Investigation of the Relationship Between Femoral Neck-Shaft Angle, Age, and Sex in Developing Children

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INTRODUCTION: Femoral neck-shaft angle (NSA) is commonly used to diagnose hip pathologies and guide treatment decisions for conditions such as coxa vara, developmental dysplasia of the hip, and proximal femoral fractures. NSA in developing children changes with age, with a gradual increase during the first year of life followed by a gradual decrease to adult values after walking commences. Previous studies utilized x-rays of different children, rather than using serial radiographs of the same children. Available reference values do not separate out sex and do not explore how variable the measurement can be in younger children. Using consecutive serial images, this study aims to clarify the year-to-year changes in NSA and delineate how variable the measurements can be in younger children.

METHODS: Subjects between the ages of 3 and 18 years were selected from the Bolton-Brush Collection, a longitudinal radiographic series of healthy children. Inclusion criteria were having serial anteroposterior left hip radiographs each being taken within 3 months of the child's birthday. ImageJ was used to measure the femoral neck-shaft angle, the angle created between the femoral long axis and the neck-shaft axis. Reliability was validated by two authors independently measuring 20 images for inter-rater reliability. One author repeated measurements after one month for intra-rater reliability and completed all measurements.

RESULTS: 214 patients were included, and 876 radiographs were measured. Multiple linear regression found a negative association between NSA and age (unstandardized β = -0.699, 95% CI -0.836 to -0.563, p=<0.001) (Figures 1-2). Additionally, decreased absolute year to year change in NSA correlated with age (unstandardized β= -0.177, 95% CI -0.255 to -0.099, p<0.001). No correlation between sex and NSA was observed (unstandardized β= 0.701, 95% CI –0.315 to 0.1.717, p=0.176).

DISCUSSION: Age demonstrated a significant negative correlation with NSA, aligning with prior research. An age-related decline in variability was observed in NSA, potentially reflecting reduced variability in imaging positioning with age. Conversely, no significant correlation was found between sex and NSA, or between mean year-to-year change in NSA and increasing age. These findings underscore the age-specific considerations in interpreting NSA, the potential for improving imaging consistency, and offer insights into the influence of age and sex on musculoskeletal assessments, contributing significantly to clinical practice and imaging protocols. Limitations include the inability to control for anteversion or retroversion of the patients during imaging. To further corroborate the trends observed with this collection of radiographs, measurements of three dimensional imaging via CT or MRI could be pursued to correction for femoral version.

SIGNIFICANCE/CLINICAL RELEVANCE: These findings underscore the age-specific considerations in interpreting NSA, and the expected variability in measurements particularly in younger children.

REFERENCES: [1] Boese. In Skeletal Radiology. 2016. [2] Zaghloul. Biomedical Journal of Scientific & Technical Research. 2018. [3] Boese. BioMed Research International. 2016. [4] Gilligan. Journal of Anatomy. 2013. [5] Robert. Standards in Pediatric Orthopaedics: Tables, Charts, and Graphs Illustrating Growth. 1986.

IMAGES AND TABLES:

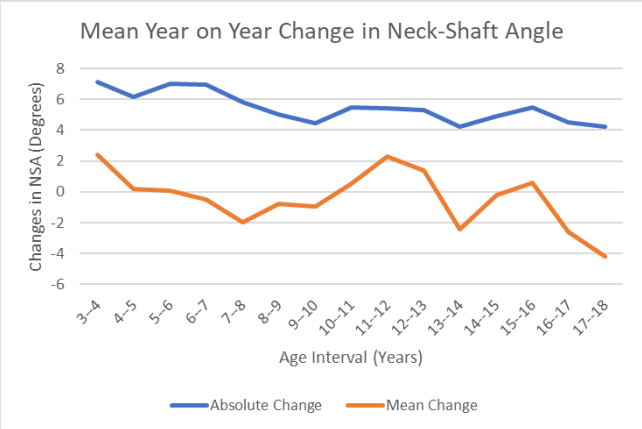

Figure 1: Increased age was correlated with absolute year by year change in NSA (p<0.001). All data points represent having two consecutive annual images on the same child.

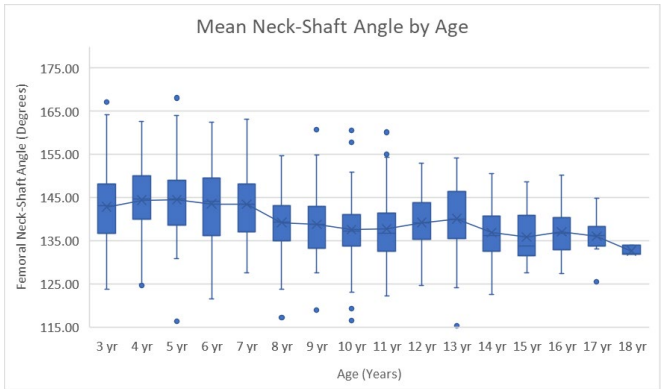

Figure 2: Increase in patient age was correlated with a decrease in mean NSA (p<0.001).