Femoral anteversion related to side differences in hip rotation

Passive rotation in 1,140 children aged 8–9 years

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We assessed whether the range of passive hip motion is reliable for predicting abnormal femoral anteversion. We measured the passive medial and lateral rotation in extension in both hips of 1,140 children between 8 and 9 years of age. The children were divided into 3 groups: group 1: difference between lateral and medial rotation less than 10°; group 2: medial rotation more than 10° greater than the lateral; group 3: lateral rotation more than 10° greater than the medial. Group 1 comprised 90% of the children, whereas 8% belonged to group 2 and 2% to group 3.

The angle of femoral neck anteversion was measured in 57 children from the first group, in 67 from the second and in 24 children from the third group, using biplane radiography. The mean anteversion angles in the 3 groups were 24°, 36° and 14°, respectively. To predict an abnormally high anteversion angle (above mean +2SD), the difference between medial and lateral rotation must be 45° or more, whereas an abnormally low anteversion angle (lower than mean −2SD) could be predicted when the lateral rotation was at least 50° higher than the medial rotation.

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The femoral anteversion angle decreases with age during childhood and adolescence (Fabry et al. 1973). Regression of anteversion is important for normal development of walking (Svenningsen et al. 1989). Abnormal femoral anteversion can be associated with many clinical problems, ranging from harmless intoeing gait to arthrosis of the hip (Insall et al. 1976, Halpern et al. 1979, Turner and Smillie 1981, Terjesen et al. 1982).

At present, there is no consensus on the criteria for clinical diagnosis of abnormal femoral anteversion. Many authors believe that markedly increased medial rotation of the hip in extension, with corresponding limitation of lateral rotation, implies excessive anteversion (Fabry et al. 1973, McEwen 1976, Kumar and McEwen 1982, Kling and Hensinger 1983). We assessed the significance of differences between medial and lateral rotation in predicting the femoral anteversion angle.

Children and methods

The study group comprised 1,140 children aged 8–9 years (589 girls), with no previous hip disease. The examinations were performed in elementary schools. The measurement of the passive rotation in both hips was done by one examiner using the following procedure: The child lay prone with hips extended and knees flexed to a right angle. The pelvis was stabilized by the examiner's hand to prevent rotation of the pelvis. The examiner measured the passive motion, with no power to increase the range of motion. The rotation was measured with a goniometer having long arms. Angles were measured to the nearest 5°.

On the basis of the differences between medial and lateral rotations, the children were divided into 3 groups:

Group 1. The difference between lateral and medial rotation was less than or equal to 10°. In this group, we expected normal values of femoral neck anteversion and this was considered the control group.

Group 2. The medial rotation was more than 10° greater than the lateral.

Group 3. The lateral rotation was more than 10° greater than the medial.

The difference between medial and lateral rotation values of more than 10° was taken as a sign of possible abnormal femoral anteversion.

In 57 children from the first group, 67 from the sec-

Table 1. The values for medial rotation (MR) and lateral rotation (LR) and the differences between passive rotational movements (DRM) for all groups (degrees, mean SD)

	n	MR	LR	DRM
Group 1	1,030	44 4	43 4.8	3.9 2.6
Group 2	86	65 10.5	30 7.9	36 11
Group 3	24	23 11.8	58 13	36 15
Total	1,140	44 6.8	42 7.1	6.8 7.6

ond and 24 children from the third group, the femoral anteversion angles were measured by radiography. We used the biplane technique described by Ryder and Crane (1953), which requires 2 radiographs. The real angles of inclination and the femoral anteversion angle were determined using a trigonometric formula (Weber 1961).

Statistical analysis was carried out, using the Student's t-test, the chi-square test and the least squares procedure. Differences were regarded as significant at $p < 0.05$.

Table 3. Femoral anteversion angles (FAA; degrees, mean SD) according to the magnitude of the difference in hip rotation (DRM; degrees)

DRM	No. of pts / hips	FAA
70	2 / 3	57 0
60	4 / 4	48 2.7
50	6 / 9	46 5
45	3 / 6	43 2.1
40	5 / 8	38 4.7
35	10 / 19	33 5.7
30	13 / 23	34 4.9
25	12 / 22	34 4.9
20	11 / 19	30 2.4
15	11 / 21	31 4.2
10	10 / 20	26 0.7
5	14 / 28	25 4.5
0	14 / 27	24 4.8
–5	10 / 20	24 4.5
–10	9 / 17	21 0.8
–15	5 / 10	23 5.6
–20	3 / 6	22 3.8
–25	4 / 7	19 3.8
–30	3 / 5	13 1.3
–35	3 / 5	13 0.5
–40	1 / 2	13 0
–45	4 / 6	14 2.5
–50	2 / 2	8.5 0.7
–60	2 / 3	7.5 1.7
–70	1 / 2	0 0

Results

1,030 of the 1,140 examined children (90%) belonged to group 1. Of the 110 children with more than 10° difference between medial and lateral rotation, 86 subjects had higher values of medial rotation and 24 children had higher values of lateral rotation. Group 1 comprised 507 boys and 523 girls. Group 2 comprised 86 children (7.5%), 30 boys and 56 girls ($p = 0.008$). The third group comprised 24 children (2.1%), 14 boys and 10 girls, with no gender differences. There were no significant differences between the left and right hips (Table 1).

The mean medial rotation in group 2 was 22° higher than in group 1 ($p = 0.007$). Medial rotation was approximately 19° less in group 3 than in group 1 ($p = 0.009$). Lateral rotation in group 2 was ,on an average 13° less than in group 1 ($p = 0.03$) and in group 3 it was 16° more than in the control group ($p = 0.01$). The average femoral anteversion angle was 24° in the first group, 36° in the second and 14° in the third group (Table 2). The differences between the second and the third group, compared to the first group, were statistically significant ($p = 0.01$).

The average values of radiographically measured neck-shaft angles were 139° in all three groups. The correlation between differences in rotational movements and the femoral anteversion was highly significant ($r = 0.93$). Since a greater difference between medial and lateral rotation was observed, the deviation of femoral anteversion from the normal values was also greater. We found a positive correlation between medial rotation and femoral anteversion ($r = 0.80$) as well as a negative correlation between lateral rotation and femoral anteversion ($r = -0.73$) (Table 3).

Table 2. Clinical and radiographic results in the 148 children in whom radiographic measurements were made (degrees, mean SD)

	No. of pts / hips	MR	LR	DRM	FAA	NSA
Group 1	56 / 112	43 4.1	43 5.4	4.1 2.6	24 4.3	139 7
Group 2	67 / 134	64 11	30 8.5	36 11	36 7.3	139 7.3
Group 3	24 / 48	23 12	58 13	36 15	14 7	139 8.7

Abbreviations see Table 1 and FAA femoral anteversion angle, NSA neck shaft angle

Analyzing the gait, we found 10/1,030 children with intoeing gait in the first, 27/86 (0.3%) in the second and 3/24 (0.1%) in the third group.

Discussion

Our findings of the mean passive medial rotation in the extended hip are in accordance with those of Staheli et al. (1985) and Svenningsen et al. (1990). For lateral rotation, the same authors found 5° higher average values than we did. The range of values that we obtained for both medial and lateral rotation was wider. The reason for this could be the number of investigated subjects. For both medial and lateral rotation in all groups, the right-left differences per pair of hips were not statistically significant, which is in agreement with Svenningsen et al. (1990).

The average values of medial rotation, lateral rotation and femoral anteversion in the first group were 42°, 43° and 24°, respectively. These values are almost identical with those obtained by Fabry et al. (1973, 1994) and McEwen (1976), described as normal. Group 2 comprised significantly more girls, in accordance with observations by others (Staheli et al. 1985, Gelberman et al. 1987, Svenningsen et al. 1990), who found that girls had significantly greater medial rotation, as well as femoral anteversion angle. Group 3, with less femoral anteversion, included a greater, but not statistically different, number of boys.

We confirmed the presence of a positive correlation between medial rotation and femoral anteversion, already described by some authors (Crane 1959, Staheli et al. 1968, Cyvin 1977). In the third group, with greater lateral than medial rotation, we verified decreased values of femoral anteversion and a negative correlation between lateral rotation and femoral anteversion, while Gelberman et al. (1989) suggested that greater lateral rotation indicates normal anteversion. Although we noticed significant correlations between medial or lateral rotation and femoral anteversion, the correlation between differences in passive movements and femoral anteversion was the most striking.

Intoeing gait in children is usually associated with an increased angle of femoral anteversion. Svenningsen et al. (1990) found that 13% of examined 7-year-old children had intoeing gait. Analyzing all subjects, we found 3.5% of children with intoeing gait. 90% of children with intoeing gait belonged to group 2. However, more than two thirds of the children in group 2 had normal gait. Thus, increased anteversion does not necessarily cause intoeing gait—which in some cases perhaps is due to compensatory external rotation of the tibia (Fabry et al. 1973).

In the group with normal femoral anteversion, nevertheless 1% of the children had intoeing gait. A subgroup of children with intoeing gait, but with normal femoral anteversion, was also observed by Gelberman et al. (1987). Interestingly, a small group (3 of 24 children) with decreased femoral anteversion had intoeing gait, which has not, to our knowledge, been described by other authors.

On the basis of previous studies by several authors, Svenningsen (1991) reported that the normal range of the femoral anteversion angle (mean ± 2SD) in children at age 8–10 years is 11°–39°. According to our findings, the medial rotation must be at least 45° greater than lateral rotation to predict an abnormally large AV angle (> 39°). To predict an abnormally low AV angle (< 11°), lateral rotation must be at least 50° higher than medial rotation.

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