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Analyzing of Rotational and Angular Deviations of Lower Extremities in Nursery School Children Based on a Turkish Sample: Gender Differences

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The main aim of the study was to identify rotational and angular profile of the lower extremities and to define the distribution of the angle deviations in terms of gender and both right and left extremities in healthy nursery school children in Denizli, Turkey. One hundred and four children (208 limbs) aged between 5 to 7 (mean; 5.65±0.46 years) were selected by multistage random sampling among nursery schools in Denizli. To identify the rotational profile of the participants, the following angles and motions were measured; the Tibiofemoral Angle, the Thigh-foot Angle, the Calcaneal Angle, external and internal rotation of the hip at three different positions, the Transmalleoler Axis Angle and the Forefoot Varus Angle. All tests were performed for both the right and left extremities using a clinical goniometry. The results obtained from the study showed that the children had normal range of motions concerning all rotational tests, except for internal rotation of the hip joint. And there was not seen significant differences between right and left extremities. On the other hand, when comparing the girls and the boys; no significant differences were detected. Otherwise, it was found that there was a significant difference between both sexes in terms of the Ryder's test scores (the part of external rotation) belonging to the left extremities ($p<0.01$). That's why; the children who have reached walking age and completed derotation of the foot of their feet should be examined carefully in term of rotational profile. Namely, to predict the rotational problems in the lower extremities provides us to prevent the deformity and gives us opportunities to correct at early stage. The current study shows that gender and extremities differences concerning the rotational and the angle deviations were not seen in the sample based on Turkish nursery school children.

Key words: Nursery school children, lower extremities, gender, rotational profile, angular deviation

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INTRODUCTION

Lower extremity rotational and angular deviations are usually seen in pediatric population and lead to postural deformities, ambulating distribution and even injuries[1-4]. The rotational deviations take form as a result of biomechanical problems of foot, knee and pelvic structure. If the problems are not identified and prevented they may cause more severe problems in years[5].

If the rotational problems of the lower extremities are not prevented and excess normal physiological limits they lead to torsional deformities in healthy subjects. Thus proper conventional treatment and surgery procedures should be selected to correct related joints problem which doesn't improve spontaneously during growing period of the children. In a study, Levine and Drennan screened radiographically the children between 4-8 years period (middle childhood) and then they pointed out that valgus deformity at knee should be detected carefully whether it's in normal physiological limits[6].

Most rotational variations in young children, such as in-toeing, out toeing and metatarsus adductus are being and resolve spontaneously. Understanding the normal variation in healthy children is vital to identify true structural abnormalities that require intervention[7].

Before focusing on the rotational and angular problems and its treatment procedures, a physiotherapist should evaluate and get some knowledge about musculoskeletal system. And she/he must be sure that the system is in normal limits. To evaluate a child with rotational abnormality, health providers should begin by assessing the rotational profile. The rotational profile provides the information needed to establish a diagnosis and quantify the severity of the rotational problem[8].

The main aim of the study was to examine the rotational and angular deviation of the lower extremities in nursery school children. The other was to define the distribution of the angle deviations by both gender and limbs.

MATERIALS AND METHODS

The present study is a cross-sectional and comparative study. The study was conducted in Denizli province, Turkey between 2003-2004 years under supervision three trained physical therapists, who had at least three years experience, from School of Physical Therapy and Rehabilitation at Pamukkale University. One hundred and four healthy nursery children (58 girls, 46 boys; average age 5.65±0.46 years), recruited from private nursery schools in that region, were studied. The inclusion criteria were: pre-school children between 5-7 years old and children who had no any kind of musculoskeletal, neurological or developmental abnormalities. Preliminary data including the child's name and nickname, sex, date of birth and present age, weight, height and Body Mass Index score (BMI) were recorded.

The rotational and angular deviations of the lower extremities data: To define the rotational and angular deviations of the lower extremities (208 limbs of the 104 subjects) belonging to the nursery school children who were studied in the current study; we assessed all subjects in terms of seven parameters as follows:

Thigh-foot angle: The Thigh-Foot Angle was measured while the children on supine position at knee 90° flexed and the foot was free. One arm of the goniometry was positioned through thigh shaft and the other arm was positioned through long shaft of the foot and then the angle between them was read and recorded in degree.

Transmalleolar axis angle: To measure The Transmalleolar Axis Angle the subject was positioned just as above. One arm of the goniometry was positioned parallel to the transmalleolar axis the other arm was positioned through the first phalanx of the foot. The angle between them was read and recorded in degree.

Q Angle: The Q Angle was measured while the subject was on supine position at knee full extension. One arm of the goniometry was positioned through a line over the anterior superior iliac spine of the pelvis and center of patella and the other arm was positioned through the center of patella and the tibial tubercle. The angle between them was read and recorded in degree.

Forefoot varus angle: In the measurement of The Forefoot Varus Angle, pivot point of the goniometry was positioned on calcaneus middle point and the subject was in prone position with knee 90° flexed and the foot was free. One arm of the goniometry was parallel to a line along middle of the heel and the other arm was positioned run through axis of the second toe. The angle between these two arms were read and recorded in degree.

Calcaneal Angle (rear-foot angle): The Calcaneal Angle was measured while the subject was in standing position. One arm of the goniometry was positioned parallel to the floor the other arm was positioned as parallel to the calcaneal middle line. The angle between them was read and recorded in degree.

Internal and external rotation of the hip (in sitting position and lying position: The ranges of motion including internal and external rotation of the hip were measured in both sitting and supine positions with the knees 90° flexed. One arm of the goniometry was positioned vertically to the floor, the other arm was positioned parallel to tibial crista the subject was asked to perform internal and external rotation (actively) as much as he/she can do it. And then the active internal and external movements of the hip joint were recorded in degree.

The Ryder's test: The magnitude of femoral torsion is measured as the angle formed by the transverse plane intersection of the femur's proximal reference axis and lateral reference axis while a child positioned at supine with the knee flexed to 90°. One arm of the goniometry was positioned vertically to floor and the other arm was parallel to tibial crista. After palpating tuberculum major, internal and external rotations were performed passively by physical therapist till tuberculum major couldn't be palpated any more. At this point the angle was read and recorded in degree.

All of the lower extremities measurements were performed using a clinical goniometry. As known, the clinical goniometry is common used by health providers such as physical therapists, orthopedic surgeon, occupational therapists etc.[9,10].

Data analysis: A total of 104 healthy nursery school children' results were given as number and its percentage (%) and also in this cross-sectional study, the results were given by gender. Descriptive results were given as mean±standard deviation (mean±SD). The student-t test and paired sample t-test were also used to look the differences between both sexes and the lower extremities. All data were computed and calculated using SPSS for Windows statistical program (10.0 version). $p<0.05$ was accepted statistically significant.

Table 1: Demographic and physical data of the sample by gender

Characteristic	Boys(n=46) Mean±SD	Girls (n=58) Mean±SD	Overall(n=104) Mean±SD
Age (year)	005.52±0.50	005.78±0.42	005.65±0.46
Height (cm)	115.79±5.62	115.23±5.04	115.52±5.33
Weight (kg)	023.54±3.51	023.81±3.51	023.67±3.31
BMI (kg/cm^2)*	017.98±1.49	017.59±1.64	017.77±1.57

* BMI: Body Mass Index

RESULTS

One hundred and four healthy nursery school children were analyzed in order to identify the distribution of the lower extremities rotational and angular deviation according to gender. Therefore two hundred and eight lower extremities (right and left) of the 104 participants were involved in the study. The average age of all the subjects was 5.63±0.48 years (Table 1). There were detected among the subject's significant differences concerning hip joint internal and external rotation, The Thigh-Foot Angle and The Ryder's Test. In the Table 2, the right and left lower extremities of the girls were compared with each other to describe differences; hip joint internal rotation (actively) was seen higher in left side than right side ($p<0.001$). Otherwise among boys it was not seen any difference between left and right lower extremities ($p>0.05$). The result of The Thigh-Foot Angle measurements of the right and left side of the boys were different statistically ($p<0.05$). But there was no significant difference among girls ($p>0.05$). At the same time the Ryder's test results showed significant differences among boys ($p<0.01$), but not among girls ($p>0.05$). Table 3 shows that the results of the rotational and angular parameters comparing the boys and girls. It was not seen any differences except for the results of the Ryder's test. The difference concerning the Ryder's test was seen for the left extremity between both sexes ($p<0.01$). On the other hand it was not seen any difference regarding right extremities ($p>0.05$).

Table 2: The comparison of rotational measurements of the sample by gender

	Girls (116 limbs)			Boys (92 limbs)		
Measurements*	Right	Left	p**-value	Right	Left	p**-value
Thigh-foot angle	11.06±2.33	10.48±2.64	>0.05	11.02±2.32	10.30±1.90	<0.05
Transmalleolar axis angle	19.08±5.39	17.91±5.14	>0.05	18.56±6.01	18.17±5.33	>0.05
Q angle	10.50±3.54	12.96±1.73	>0.05	09.86±1.49	10.41±1.98	>0.05
Forefoot varus angle	03.98±1.06	3.72±1.05	>0.05	03.91±1.18	03.84±1.11	>0.05
Calcaneal angle	08.86±3.55	8.18±2.53	>0.05	07.80±2.75	08.32±2.40	>0.05
In sitting position						
Hip internal rotation	33.39±10.39	31.91±8.56	>0.05	34.76±9.53	32.52±9.61	>0.05
Hip external rotation	27.53±7.98	27.32±8.15	>0.05	27.36±7.57	26.78±8.20	>0.05
In lying position						
Hip internal rotation	52.20±15.02	58.58±13.36	<0.001	54.63±14.43	55.36±12.93	>0.05
Hip external rotation	59.44±15.22	62.24±16.17	>0.05	63.52±12.98	67.17±15.69	>0.05
The ryder's test						
Hip internal rotation	34.39±14.82	35.18±16.57	>0.05	35.50±15.30	38.10±18.89	>0.01
Hip external rotation	44.60±19.81	45.86±19.16	>0.05	42.43±19.08	43.26±17.87	>0.05

* All data are illustrated as mean±Standard Deviation (SD) **Paired-sample t test was used

Table 3: The comparison of the rotational measurements of the sample by gender

	Right extremity (n=104)				Left extremity			
Measurement*	Girl	Boy	F	p**-value	Girl	Boy	F	p**-value
Thigh-foot angle	11.06±2.33	11.02±2.32	0.0004	>0.05	10.48±2.64	10.30±1.90	2.302	>0.05
Transmalleolar axis angle	19.08±5.39	18.56±6.01	0.068	>0.05	17.91±5.14	18.17±5.33	0.005	>0.05
Q angle	10.50±3.54	09.86±1.49	3.415	>0.05	12.96±1.73	10.41±1.98	2.989	>0.05
Forefoot varus angle	03.98±1.06	03.91±1.18	0.007	>0.05	3.72±1.05	03.84±1.11	0.008	>0.05
Calcaneal angle	08.86±3.55	07.80±2.75	3.510	>0.05	8.18±2.53	08.32±2.40	0.043	>0.05
In sitting position								
Hip internal rotation	33.39±10.39	34.76±9.53	0.004	>0.05	31.91±8.56	32.52±9.61	0.515	>0.05
Hip external rotation	27.53±7.98	27.36±7.57	0.680	>0.05	27.32±8.15	26.78±8.20	2.269	>0.05
In lying position								
Hip internal rotation	52.20±15.02	54.63±14.43	0.186	>0.05	58.58±13.36	55.36±12.93	0.050	>0.05
Hip external rotation	59.44±15.22	63.52±12.98	1.219	>0.05	62.24±16.17	67.17±15.69	0.163	>0.05
The ryder's test								
Hip internal rotation	34.39±14.82	35.50±15.30	0.501	>0.05	35.18±16.57	38.10±18.89	1.175	>0.05
Hip external rotation	44.60±19.81	42.43±19.08	1.327	>0.05	45.86±19.16	43.26±17.87	7.887	<0.01

* All data are illustrated as mean±Standard Deviation (SD) **Independent-samples t test was used

DISCUSSION

Torsion is defined as the rotation of bone around longitudinal axis. The rotational problems of lower extremities are most common seen in children and infants. Environmental and physiological factors, such as the use of unsuitable footwear in toddlers, allowing sitting in internal rotation position of hip, failure to reach normal level of anteversion angle of the pelvis in relation with genetically factors, lead to deformities and rotational deviations during childhood and early adolescence period. These problems may cause non-normal walking patterns, knee joint and low back region deformities in adults unless necessary precautions and therapeutic approaches are applied[11,12].

To know or to predict the physiological limits of the rational angles provides us to understand the type of pathologies. As known, torsional problems are related with intrauterine position. In the intrauterine position; pelvis is typically at flexion, abduction and external rotation. On the other hand knee joints are at flexion, legs are at internal rotation and the feet are at equines and supination. The combination of the leg's internal rotation and the hip external rotation are seen when the children begin to walk[13]. The biomechanics alignment in a normal adult is constituted between 5-8 ages. The average tibiofemoral angle (Q angle) is 15 degree with varus at birth. The Q angle decreases till 10 years old and becomes 10 degree. Neutral alignments are constituted between 18-20 months. The Q angle becomes 12° at valgus position between 3-4 years old. The angle is similar to both girls and boys. But the Q angle reaches its normal value at the age of 7-8[14]. In several studies in the literature have been shown the Q angle's ranges in from 10° to 14° for male and from 14.5° to 17° for female[15,16]. In the present study we found that the Q angle was 10.50° in right side and 12.96° in left side for girls on the other hand in boys, it was 9.86° in right side and 10.41° in left side. These results obtained from the current study show the similar the Q angle degree to above mentioned studies. Similar results were also reported by Arazi *et al.*[17] from Turkey (mean Q angle 9.6° for boys, 9.8° for girls). Contrary to previous studies, Hadari and Javid[18] from Iran reported that the mean Q angle was found 5.5±1.2° (ranging from 3.1°-8.3°.

In the literature, the hip rotation (internal and external rotation) is 45° until first year of the life. In addition, the internal rotation of the hip is 70° below in normal situation. If it is between 70-80°, the rotation is considered as mild, between 80-90° is accepted as moderate and 90° and more is accepted as severe. The internal rotation of the hip reaches the highest level between 5-6 years old. While the external rotation of the hip is between 70-80°, the internal rotation of the hip is decreases to between 0-20°. Indeed, severe external rotation of the hip is an important sign to predict the in toeing gait[19]. Svenningsen *et al.*[20] suggested that especially in children the internal rotation of the hip is seen more than external rotation because of the femoral anteversion angle is more than its normal range.

We measured the rotational angles of the hip in three different positions. The first in prone position is defined as 55.35° internal rotation and 60.84° external rotation among girls, 54.95° internal rotation and 65.34° external rotation among boys. We found that the hip rotation in sitting position was seen lower than prone position. In the sitting position, the hip rotation results were 32.65° for internal rotation, 27.42° for external rotation. Since the hip rotation was measured against the gravity force in the sitting position, the score was seen lower compared with the prone position.

As reported in the literature the average range of the Rider's test is 40° at birth, 31° at 2 years old and 25°

at 8 years old[21]. But in our study, the internal rotation was seen at 34° and the external rotation was seen at 45°. That means these results from the current study are higher than previous studies.

Another component of the torsional profile is the Thigh-Foot angle. Although the normal range of the Thigh-Foot Angle is higher at birth though age 2 years, the mean angle lies between -10 and 0°. Infants have a mean angle of -5° (range -34 to 40°) as a consequence of normal in utero position. The angle gradually increases to a mean of 10° from middle childhood on (range, -5 to 30°)[14,22]. In this study, the mean angle was defined as approximately 11° for both girls (10.77°) and boys (10.66°). In another study by the author of the work, N Yagci the mean angle was reported 11.19±2.54° among 116 children aged 6-7 years. And the author also reported that these results from their study can be considered in normal physiologic limits[23].

To evaluate the Forefoot varus angle; measuring of the shape of the feet is very important issue. Therefore, when a child is screening about torsional profile and rotational abnormalities, The Forefoot Varus Angle should be evaluated. In the literature the normal range of the Forefoot varus angle was reported in various degrees. Uygur reported that the angle is between 14-16° for health adults[24]. The other author pointed that the ideal angle must be 0 degree for children[21]. In other hand Chen et al reported that the angle is between 5.01±4.51° for healthy subjects aged 10-50 years[25]. In this study, we found that the mean the Forefoot Varus Angle was 3.85° for girls and 3.87° for boys. These results showed us there was not difference regarding angular deviation between girls and boys.

According to the studies in the literature the Calcaneal Angle (Rear-Foot Angle) is 0 degree (neutral) or 2-3° in varus position among healthy adults[26]. Contrary of the above study; Yagci et al.[23] assessed the healthy children and reported that the mean Calcaneal angle was defined 6.66° (12,3 %) in calcaneo-varus position and 7.46° (23,8 %) in calcaneo-valgus position. In the current study, we defined that those feet of all children had calcaneo-valgus position and the mean the Calcaneal angle was defined as 8.52° for girls and 8.06° for boys. In the literature, before 8-9 years old until derotation of the foot completes, the rear foot is to be in calcaneo-valgus position is accepted in physiologic limits[24].

The Transmalleolar Axis Angle is also important to define lower extremities rotational profile. Its normal range is a little bit higher than 10°. The angle is 0 degree at birth (ranges:-30°-20°). In the middle childhood and later it gradually increases to 20° (ranges: 0°-45°)[22]. At the same time, we found that the Transmalleolar Axis Angle over ranging 18.49° in girls and 18.36° in boys. These results are similar to normal ranges were reported in the literature.

The rotational and angular deviations of the lower extremities cause concern in parents and sometimes procedure minor functional problems in children at birth and childhood on. That's why; to predict those problems, such as in toeing gait, out toeing gait, abnormal walking, femoral anteversion abnormalities, external or internal tibial torsion, pesplanus etc., provides us to prevent and to treatment of the rotational problems without surgery at early stage. All results from the literature and the current study show that to take the parents' concerns seriously is a vital condition. And also, the health providers including orthopedic surgeon, pediatrics and physical therapists should evaluate the children carefully and make an accurate observation to predict severe deformities. Otherwise the severe deformities can not be treated without surgery procedures.

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REFERENCES

1. Wells, L., 1996. Common lower extremity problems in children. Prim. Care, 23: 299-303.
2. Kling, T.F. and RN. Hensinger, 1983. Angular and torsional deformities of the lower limbs in children. Clin. Orthop., 176: 136-47.
3. Killam, P.E., 1989. Orthopedic assessment of young children: Developmental variations. Nurse Pract., 14: 27-36.
4. Staheli, L.T., 1983. In-toeing and out-toeing in children. J. Fam. Pract., 16: 1005-11.
5. McDonough M.W., 1984. Angular and axial deformities of the legs of children. Clin. Podiatry, 1: 601-20.
6. Levine, A.M. and J.C. Drennan, 1982. Physiological bowing and tibia vara. The metaphyseal-diaphyseal angle in the measurement of bowleg deformities. J. Bone Joint Surg. (Am)., 64: 1158-63.
7. Hensinger, R.N., 1976. Rotational problems of the lower extremity. Postgrad. Med., 60: 161-7.
8. Staheli, L.T., M. Corbett, C. Wyss and H. King, 1985. Lower extremity rotational problems in children. Normal values to guide management. J. Bone Joint Surg., 67A: 39.
9. Somers, D.L., J.A. Hanson, C.M. Kedzierski, K.L. Nestor and K.Y. Quinlivan, 1997. The influence of experience on the reliability of goniometric and visual measurement of forefoot position. J. Orthop. Sports Phys. Ther., 25: 192-202.

10. Elveru, R.A., J.M. Rothstein and R.L. Lamb, 1988. Goniometric reliability in a clinical setting. Subtalar and ankle joint measurements. Phys. Ther., 68: 672-7.
11. Akman, M.N., Y. Ersoy, M. Ari, Z. Sari, A. Sari and S. Tanacan, 1995. Postural deformities of the spine and lower extremities in school children: An epidemiologic study. J. Turgut Özal Med. Center, 2: 49-53.
12. Staheli, L.T., 1989. Torsion-treatment indications. Clin.Orthop., pp: 61-6.
13. Guidera, K.J., T.M. Ganey, C.R. Kelleally and J.A. Ogden, 1994. The embryology of low-extremity torsion. Clin. Orthop. Rel. Res., 302: 17-21.
14. Thompson, G.H. and P.V. Scales, 1996. Torsional and Angular Deformities: Nelson Textbook of Pediatrics. W.B. Saunders Company, pp: 1925-1933.
15. Woodland, L.H. and R.S. Francis, 1992. Parameters and comparison for the quadriceps angle of college-age men and women in supine and standing position. Am. J. Sports Med., 20: 208-11.
16. Kernozek, T.W. and N.L. Greer, 1993. Quadriceps angle and rear foot motion: Relationships in walking. Arch. Phys. Med. Rehabil., 74: 407-410.
17. Arazi, M., T.C. Ogun and R. Mimik, 2001. Normal development of tibiofemoral angle in children: A clinical study of 590 normal subjects from 3-17 years of age. J. Pediatr. Orthop., 21: 264-7.
18. Javid, M. and F. Hadari, 2003. Normal limits of tibiofemoral angle in primary school children in Iran. Irn. J. Orthop. Surg., 3: 5-9.
19. Li, Y.H. and J.C.Y. Leong, 1999. In toeing gait in children. HKMJ., 5: 360-6.
20. Svenningsen, S., K. Apalset, T. Terjesen and S. Anda, 1989. Regression of femoral anteversion. Acta. Orthop. Scand., 60: 170-5.
21. Cusick, B.D. and W.A. Stuberg, 1992. Assessment of lower extremity alignment in the transverse plane: Implication for management of children with neuromotor dysfunction. Phys. Ther., 72: 13-25.
22. Staheli, L.T., M. Corbett, C. Wyss and H. King, 1985. Lower extremity rotational problems in children. J. Bone Joint Surg. (Am)., 67: 39-44.
23. Yagci, N., S. Gursoy and U. Aslan, 2000. Foot Deformities and Angular Abnormalities in Primary School Children. Intl. Public Health Cong. Health 21 in Action. Istanbul, Abstract Book pp: 8-12.
24. Uygur, F.S., 1992. Foot deformities and orthosis. Publication of Hacettepe University School of Physical Therapy and Rehabilitation, pp: 18-22.
25. Chen, M.J.L., C.P.C. Chen, H.L. Lew, W.C. Hsieh, W.P. Yang and S.F.T. Tang, 2003. Measurement of forefoot varus angle by laser technology in people with flexible flatfoot. Am. J. Phys. Med. Rehabil., 82: 842-46.
26. Tiberio, D., 1988. Pathomechanics of structural foot deformities. Phys. Ther., 68: 1840-49.