del paciente y de derechos y obligaciones en materia de información y documentación clínica.

Publicado en: «BOE» núm. 274, de 15/11/2002.

Referencia: BOE-A-2002-22188

http://www.boe.es/boe/dias/2002/11/15/pdfs/A40126-40132.pdf

El artículo 7.1 de esta Ley establece que: «Toda persona tiene derecho a que se respete el carácter confidencial de los datos referentes a su salud, y a que nadie pueda acceder a ellos sin previa autorización amparada en la Ley.»

Ley 14/2007, de 3 de julio, de Investigación biomédica.
Publicado en: «BOE» núm. 159, de 4 de julio de 2007, páginas 28826 a 28848 (23 págs.)
Referencia: BOE-A-2007-1294
https://www.boe.es/boe/dias/2007/07/04/pdfs/A28826-28848.pdf

Ley Orgánica 3/2018, de 5 de diciembre, de Protección de Datos Personales y garantía de los derechos digitales
https://www.boe.es/eli/es/lo/2018/12/05/3

5.6.4. Informed consent

This was an observational and retrospective study in which the database was pseudonymized. There was no harm or risk for the patients included in the study. This was the reason why an exemption from informed consent was requested from the ethics committee, which was granted.

6. Results

6.1. Patient selection and sample population characteristics

Figure 1 shows how patients were selected to be part of this study, applying the inclusion and exclusion criteria. Initially, 146 patients were considered, but only 142 patients were eligible for the study. Out of the 142 patients, 87 had hip dysplasia and 55 did not.

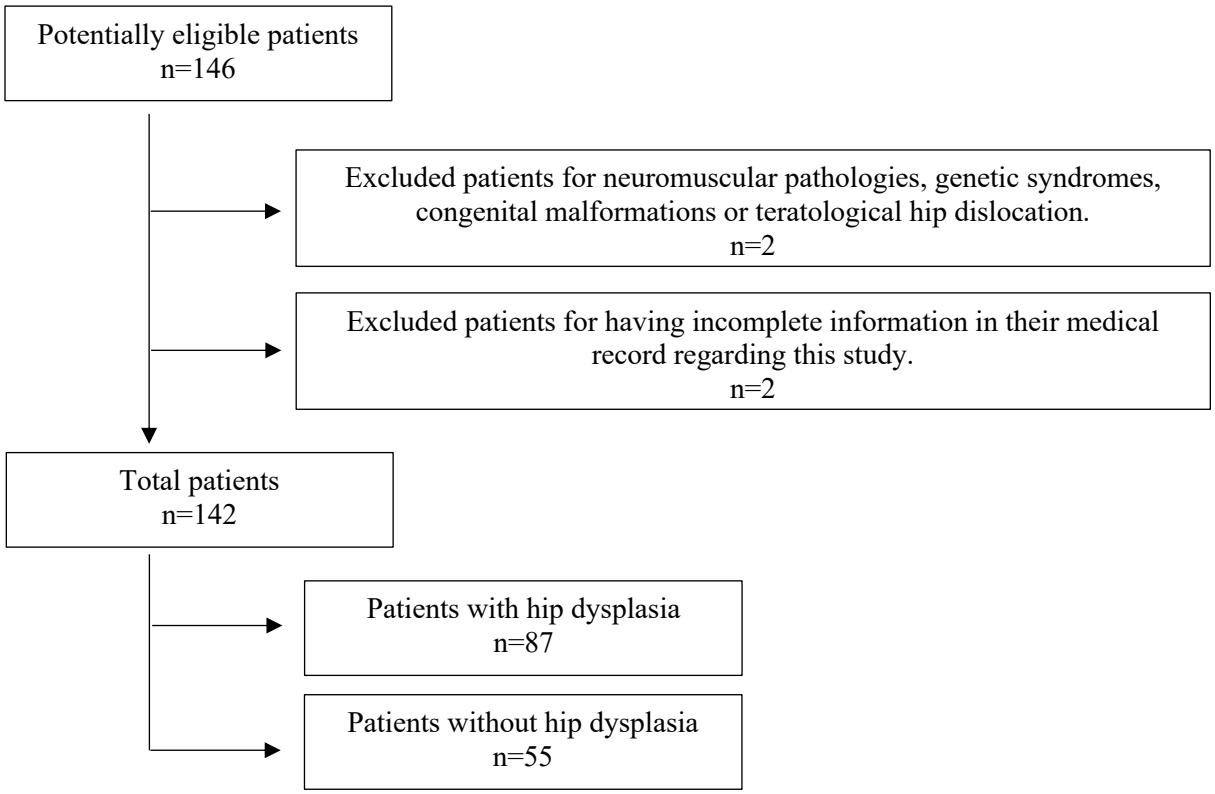

Figure 1. Eligible patients flow diagram

All variables used in this study were qualitative. Table 1 shows the absolute and relative frequencies that describe the population's characteristics. A total of 142 patients were included in this study. The two main variables are hip dysplasia and presenting at least 2 risk factors. A total of 87 patients developed hip dysplasia and 55 did not. This is why 55 patients presented a Type I in the Graf Classification, which corresponds to a normal alpha angle and indicates the absence of hip dysplasia. Out of all patients, 79 neonates had a minimum of 2 risk factors, while 63 neonates had either 1 risk factor or none.

Table 1. Descriptive analysis of variables

Qualitative variables		Total n (%); [CI[1] 95%]
Hip dysplasia[2]	Yes	87 (61.30); [52.73 – 69.32]
	No	55 (38.70); [30.68 – 47.26]
≥ 2 Risk factors	Yes	79 (55.60); [47.06 – 63.96]
	No	63 (44.40) [36.03 – 52.93]
Sex	Male	59 (41.50); [33.30 – 50.10]
	Female	83 (58.50); [49.90 – 66.70]
Firstborn	Yes	90 (63.40); [54.89 – 71.30]
	No	52 (36.60); [28.70 – 45.11]
Family history	Yes	23 (16.20); [10.55 – 23.31]
	No	119 (83.80); [76.69 – 89.45]
Multiple Gestation	Yes	2 (1.40); [0.17 – 5.00]
	No	140 (98.60); [95.01 – 99.83]
Fetal presentation	Cephalic	116 (81.70); [74.33 – 87.68]
	Breech	26 (18.30); [12.32 – 25.67]
Oligohydramnios	Yes	6 (4.20); [1.56 – 8.97]
	No	136 (95.80); [91.03 – 98.43]
Lower extremities deformities	Yes	4 (2.80); [0.77 – 7.06]
	No	138 (97.20); [92.94 – 99.23]
Congenital torticollis	Yes	7 (4.90); [2.01 – 9.89]
	No	135 (95.10); [90.11 – 98.00]
Gestational age	Preterm delivery	20 (14.10); [8.82 – 20.91]
	Term delivery	122 (85.90); [79.08 – 91.18]
Type of birth	Vaginal birth	99 (69.70); [61.45 – 77.14]
	Cesarean section	43 (30.30); [22.85 – 38.55]
Type of hip dysplasia (Graf Classification	Type I	55 (38.70); [30.68 – 47.26]
	Type II	85 (59.90); [51.31 – 67.99]
	Type III/IV	2 (1.40) [0.17 – 5.00]

[1]CI: confidence interval
[2]hip dysplasia: abnormal physical examination with the Ortolani and Barlow maneuvers and/or a Graf angle <60 degrees.

6.2. Main objective

To answer the main objective, Table 2 shows the relationship between having at least 2 risk factors and developing hip dysplasia. A total of 142 patients were included. Among patients with hip dysplasia, 66.70% presented at least 2 risk factors, whereas 33.30% presented none or 1 risk factor. Overall, 40.80% of patients had at least 2 risk factors and developed hip dysplasia, while 14.80% had at least 2 risk factors without developing the condition. Additionally, 20.40% of patients had fewer than 2 risk factors and developed hip dysplasia, while 23.90% had fewer than 2 risk factors and did not develop the condition. Statistically significant differences were observed according to the number of risk factors ($p<0.001$). The odds ratio (OR) was 3.24.

Table 2. Association between presenting 2 or more risk factors and developing hip dysplasia

Variables	Total	With hip dysplasia[1] n (%)	Without hip dysplasia n (%)	Confidence interval (Odds Ratio)	$X^{2(2)}$; p-value
≥ 2 risk factors	79	58 (66.70)	21 (38.20)	1.60 – 6.54 (3.24)	$X^2(1)=11.10$; p<0.001
< 2 risk factors	63	29 (33.30)	34 (61.80)		
[1]hip dysplasia: abnormal physical examination with the Ortolani and Barlow maneuvers and/or a Graf angle <60 degrees. [2]statistical test used: Chi-Square Test.					

6.3. First secondary objective

To determine if known risk factors from literature are risk factors for the sample population of this study, Table 3 shows the population's characteristics with known and yet to assess risk factors. All patients were included for this analysis. From the risk factors listed below, only family history, breech presentation, firstborn status and term delivery proved to be statistically significant since all p-values were <0.05. Notably, family history, breech presentation and firstborn presented an OR>1, whereas term delivery presented an OR<1.

Table 3. Assessment of risk factors in the sample population.

Variables	Total	With hip dysplasia n (%)	Without hip dysplasia n (%)	Confidence interval 95% (Odds Ratio)	X^2/Fisher's exact test[3]; p-value
Female sex[1]	83	55 (63.20)	28 (50.90)	0.83 – 3.29 (1.66)	$X^2(1)=2.10$; p=0.147
Male sex	59	32 (36.80)	27 (49.10)		
With family history[1]	23	20 (23.00)	3 (5.50)	1.46 – 18.40 (**5.17**)	**p=0.005**
Without family history	119	67 (77.00)	52 (94.50)		
Multiple gestation[1]	2	2 (2.30)	0 (0.00)	0.15 – 68.90 (3.25)	p=0.522
Single gestation	140	85 (97.70)	55 (100.00)		
Breech presentation[1]	26	22 (25.30)	4 (7.30)	1.40 – 13.30 (**4.32**)	**p=0.007**
Cephalic presentation	116	65 (74.70)	51 (92.70)		
Oligohydramnios[1]	6	6 (6.90)	0 (0.00)	0.48 – 160.00 (8.85)	p=0.082
Adequate amniotic fluid	136	81 (93.10)	55 (100.00)		
With lower extremities deformities[1]	4	4 (4.60)	0 (0.00)	0.32 – 113.00 (5.98)	p=0.158
Without lower extremities deformities	138	83 (95.40)	55 (100.00)		
With congenital torticollis[1]	7	2 (2.30)	5 (9.10)	0.04 – 1.26 (0.23)	p=0.109
Without congenital torticollis	135	85 (97.70)	50 (90.90)		
Firstborn[1]	90	64 (73.60)	26 (47.30)	1.52 – 6.33 (**3.10**)	$X^2(1)=10.00$; **p=0.002**
Not firstborn	52	23 (26.40)	29 (52.70)		

Variables	Total	With hip dysplasia n (%)	Without hip dysplasia n (%)	Confidence interval 95% (Odds Ratio)	X^2/Fisher's exact test[3]; p-value
Term delivery[2]	122	69 (79.30)	53 (96.40)	0.03 – 0.65 (**0.15**)	**p=0.005**
Preterm delivery	20	18 (20.70)	2 (3.60)		
Vaginal birth[2]	99	59 (67.80)	40 (72.70)	0.38 – 1.66 (0.79)	$X^2(1)=0.39$; p=0.535
Cesarean section	43	28 (32.20)	15 (27.30)		

[1]known risk factors to develop hip dysplasia
[2]possible risk factors not confirmed by previous studies
[3]statistical test used: Chi-Square Test (X^2) and Fisher's exact test
Values in bold indicate statistically significant differences ($p<0.05$).

6.4. Second secondary objective

The risk factor distribution of the sample population is shown in Figure 2. A total of 87 patients were included for this analysis since only 87 out of the 142 patients had hip dysplasia. The absolute and relative frequencies of each risk factor are shown in Table 4. The 3 most frequent risk factors were being firstborn (73.30%), female sex (63.20%) and breech presentation (25.30%). The most prevalent risk factor among the patients with hip dysplasia was being firstborn with a total of 64 patients (73.30%). The least frequent risk factors were congenital torticollis and multiple gestation, with a total of 2 patients (2.30%) for each factor.

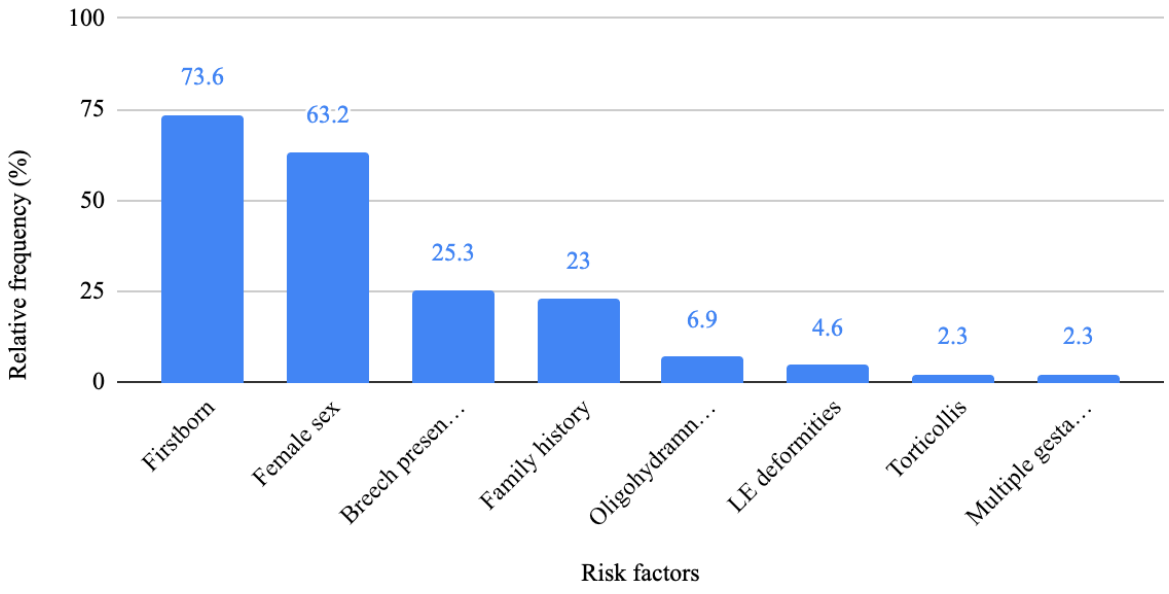

Figure 2. Distribution of risk factors for hip dysplasia in neonates from Quirónsalud Madrid University Hospital between 2021-2023

Table 4. Risk factors frequency on patients with hip dysplasia

Risk factors	Absolute frequency (n)	Relative frequency (%)	Confidence interval [95%]
Firstborn	64	73.60	[63.02 – 82.45]
Female sex	55	63.20	[52.20 – 73.31]
Breech presentation	22	25.30	[16.57 – 35.75]
Family history	20	23.00	[14.64 – 33.25]
Oligohydramnios	6	6.90	[2.57 – 14.41]
Lower extremities deformities	4	4.60	[1.26 – 11.36]
Congenital torticollis	2	2.30	[0.28 – 8.06]
Multiple gestation	2	2.30	[0.28 – 8.06]

6.5. Third secondary objective

To show how many patients had a specific risk factor, Figure 3 illustrates the number of risk factors neonates from the sample population had. All patients (n=142) were included for this analysis. The absolute and relative frequency of the number of risk factors present in the sample population is shown in Table 5. Most patients from the sample population had 2 risk factors (n=49; 34.50%), followed by having 1 risk factor (n=47; 33.10%). The maximum number of risk factors within a single patient was 4 (n=6). None of the patients had 5 or more risk factors.

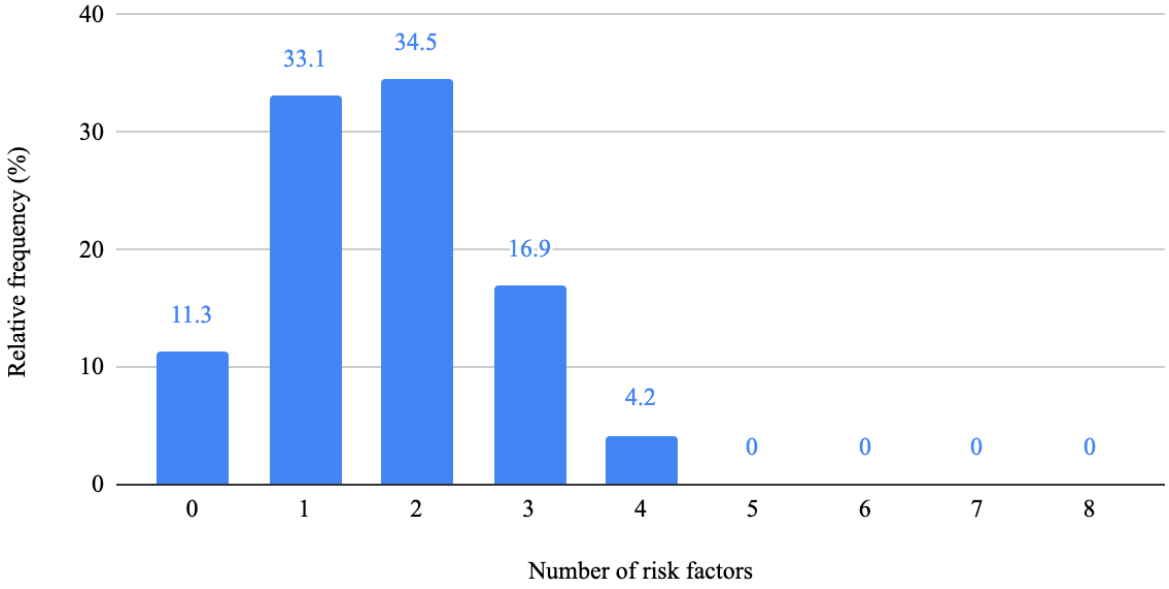

Figure 3. Risk factors quantity for neonates from Quirónsalud Madrid University Hospital between 2021-2023.

Table 5. Number of risk factors present in the sample population

Number of risk factors	Absolute frequency (n)	Relative frequency (%)
0	16	11.30%
1	47	33.10%
2	49	34.50%
3	24	16.90%
4	6	4.20%
5	0	0.00%
6	0	0.00%
7	0	0.00%
8	0	0.00%

Table 6 shows two groups, patients with and without hip dysplasia, that were analyzed to determine which group presented a higher number of risk factors. The distribution was not normal, so for the patients with hip dysplasia the median was 2 risk factors (interquartile range [IQR] 1-3), and for the patients without hip dysplasia the median was 1 risk factor (IQR 0.50-2.00). The Mann-Whitney U test was used to compare patients with and without hip dysplasia. The result was statistically significant in the distribution of risk factors between the two groups ($p<0.001$).

Table 6. Comparison of median number of risk factors in patients with and without hip dysplasia

		Risk factors		
	n	**Median**	**Interquartile range**	**Mann-Whitney U statistic[1]; p-value**
With hip dysplasia	87	2	[1 – 3]	1373; p<0.001
Without hip dysplasia	55	1	[0.50 – 2]	

[1]*statistical test used: Mann-Whitney U, because it followed a non-normal distribution*

6.6. Fourth secondary objective

The association between having at least 2 risk factors and developing a Type II or Type III/IV hip dysplasia is shown in Table 7. Among patients with a Type II hip dysplasia (n=58), 68.20% had at least 2 risk factors. In contrast, 36.80% of patients with at least 2 risk factors had a Type III/IV hip dysplasia or did not develop hip dysplasia (Type I). Most patients in the sample with a minimum of 2 risk factors developed hip dysplasia, specifically a Type II in the Graf Classification (68.20%; $p<0.001$). None had at least 2 risk factors combined with a Type III/IV in the Graf Classification. There were only 2 patients with a Type III/IV. Both had only 1 risk factor in total, representing 1.40% of all patients in the study. This association was not statistically significant ($p=0.195$).

Table 7. Association between number of risk factors and the severity of the hip dysplasia.

Variables	With ≥ 2 Risk factors	Without ≥ 2 Risk factors	Confidence interval (Odds Ratio)	p-value[1]
Total	79	63	-	-
Graf II n (%)	58 (68.20)	27 (31.80)	1.82 – 7.46 (3.68)	$X^2(1)=13.60$; $p<0.001$
Graf I or III/IV n (%)	21 (36.80)	36 (63.20)		
Graf III/IV n (%)	0 (0.00)	2 (100.00)	0.31 – 137.00 (6.46)	0.195
Graf I or II n (%)	79 (56.40)	61 (43.60)		

[1]*the p-value was obtained using a Chi-Square Test or a Fisher's exact test.*

7. Discussion

7.1. Answering the main objective

This study proved that having a minimum of 2 risk factors increases the risk of developing hip dysplasia by 3.24 times (OR=3.24, 95% CI: 1.60-6.54, p<0.001) compared to those who have fewer than 2 risk factors. This means that the hypothesis proposed for this study was confirmed. Patients with at least 2 risk factors were more likely to have hip dysplasia, while patients with fewer than 2 risk factors were more likely to not have dysplasia. Currently, there is no consensus on how many risk factors are needed to develop DDH. However, the results from this study support previous studies in which the threshold was set at 2 risk factors (14,15). A minimum of 2 risk factors may seem insufficient, but they have proven otherwise by being statistically significant in contrast to patients who had only 1 risk factor or none. This result means that physicians can predict which patients are more likely to develop hip dysplasia. These patients need to be closely monitored and treated early if needed. Knowing the risk factors each child presents before birth allows doctors to anticipate the outcome of DDH and be prepared to treat the patient as soon as possible, preventing future complications in adulthood. This outcome should be further studied, since countries have different ways of screening for DDH. In some, ultrasound is only performed on at-risk patients, who may be undertreated if they do not meet all the necessary risk factors (26). Even though DDH screening is performed on all newborns in Spain, the accumulation of risk factors can better predict which patients will probably need additional diagnostic tools such as ultrasound or X-ray. This approach can prevent older children, teenagers or adults from undergoing surgery to correct a condition that could have been detected earlier without significantly affecting hip stabilization.

7.2. Answering the secondary objectives

Other studies argue that if patients present at least one of the three major risk factors (female sex, breech presentation and family history), then the likelihood of developing DDH is higher (3). Known risk factors for DDH from the literature were tested to see if they could be considered risk factors for the sample population of this study. As mentioned before, some risk factors include female sex, breech presentation, positive family history, cesarean section, oligohydramnios, swaddling, firstborn status, and musculoskeletal deformities (27). Not all risk factors were considered for this study, only those registered in the patients' medical records. Only four out of the ten risk factors studied proved to be statistically significant. These factors were family history (OR=5.17; 95% CI: 1.46-18.40; p=0.005), breech presentation (OR=4.32; 95% CI: 1.40-13.30; p=0.007), term delivery (OR=0.15; 95% CI: 0.03-0.65; p=0.005) and firstborn (OR=3.10; 95% CI: 1.52-6.33; p=0.002). Even though these results were statistically significant, only 3 were considered to increase the risk because their Odds Ratio was greater than 1: family history, breech

presentation and being firstborn. On the contrary, term delivery appeared to be a protective factor, since term-delivered neonates were 85% less likely to develop hip dysplasia than those delivered preterm. The lower extremities deformities and congenital torticollis had an OR>1, but these associations did not reach statistical significance. These findings in the sample population partially mirrored the globally accepted risk factors for DDH. This could be due to the small sample size compared to other studies that included thousands of participants. As a result, very few patients in the sample presented risk factors such as oligohydramnios (n=6), lower extremities deformities (n=4) or congenital torticollis (n=7). Other factors that could influence the results are discussed later.

There is no single risk factor considered the most prevalent among DDH patients globally. In this study, however, the most prevalent risk factor was being firstborn, followed by female sex, breech presentation and family history (the last 3 being the major risk factors known from existing literature). 64 patients from the sample population were firstborns, which is why it was the most prevalent risk factor, but the following three risk factors followed the pattern that would be expected in the general population. 73.30% of patients were firstborns with a 95% probability that the true prevalence in the population is between 63.02% and 82.45%.

Additionally, most neonates in this study had 2 risk factors (n=49), followed by 1 risk factor (n=47). Interestingly, the median number of risk factors was 2 for patients with hip dysplasia and 1 for patients without it ($p<0.001$). This finding also supports the hypothesis of this study that patients at higher risk of DDH have 2 or more risk factors. None of the patients in this study had all risk factors evaluated. The maximum number of risk factors within a single patient was 4. This is important because it shows that even with a few risk factors, a person can still develop the condition and must be treated for it. The IQR was 1-3 for patients with hip dysplasia and 0.50-2.00 for those without. This again supports the statement that a minimum of 2 risk factors increases the chance of developing DDH.

Moreover, there was no association between having a greater number of risk factors and developing a Type III or IV in the Graf Classification. According to previous studies, it is not only the quantity that counts but also which specific risk factors are present. For example, family history and swaddling are two of the main causes of a more severe DDH type (15). Swaddling was not one of the risk factors included in this study, but further studies can be conducted to see the influence of each risk factor on developing hip dysplasia. Even though having at least 2 risk factors and developing a Type III/IV DDH did not prove to be statistically significant, what proved to be significant was developing a Type II. This is important because it demonstrates that having a greater number of risk factors does not necessarily imply developing a more

severe condition, but it shows that they are enough to develop DDH even in milder cases. Doctors should not wait to see a severe case of hip dysplasia. They should assess the number of risk factors a newborn presents and be ready to treat them as soon as possible.

7.3. Limitations, potential biases and future research

The major limitation of this study was the sample size. The sample population may have been too small to be able to demonstrate statistical differences for some of the objectives proposed. Even though all patients from the Trauma and Orthopedic Surgery department were selected (excluding the 4 patients who were unfit for the study), it may still not be enough to represent the whole population. The sample size calculation indicated that 63 patients were needed to accept statistically significant differences, with 142 patients ultimately included. This criterion was clearly met. However, if this study were to be repeated in the future, increasing the sample size could improve the quality and reliability of the results, allowing them to be extrapolated to the population. Increasing the sample size would decrease the random error. Another option would be to extend the time interval. For instance, instead of 2021-2023, the study could cover 2011-2021 to ensure that a larger number of patients are included.

Furthermore, this study could be improved by including neonate patients from the Pediatric department or neonates treated at the hospital during the same period. Not restricting patient selection by medical department would not only allow for a greater sample size but would also better reflect the true population. The current study had 87 patients with hip dysplasia out of 142, but given the incidence of DDH, which is 1-10 cases per 1,000 births (1), results would be more representative if the study population without hip dysplasia was larger than the affected one.

One of this study's strengths was the strict exclusion criteria, making sure patients with neuromuscular pathologies, genetic syndromes, congenital malformations or teratological hip dislocation would not bias the results. More importantly, the main strength of this study lies in the relevance of prevention and its practical utility for physicians. The findings prove that there is a clear threshold of 2 risk factors, helping physicians to prioritize which neonates require more intensive monitoring and an urgent ultrasound.

This study was focused on how the quantity of risk factors that a person has may influence the probability of them developing hip dysplasia, but it would be interesting to go deeper into this and study how these risk factors may affect the possibility of success or failure of treatment. It is already known that early detection and treatment are key to preventing future hip complications and a negative impact on quality of life.

However, not all risk factors have the same weight. Some studies have already been conducted to predict the failure of the Pavlik harness (10). It would be useful to investigate whether these risk factors affect the way infants are treated in Spain, since this is the population studied in this research. Furthermore, this study was conducted in a single hospital, so it would be relevant to replicate this study in multiple hospitals throughout Spain. It would be worthwhile to compare how other hospitals screen newborns for DDH, including which imaging tools they use, how long it takes to diagnose and treat a patient, and how long treatment lasts. It would also be relevant to assess whether risk factors are taken into consideration when deciding which patients require close follow-up, or whether the screening algorithm is followed without acknowledging the number of risk factors.

Beyond these limitations, this study intends to raise awareness of the importance of risk factors because they not only predict the risk a patient has, but also how high that risk is. This study proved that the difference between having 1 risk factor and 2 risk factors already has a great impact on the development of DDH in a child. Small as this difference may seem, just 1 additional risk factor can make a meaningful difference. In addition, this study encourages physicians to make thorough medical records, specifically asking about family history and other risk factors that may predispose a patient to hip dysplasia. Some parents are unaware that certain factors may affect whether their child develops the condition, so physicians have an obligation to inform parents about influencing factors and to ask specifically about them.

This study aligned with the United Nations Sustainable Development Goal of "good health and well-being". It provided relevant information on risk factors of developmental dysplasia of the hip, with results from a sample population that demonstrated the importance of the number of risk factors in a child's life. These risk factors, mostly non-modifiable, play an important role in deciding early treatment or surgical interventions that could eventually improve the quality of life and even prevent a greater economic cost if DDH goes undetected during childhood. If not detected early, this would entail a greater use of medical resources such as pre-surgical imaging, more surgical interventions and subsequent postoperative physical rehabilitation. So, if the way this condition is detected and treated is improved, then the good health and well-being of the population will increase as well.

To conclude, medicine is not only about knowing when and how to treat patients. Physicians also have the responsibility of anticipating when a patient is at risk, using the correct diagnostic tools, and promoting early interventions to minimize undetected DDH cases, reduce treatment failure and ensure the best possible quality of life.

8. Conclusions

- This study confirmed that having at least 2 risk factors increases the risk of developing hip dysplasia (OR: 3.24, 95% CI: 1.60 – 6.54), so these neonates should be assessed early to ensure early treatment and a better prognosis.
- Not all known risk factors for DDH proved significant in the sample. Only family history, breech presentation and firstborn status were associated with an increased risk, whereas term delivery emerged as a protective factor.
- The most prevalent risk factor among the patients was being firstborn, followed by the female sex and breech presentation. The least frequent risk factors were congenital torticollis and multiple gestation.
- Most patients from the sample population had 2 risk factors (34.50%). The maximum number of risk factors within a single patient with hip dysplasia was 4 (4.20%), while 11.30% of patients did not present any risk factors.
- Patients with 2 or more risk factors did not appear more likely to have a more severe form of hip dysplasia (Type III or IV), but did appear to be more likely to develop a Type II.

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10. Annexes

10.1. Declaración sobre el uso de ChatGPT y herramientas de IA

Declaración sobre el uso de ChatGPT y herramientas de IA

Yo, Ana Paula Espinosa Romero, estudiante del Grado en medicina, y autor/a del Trabajo Fin de Grado titulado: "A STUDY OF RISK FACTORS FOR DEVELOPING HIP DYSPLASIA IN NEONATES FROM THE TRAUMA AND ORTHOPEDIC SURGERY DEPARTMENT AT QUIRÓNSALUD MADRID UNIVERSITY HOSPITAL BETWEEN 2021-2023", declaro que:

1. Uso no permitido:

- No he utilizado ChatGPT ni otras herramientas de inteligencia artificial para realizar análisis estadísticos, procesar datos, ni para elaborar de forma automática el contenido principal del Protocolo.
- El diseño metodológico, la recogida y análisis de los datos, así como la redacción científica del trabajo, son fruto de mi propio esfuerzo académico.

2. Uso permitido:

- Reconozco que he podido emplear ChatGPT y/o herramientas similares exclusivamente como apoyo en:
  - Mejora de la redacción y claridad del texto.
  - Resolución de dudas conceptuales o terminológicas.

3. Responsabilidad académica:

- Soy plenamente responsable de todo el contenido de este Trabajo Fin de Grado.
- Garantizo que las ideas, aquí presentados reflejan mi propio trabajo, y que cualquier recurso bibliográfico utilizado ha sido adecuadamente citado siguiendo las normas de la universidad.

En Madrid, a 4 de mayo de 2026.

Firma del/de la estudiante: Ana Paula Espinosa Romero

10.2. Approval resolution from CEIm or Commission

TFG048-25_HUQM

INFORME DEL COMITÉ DE ETICA DE LA INVESTIGACION

Título del proyecto: "Estudio de los factores de riesgo para desarrollar displasia de cadera en neonatos del hospital quirónsalud madrid entre los años 2021-2023".
Documentos con versiones:
PROTOCOLO Versión 1.0, 08 de Julio de 2025
Investigador Principal: IGNACIO MERINO GUTIERREZ; JUAN DE MATA DONADO CAMPOS;
Servicio: Traumatología
Centro: Hospital Universitario Quirónsalud Madrid
Estudiante:
- ANA PAULA ESPINOSA ROMERO. Universidad Europea de Madrid.

Este Trabajo de Fin de Grado ha sido evaluado, por procedimiento abreviado, por el Comité de Etica de la Investigación de la Fundación Jiménez Díaz, y se considera que reúne las normas éticas estándar para la realización de este tipo de estudios.

Lo que firma en Madrid a 25 de agosto de 2025

Dr. Javier Bécares Martínez
Presidente CEImFJD

Nota: La obtención de la información clínica necesaria para llevar a cabo el TFG se llevará a cabo de acuerdo al procedimiento establecido en cada centro y departamento de Docencia, siempre de acuerdo a la normativa aplicable en materia de protección de datos.

10.3. Variables table

Table A 1. Variables table

Main variables	Explanation/Definition	Type	Units/Categories
Hip dysplasia	Having a hip dysplasia diagnosis. (outcome variable)	Qualitative	YES / NO
Number of risk factors	Presenting: **≥ 2 risk factors** (grouping variable)	Qualitative	YES / NO
Secondary variables (Risk Factors)	**Explanation/Definition**	**Type**	**Units/Categories**
Sex	N/A	Qualitative	Male / Female
Firstborn	First child born alive to a mother.	Qualitative	YES / NO
Family history	Family history of hip dysplasia.	Qualitative	YES / NO
Multiple gestation	Two or more fetuses coexist within the uterus.	Qualitative	YES / NO
Fetal presentation	Part of the fetus positioned in the birth canal.	Qualitative	Cephalic / Breech
Oligohydramnios	Abnormally low volume of amniotic fluid. (amniotic fluid index (AFI) ≤ 5 cm or single deepest vertical pocket (SDVP) < 2 cm).	Qualitative	YES / NO
Lower extremities deformities	Abnormal alignment of the lower limbs.	Qualitative	YES / NO
Congenital torticollis	Abnormal head posture due to unilateral involvement of the sternocleidomastoid muscle.	Qualitative	YES / NO
Neuromuscular pathology	Damage to any component of the motor unit.	Qualitative	YES / NO
Other secondary variables	**Explanation/Definition**	**Type**	**Units/Categories**
Gestational age	Completed weeks of intrauterine life. **Preterm:** GE <37 weeks **Term:** GE 37-41 weeks	Qualitative	Preterm delivery / Term delivery
Type of birth	N/A	Qualitative	Vaginal birth / Cesarean section

Other secondary variables	Explanation/Definition	Type	Units/Categories
Alpha angle	Angle between the acetabular roof line and the iliac bone. Used for the Graf Classification system.	Quantitative	1, 2, 3… degrees
Type of hip dysplasia (Graf Classification)	Ultrasound classification that classifies hips according to the femoral head position and acetabular development.	Qualitative	Type I, II, III, IV

10.4. Abbreviations

CI: confidence interval

DDH: Developmental dysplasia of the hip

IQR: interquartile range

OR: Odds Ratio