CHAPTER **51**

THE NEWBORN MUSCULOSKELETAL EXAMINATION: Assessment of Lower Extremity Range of Motion

Mitzi L. Williams, DPM
Donald R. Green, DPM
Mario Eyzaguirre, MD
Dana Tanikawa, DPM

INTRODUCTION

The medical history of a pediatric patient is paramount. Still, the majority of children, especially newborns, present with a past void of pathology or detriment. This places great emphasis on a standard, methodic, accurate pediatric physical exam. Often, a physician's external findings are a manifestation of a systemic etiology. Conditions such as myelomeningocele, Duchene's muscular dystrophy, and Charcot-Marie-Tooth disease present with musculoskeletal findings. Conversely, clubfoot and the cavus foot type may present with neurological disease. Hence, a comprehensive pediatric physical exam should include evaluation of the dermatologic, vascular, neurologic, and musculoskeletal systems.

Often the external musculoskeletal findings such as symmetry, muscle bulk, rigidity, and gross deformities precede future developmental delay and neuromuscular disease. These early findings can only assist the pediatric patient with an expedited treatment plan. From this, physicians should value the necessity in performing thorough and accurate musculoskeletal exams. As great importance is placed on diagnosis of developmental hip dysplasia, little research exists on the normal range of motion with respect to the foot and ankle.

The aim of this study was to determine normal range of motion of the newborn ankle joint, subtalar joint, and metatarsophalangeal joint. Understanding normal motion, strength, and physiologic flexion will assist with the diagnosis of pathology. Also, early detection of foot problems in newborns allows timely corrective treatment, if required. This study is also designed to evaluate metatarsus adductus and malleolar position in the newborn patient. These findings should serve as a child's baseline and may foreshadow future biomechanical problems. Both position of the osseous structures and joint range of motion should serve as a valuable component to a comprehensive physical exam.

PATIENTS AND METHODS

This prospective study included 100 consecutive newborns (200 feet, 42 males, 58 females) examined at Scripps Mercy Hospital. Examinations were conducted from January 2007 through May 2007. Newborns were noted to all have an Apgar score >7 (average 9) and a gestation period >37 weeks (average 39 weeks). Birth route, maternal history, patient ethnicity, and newborn medical history were documented (Tables 1, 2).

Table 1

DELIVERY

Route of Delivery	No.
Normal Vaginal Delivery (NVD)	69
Caesarean	31

Table 2

ETHNICITY

Ethnicity	No.
Hispanic	61
Caucasian	34
Asian	4
African-American	1

A complete lower extremity musculoskeletal examination was performed with pertinent dermatologic and neurologic findings documented. Each patient was examined by the same physician, and the following were evaluated based on range of motion in degrees: ankle joint, subtalar joint, and metatarsophalangeal joint. Malleolar position and metatarsus adductus was also determined. Although emphasis was placed on the foot and ankle, the examiner evaluated each newborn for developmental hip dysplasia as well. Systematically, proximal joints were evaluated prior to distal joints.

Hip Exam

Although many frank dislocations can be detected at birth, hip dysplasia can also be a progressive disorder. As maturity occurs during the first year of life, the acetabulum may fail to develop. A dysplastic acetabulum is one that is not deep enough to contain the femoral head. Over time, the femur gradually displaces laterally. This places emphasis on the importance of serial hip exams performed throughout the first year of life. Each newborn in this study was examined for a dislocatable or dislocated hip. The Ortolani maneuver screens for presence of dislocation while Barlow's maneuver attempts to displace the femoral head from within an acetabulum. These maneuvers were performed on all 100 newborns.

Ortolani's maneuver was performed with the newborn in a supine position. The pelvis was stabilized with one hand. With the opposite hand, the newborn's knee and hip were flexed. The hip was gently abducted individually. A dislocated hip may produce a "clunk" as it relocates into the acetabulum. Barlow's maneuver was performed with a supine newborn. The hip was flexed to 45-60 degrees and held in slight abduction. Gentle pressure was then applied posteriorly and laterally. A positive sign is a palpable femoral head leaving the acetabulum (Figures 1, 2). The remainder of the hip examination included hip range of motion and height comparison of the femur at the knees: the Galleazzi test (Figure 3).

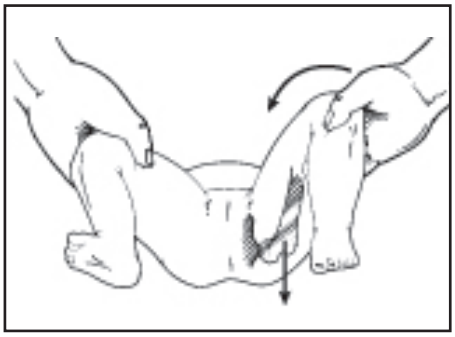

Figure 1. Ortolani's Maneuver.

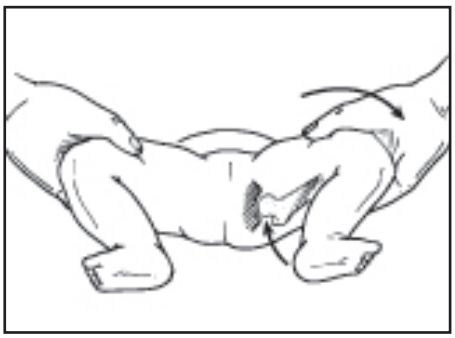

Figure 2. Barlow's Maneuver.

Foot and Ankle Examination

Foot deformities are common in the newborn. Deformities include clubfoot, metatarsus adductus, vertical talus, calcaneovalgus, polydactyly, or syndactyly (Figure 4). The physical examination is key since radiographs are of limited use. Ossification centers may not be present or viewable on the radiograph of a newborn (Table 3). Still, prognosis is good if identification and treatment are early.

Figure 3. Galeazzi Test.

Figure 4. Ponseti casting for treatment of idiopathic unilateral clubfoot. Early manipulation via the Ponseti method is associated with a good prognosis.

Table 3

OSSIFICATION PATTERN

Osseous Structure	Appearance Age
Metatarsals	3 months fetal
Phalanges	3 months fetal
Calcaneus	3-4 months fetal
Talus	6 months fetal
Cuboid	9 months fetal
3rd Cunieform	6 months in age
2nd Cunieform	1 year in age
1st Cunieform	1½ years in age
Navicular	2½- 5 years in age

Figure 5. Ankle dorsiflexion.

Figure 6. Malleolar position.

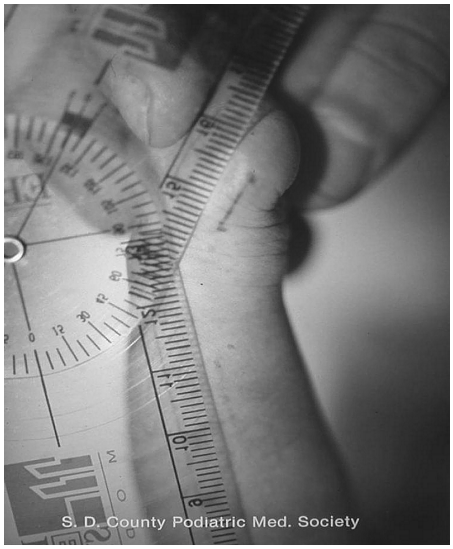

Figure 7. Subtalar joint range of motion.

Ankle Examination

The general appearance, ease of motion, and position of the ankle were documented. The foot at rest should be neither excessively dorsiflexed or plantarflexed. Ankle joint range of motion was evaluated with the knee extended under a newborn's normal physiologic flexion. The subtalar joint was placed in neutral position with the midtarsal joint maximally pronated. Then, ankle dorsiflexion was measured via a tractograph aligned to the lateral bisection of the lower leg with respect to the lateral border of the foot. Dorsiflexion and plantarflexion were recorded for each ankle joint (Figure 5).

Malleolar Position

The patient was placed in a supine position with the knee extended in the frontal plane. Malleolar position was then determined with one tractograph arm bisecting both medial and lateral malleoli while the second arm bisected the plantar midfoot transversely. Tibial torsion was not documented in this study, yet is typically calculated by adding 5 degrees to malleolar position (Figure 6).

Subtalar Joint Examination

The patient remained in the supine position with the knee extended. Vertically, the inversion and eversion of the subtalar joint in the frontal plane was measured. One arm of the tractograph remained parallel to the bisection of the posterior lower leg while the second arm was aligned parallel to the posterior bisection of the heel (Figure 7).

Figure 8. First metatarsophalangeal joint range of motion.

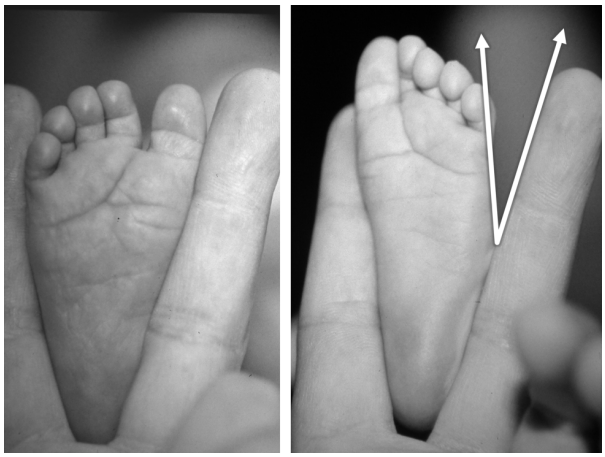

Figure 9. Forefoot to rearfoot lateral column measurement.

Metatarsophalangeal Joint Examination

The examiner progressed distally to assess ease and degrees of first metatarsophalangeal joint range of motion. One arm of the tractograph was placed parallel to the medial aspect of the first metatarsal. The center of the device was placed at the joint itself. The second arm was positioned parallel to the medial longitudinal axis of the hallux. Degrees of dorsiflexion and plantarflexion were recorded (Figure 8).

Metatarsus Adductus

One of the goals of this study was to determine an accurate, reproducible maneuver for both measuring and evaluating metatarsus adductus. Bleck's method as compared with measuring the lateral forefoot to rearfoot relationship was utilized.

In this study the heel was placed into the space created by holding one's index finger and thumb at 90 degrees to one another. The examiner's straight index finger was compared with the lateral border of the foot. A rectus foot would render a straight lateral border while metatarsus adductus would produce a curvature. Metatarsus adductus was then measured via tractograph (Figure 9).

Bleck's method was performed second. A tractograph was aligned to the plantar longitudinal aspect of the heel. The distal aspect of the tractograph was recorded with respect to bisection between metatarsals (Figure 10).

Physical Findings

The newborn was further evaluated for any abnormal physical exam findings that may assist with medical diagnoses. Dermatologic and neurologic pertinent findings were recorded. General tonicity and symmetry was observed.

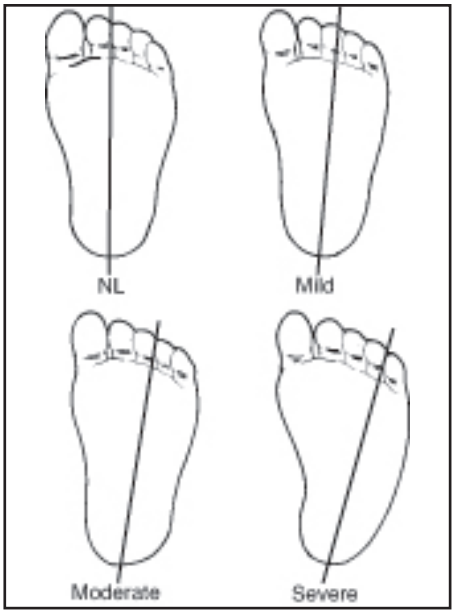

Figure 10. Bleck's method.

RESULTS

Total range of motion was determined for the ankle, subtalar joint, and first metatarsophalangeal joint. Furthermore, normal malleolar position and metatarsus adductus were determined. Motion per each joint was noted to be smooth and free of crepitus. No patients had a dislocated or dislocatable hip on examination. One evaluator took all measurements for this study and documented end range of motion

The average malleolar position was determined to be

4 degrees external (range 2-5 degrees external). Total ankle range of motion was found to be 105 degrees with dorsiflexion and plantarflexion being 64 degrees (range 60-72 degrees) and 41 degrees (range 40-45°) respectively. Subtalar joint inversion was found to be 22° (range 22-24 degrees) while eversion was 15 degrees (range 10-18). Total subtalar joint range of motion equaled 37 degrees. Total first metatarsophalageal joint range of motion was determined to be 181 degrees. First metatarsophalangeal joint dorsiflexion was 91 degrees (range 86-91 degrees) with plantarflexion noted to be 90 degrees (range 90-92 degrees) (Tables 4-6).

As for metatarsus adductus, an increase in the angle produced by the lateral aspect of the forefoot to the rearfoot correlated to an increase in the bisection per Bleck's method. An increase in inversion of the forefoot to the rearfoot correlated to lateral displacement of Bleck's line when measuring metatarsus adductus. When evaluating Bleck's method, 97 newborns showed bisection between the second and third metatarsals. Bisection of the third and fourth metatarsal was recorded for the remaining 3 patients. The three patients that had a bisection between the third and foiurth metatarsals also had between 8-10 degrees of inversion per the lateral border test. An average lateral border measurement showed the forefoot to be 2 inverted (range 0-10) to the rearfoot.

DISCUSSION

This study focused on the newborn lower extremity musculoskeletal examination. Many newborns present with a benign past medical history including one void of neuromuscular disease. Emphasis should be placed on understanding the normal examination and values to appreciate an abnormal finding. To date little research is published on normal range of motion of the newborn. A normal range of motion for the ankle, subtalar, and metatarsophalangeal joints was determined in this study. Malleolar position and metatarsus adductus was also determined from 100 patients (200 feet).

A single evaluator was used in this study to reduce subjectivity in the measurements. The authors stress the importance of being consistent and measuring end range of motion to also reduce biomechanical subjectivity. Other medical staff are important to assist with soothing the infant. It can be quite difficult to accurately measure with an agitated infant. The examination should not cause pain.

On examination, each joint examined was noted to move with ease. No crepitus was detected among joints. No severe pathology was detected yet this is likely secondary to the healthy newborn population tested. It is likely that infants with neuromuscular disease and congenital syndromes would have values that vary from this study. Still an accurate newborn musculoskeletal examination can assist with early detection and treatment.

This study has produced normal values for range of motion of lower extremity joints that may be used as a guide when examining infants. Infant range of motion is one that changes as the infant progresses to adulthood. Life experiences, including trauma, as well as biomechanic influence will predispose the individual to pathology. A baseline of normal values as an infant and child can assist the physician with a more adequate history and timeline of events. The history and physical of any patient is paramount. An accurate baseline musculoskeletal exam is helpful component.

Table 4

ACTUAL MEASUREMENTS

Joint location	ROM (degrees)	ROM (degrees)
Ankle	Dorsiflexion: 63.575	Plantarflexion: 41.174
STJ	Inversion: 22.24	Eversion: 14.77
1st MPJ	Dorsiflexion: 90.6	Plantarflexion: 90.1

Table 5

MALLEOLAR POSITION

Actual measurement	Range (degrees)
3.51 external	2-5 external

Table 6

METATARSUS ADDUCTUS

Bleck's Method	97 patients: between 2nd and 3rd metatarsals	3 patients: between 3rd and 4th metatarsals
Lateral Border FF:RF	Actual measurement: 1.875 inverted	Range: 0-10 inverte

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