FEMORAL NECK ANTEVERSION: A CLINICAL VS RADIOLOGICAL EVALUATION

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SUMMARY

The purpose of the present study was to verify the correlation between the femoral anteversion angle measured by biplane radiography and the values of internal and external rotation of the hip obtained by clinical assessment. Sixty-four hips of 32 individuals with no previous coxofemoral pathologies were studied by taking their hip rotation values with a proper instrument - the fleximeter – and taking radiographic images using the Rippstein- Müller method. The results obtained were statistically analyzed and it was concluded that there was no statistically significant correlation and that it is possible that other factors, in addition to the femoral anteversion angle, may be important in determining the range of rotation of the hip joint.

Keywords: Statistics; Nonparametric; Femur neck; Hip.

INTRODUCTION

The anteversion angle (declination) of the femur neck can be defined as the angle formed by the femoral condyles plane (bicondylar plane) and a plane passing through the center of the neck and femoral head[1,2]. If this transverse plane (bicondylar) passes behind the center of femoral head, neck anteversion is present; if the plane described above passes in front of the femoral head, retroversion is present[2,3].

Femoral neck anteversion usually diminishes with age[4]. Between three and 12 months of age, the anteversion average value is 39°, reaching adult life with a value close to 16°[5,6].

There are many imaging methods described and used for measuring femoral anteversion, such as fluoroscopy[6], biplane x-rays[5,6,7], axial x-ray[6], ultrasound[1,9], computed tomography[1,3], nuclear magnetic resonance[1] and 3D modeling[1]. From these, the method with biplane x-rays is the most widely used and the one with the lowest cost.

According to Staheli et al.[10], there is a clinical correlation among inward and outward hip rotations and femoral anteversion angle measured by x-ray. A clinical evaluation of patients is important for those presenting with pathologic hips, since such pictures may or may not change the anteversion angle[2].

Determining the anteversion angle value is crucial for the diagnostic and therapeutic planning of patients with various pathologies, such as hip development dysplasias, cerebral palsy, varum thigh, flat thigh, epiphysiolysis, congenital club foot, other development abnormalities and metabolic diseases[2].

Therefore, the objective of this study is exactly to check the statistical significance of the correlation among the femoral anteversion angle measured by x-ray, and hip rotation values in a population presenting with no previous pathology.

MATERIALS AND METHODS

The sample was formed by clinical and radiographic evaluation of 32 individuals from both genders, with average age of 35.34 + 16.38, proceeding from the Orthopaedics and Traumatology Outpatient Care Facility, of the Federal University of Uberlândia (UFU), either patients or their escorts, randomly selected, being the only pre-requirement the absence of any hip conditions or gait problems.

This research was conducted with the approval of the Committee on Ethics in Research in human beings, from the same institution and with the consent of the volunteers, after they were informed about the objectives of the proposed study.

The clinical evaluation of the universe of individuals studied was restricted to the comparison of inward and outward hip rotations. For this, a proper instrument was used - the fleximeter - designed from studies[15], developed and manufactured in Brazil, patented and registered at the Code Research Institute (REG.UM 8320-3 RJ).

In this series, measurements were taken, positioning the patient in ventral decubitus, with pelvis horizontally stabilized, being the patient duly relaxed and wearing clothes that allowed for hips full range of motion (the majority wearing underwear). No previous warm-up, passive or active movements were performed with lower limbs. The fleximeter was positioned at the distal third of the leg anterior region, fixed by means of a Velcro band with the tip placed in neutral position 0°/360° (Figure 1). From this position, the right hip inward rotation (RIR), right hip outward rotation (ROR) (Figure 2), and the left hip inward rotation (LIR), left hip outward rotation (LOR) were performed and measured, up to the angle that gravity would support, according to Staheli et al.[10]. The test was performed three times in both hips, and the result taken was the arithmetic average of the three measurements.

In the radiological evaluation, x-rays were standardized according to the method by Müller for determining femoral necks anteversion angle values[7].

Frontal pelvic x-ray was performed with the patient positioned in dorsal decubitus, with parallel extended thighs and knees flexed in 90º, at the edge of the x-ray table (Figure 3).

In order to determine the femoral neck anteversion, the Rippstein-Müller position was used: hips remained flexed at 90º, with abduction of 15º and legs strictly in parallel from each other and to the plane of exam table. Such parallelism is important, as well as the vertical position of the femur in a perpendicular plane to the table, because it was from this plane that the projection of the posterior surface of the femoral condyles appeared in parallel to the x-ray lower edge[9]. In order to facilitate, and in order to obtain standardized x-rays, a proper instrument was used, which maintained the thighs and legs angles steady. That instrument was built using a cursor to adjust variable distances of the hips, as well as to adjust the length of the thighs (Figures 4a and 4b).

After x-rays were taken, the anteversion and inclination angles were determined (Figures 5a and 5b).

The inclination angle corresponds to the angle formed between the femur neck axis and the diaphysis axis: it is also called Muller's cervicodiaphyseal angle[7].

The anteversion angle is formed between the condylar transversal axis and femoral neck axis. This angle could be precisely measured only when an axial x-ray of the femur was captured[7].

Because of the femoral neck anteversion, indeed, at the frontal x-ray to the inclination angle measurement, only the projection of the same angle could be measured. Thus, in usual, anteroposterior, and Rippstein-Müller position projections, we measure such an angle with an accuracy of ± 5º. As it is impossible to take in vivo x-rays in femoral axial measurements, the x-ray for determining the anteversion angle was performed with abduction of 15º (Rippstein projection). As such errors are systematic, they are potentially correctable[7].

For this, tables exist allowing for the correction of values obtained directly from x-rays. In this case, the Müller Table was used (Figure 6), in which corrected values for right hip anteversion angle (RA) and left hip anteversion angle (LA) were found[7].

The authors divided themselves into two teams so that those who performed clinical measurements with the fleximeter could not participate on determining x-ray angles.

The collection provided the following data: gender; age; race; ROR; RIR; ROR+RIR; RA; LOR; LIR; LOR+LIR, and; LA.

For the statistical analysis, the verification on data distribution normality or abnormality was firstly performed by the proof "An analysis of variance test for normality". Such test indicated that the distribution did not comply with normality curve.

In view of those results, nonparametric methods were applied.

With the purpose of checking the existence or not of significant correlations among rotation measurements and anteversion angles, the Spearman's Correlation Coefficient by Posts was applied to the data.

With the purpose of comparing inward and outward rotations in the same side, the Wilcoxon test was applied to the values series, combined in pairs.

The significance level was established at 0.05 for all tests applied.

RESULTS

Table 1 presents, in a systematized way, the descriptive analysis of data regarding right and left hips, concerning the femoral neck anteversion angle measured by x-ray, the inward and outward rotations measured with the fleximeter, and the left hip rotation range, represented by the sum of outward and inward rotations.

Tables 2 and 3 show the rs values found and the probabilities associated to them, obtained when the Spearman's Correlation Coefficient by Posts was applied to ROR and RIR measurements, and to the sum of the ROR and RIR measurements with the measurements of the right femoral neck anteversion angle, as well as when applied to LOR and LIR measurements, and to the sum of the LOR and LIR measurements with the measurements of left femoral neck anteversion angle, with and without differentiation by gender. In Table 2, a significant negative correlation can be observed only among the measurements of LOR x LA and LOR + LIR x LA, and, in Table 3, a significant negative correlation was found only among the measurements of LOR x LA, within the female group.
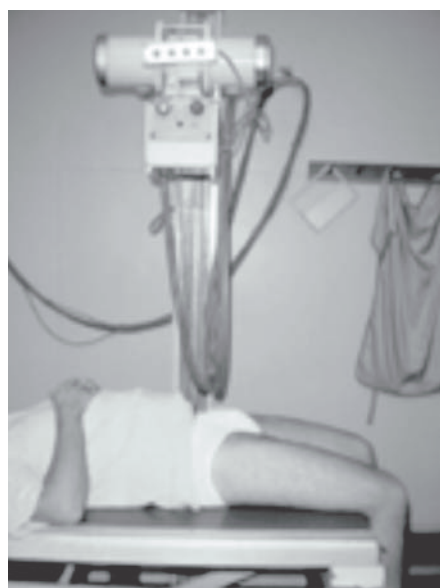
Significant differences were found among outward and inward rotations to the right (p=0.0002) and to the left (p=0.00006).

Figure 1 - *Positioning of fleximeter in the patient with the hip in neutral position*


Figure 2 - *Hip rotation measurement.*

**Figure 3 -** *Patient positioned for frontal x-ray to determine femur inclination angle.*

DISCUSSION

According to Maud[11] ten to twenty full range passive movements should be performed in order to assure an appropriate musculoarticular relaxation for a more accurate measurement of the hip motion degree. Nevertheless, we chose not to perform such warm-up, because it does not represent the daily reality of an orthopaedic doctor. On the hip inward and outward rotation range evaluation by Bloomfield et al.[12] and on the correlation study between passive rotation and femoral anteversion in children, performed by Kozic et al.[13], volunteers were assessed when positioned in dorsal decubitus on the bed, with extended lower limbs. The goniometer was positioned at planta pedis, and the outward and inward rotations from the feet were performed, respectively, and recording the ranges of motion indicated by the tip. In turn, Staheli et al.[10] preferred the patient positioned in ventral decubitus, with knees flexed at 90°, rotating thighs inwards and outwards, allowing legs to be pending from one side to the other by gravitational forces, thus recording the angles found. In this study, the methodology by Staheli et al.[10] was preferable to those by Bloomfield et al.[12] and Kozic et al.[13], because it was considered that, when evaluation was performed with the extended limb and the fleximeter positioned at the foot, there is a higher potential for errors due to movements on knee joints, tibiotarsal and subtalar. The evaluation with knee flexed at 90° and fleximeter positioned at the leg eliminates those potentials and allows for a clearer assessment, since leg's range of motion is more noticeable than foot's, due to its dimension.

In this study, we saw that, in a 95% confidence interval, the anteversion angle ranged from 12.10° to 17.59° to the right, and from 14.77° to 19.73° to the left, making an average of 14.84° + 7.60° to the right and, to the left, 17.25° + 6.89, which perfectly agrees with literature, describing an average of 16°[4,5] in adult life. Results are also in accordance to literature concerning hip rotations. In the studied population, the left outward rotation angle, measured by the fleximeter, varied
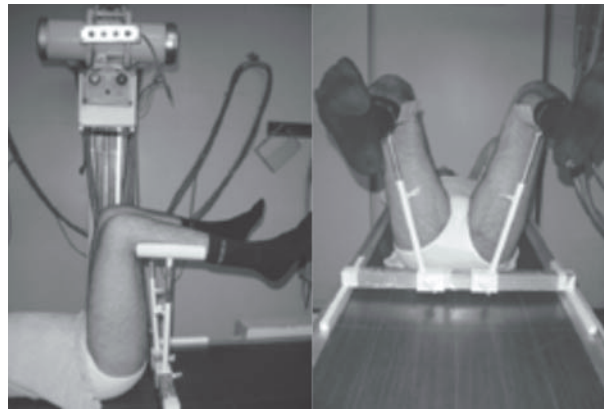
Figure 4 - *Lateral (a) and frontal (a) view of the patient positioned for x-ray in Rippstein-Müller position to determine femoral neck anteversion angle.*
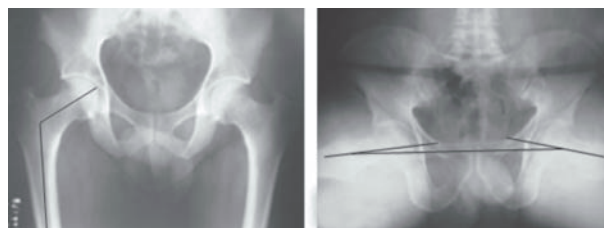
Figure 5 - *X-rays showing inclination (a) and anteversion (b) angles.*

	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	80°
	4	9	15	20	25	30	35	40	45	50	55	60	65	70	75	80
100°	101	100	100	100	100	99	99	98	97	96	95	94	94	93	92	91
	5	9	15	20	25	31	35	41	4	51	56	60	65	70	75	80
105°	105	105	104	104	103	103	102	100	100	99	98	97	96	95	94	92
	5	10	16	21	27	32	36	42	47	52	56	61	66	71	76	80
110°	110	110	109	108	108	106	106	105	104	103	101	99	98	97	95	93
	5	10	16	21	27	32	37	43	48	52	57	62	67	71	76	81
115°	115	115	114	112	112	111	110	109	107	105	104	102	101	99	96	94
	6	11	16	22	28	33	38	44	49	53	58	63	68	72	77	81
120°	120	119	118	117	116	115	114	112	110	108	106	104	103	101	98	95
	6	11	17	23	28	34	39	44	50	54	58	63	68	72	77	81
125°	125	124	123	121	120	119	118	116	114	112	109	107	105	103	100	95
	6	12	18	24	29	35	40	46	51	55	60	64	69	73	78	82
130°	130	129	127	126	125	124	122	120	117	116	112	109	107	104	101	96
	7	13	19	25	31	36	42	47	52	56	61	65	70	74	78	82
135°	135	133	132	131	130	129	126	124	120	118	114	112	109	105	102	96
	7	13	20	27	32	38	44	49	53	58	63	67	71	75	79	83
140°	139	138	137	135	134	132	130	127	124	120	117	114	111	107	103	97
	8	14	21	28	34	40	45	50	55	59	64	68	72	75	79	83
145°	144	142	141	139	138	136	134	131	128	124	120	117	114	110	104	98
	8	15	22	29	35	42	47	52	56	61	65	69	73	76	70	84
150°	149	147	146	144	143	141	138	136	134	129	124	120	116	112	105	100
	9	17	24	32	38	44	50	54	58	63	67	71	74	77	81	84
155°	154	152	151	149	148	145	142	139	137	132	128	124	119	115	108	102
	10	18	27	34	44	46	52	57	61	65	69	73	76	79	82	85
160°	159	158	157	155	153	151	147	144	141	134	132	128	122	116	111	103
	13	22	31	39	47	53	57	62	67	69	73	76	78	81	83	86
165°	164	164	163	161	158	156	153	148	144	140	135	130	122	119	113	106
	15	27	37	46	53	58	63	67	70	73	76	78	80	83	84	87
170°	169	167	166	161	163	159	157	154	150	145	142	131	130	122	118	113

Figure 6 - *Table of Müller*

in an interval of 42.31° to 47.63°. In Table 1, we can see an average for the left outward rotation angle of 44.97° + 7.37°, and for the right angle of 43.95° + 7.36°, while Staheli et al.[10] expect an average of 45°.

According to the results shown in Table 2, a significant negative correlation was found only among the LOR x LA and LOR + LIR x LA measurements. This means that, as values for one variant increase, the values for the other variant decrease, and vice-versa. The statistical evaluation, thus, as opposite to expected from literature, does not present a correlation among hips rotations (ROR and RIR), range of hip rotation (ROR + RIR and LOR + LIR) and femoral necks anteversion angles of the respective sides. Exceptions are those two situations in which a negative correlation occurs (LOR x LA and LOR + LIR x LA), according to foreseen in literature[1,10,14].

According to the results shown in Table 3, a significant negative correlation was found only among LOR x LA measurements, within the female group, which only corroborates the observations on the previous table, demonstrating the lack of correlation among rotations, joint range of motion, and femoral neck anteversion angles, being the only correlation existent due to the LOR in female patients.

Although there is a statistical significance between LOR x LA only for females, no other significant correlation was found among the anteversion angle and rotation measurements. This single statistically significant correlation found in this group comprised of 11 women (hardly explained) allow us to confirm, based on all other findings, that a statistical significance would really be inexistent, by the design in which the study was developed, among the x-ray anteversion angle and inward and outward rotation degrees measured by the fleximeter. Although Staheli et al.[10] and Kozic et al.[13] state that the anteversion strongly clinically influences hip rotations, also reporting that, in the severe form of anteversion, inward rotation is greater than 90° and the outward rotation is equal to 0°, and that the evaluation of hip passive range of rotation serves as a predictor to abnormal

femoral anteversion in children. However, it is worthy to highlight that those studies were performed in children presenting with lower limbs' orthopaedic problems, such as "in toe" and "out toe"[15], as opposed to our research, performed in healthy adult individuals, not presenting with any deformities.

Nonetheless, in the studies by Tonnis and Heinecke[14] performed in adults with no lower limbs' problems, the significant correlation between the hip anteversion angle and hip rotation was found, although minimal. According to those authors, patients with an outward rotation greater than the inward rotation had femoral retroversion, while those with greater inward rotation presented femoral anteversion.

In this study, statistically significant differences were found among rotations, being the outward rotation averages higher than inward rotation averages. However, there was no influence of femur neck retroversion on the outward rotation.

In view of these results, we can conclude that, for the great majority of people whose anteversion degree is close to normal values in the general population, hips rotation range of motion is

VARIANTS	AVERAGE	SD	CV
Age	35.34	16.38	46.35
RA	14.84	7.60	51.22
rOR	43.75	7.36	16.82
rIR	34.09	6.77	19.86
rOR +rIR	77.84	6.96	8.94
LA	17.25	6.89	39.92
lOR	44.97	7.37	16.38
lIR	33.28	9.00	27.05
lOR+ lIR	78.25	9.86	12.61

OR= outward rotation; IR= inward rotation; r= right; l= left; A= Anteversion angle.

Table 1 - *Descriptive analysis of the statistical data. Source: Federal University of Uberlândia - UFU*

Variants Analyzed	r_s	Probabilities
rOR x RA	0.0506	0.783
rIR x RA	0.0786	0.669
rOR + rIR x RA	0.0162	0.930
lOR x LA	-0.4124	0.019*
lIR x LA	-0.1840	0.314
lOR + lIR x LA	-0.3856	0.029*

(*)$p < 0.05$.
OR= outward rotation; IR= inward rotation; r= right; l= left; A= anteversion angle.

Table 2 - *Values of the probabilities and of the rs values associated to hips rotations and to the corresponding femoral neck anteversion angle when Spearman' Correlation Coefficient is applied. Source: Federal University of Uberlândia - UFU*

Variants analyzed	Male		Female	
	r_s	probabilities	r_s	probabilities
rOR x RA	0.1509	0.514	-0.2483	0.462
rIR x RA	-0.0180	0.938	0.0535	0.876
rOR + rIR x RA	0.0075	0.974	-0.0186	0.957
lOR x LA	-0.2942	0.195	-0.7094	0.014*
lIR x LA	-0.2960	0.193	-0.0936	0.784
lOR + lIR x LA	-0.3995	0.073	-0.3456	0.298

(*)$p < 0,05$.
OR= outward rotation; IR= inward rotation; r= right; l= left; A= Anteversion angle.

Table 3 - *Values of the probabilities and of the rs values associated to hips rotations and to the corresponding femoral neck anteversion angle when the Spearman's Correlation Coefficient is applied, in males versus females.*

also influenced by other factors, and not only by femoral anatomical configuration.

We can say that, although most of times the clinical test gives a close view of the femoral neck anteversion, the values found cannot be fully reliable in representing the value of the x-ray angle, according to the findings of this study. Grunert et al.[8] report, however, that the Rippstein-Muller method shows a variance of 5 to 15° on the evaluation of femoral neck anteversion and propose the use of alternative methods for this kind of orthopaedic evaluation.

It would be interesting in the future, if this investigation method is maintained, to submit volunteers to a warm-up and flexibility gain program before taking clinical measurements. Some authors advocate the use of controlled temperature rooms for measuring the range of motion[9].

CONCLUSION

There were no statistically significant correlations among clinical measurements of hips inward and outward rotations, measured with the use of a fleximeter, with femoral necks anteversion angles measured by x-ray.

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