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Acetabular index values in healthy Turkish children between 6 months and 8 years of age: a cross-sectional radiological study

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Objective: The aim of this study was to determine the normal acetabular index values in children between 6 months and 8 years of age based on sex, age and side and to define the cutoff values for mild and severe acetabular dysplasia.

Methods: The records collected from the data pool that was gathered to define the prevalence of untreated congenital hip dislocation in Turkish children between 6 months and 14 years of age was used. The acetabular index was measured on pelvic and abdominal radiographs of children between 6 months and 8 years of age, taken in 19 different cities for non-dysplasia related causes. The distribution of the index values based on age, sex and side.

Results: Thirty-three hips of 21 children (0.75%) out of 2788 children were found to be subluxated or luxated. Acetabular index values of 5534 hips of 2767 children were measured. Acetabular index values of 723 (13%) hips of 493 children (17.8%) were found to be between 1 and 2 standard deviations. Acetabular index values of 147 hips (2.65%) of 118 children (4.3%) were calculated to be above 2 standard deviations. There was a negative correlation between the acetabular index and age.

Conclusions: The study defines the normal acetabular index values in healthy Turkish children between 6 months and 8 years of age and the expected acetabular index values for mild and severe dysplasia.

Key words: Acetabular index; children; dysplasia; Turkish.

Early diagnosis of developmental dysplasia of the hip (DDH) increases the chance of favorable results following treatment and healthy development of hip joint. Acetabular index (AI) is a useful tool to evaluate the acetabular coverage.[1,2]

First described by Hilgenreiner, acetabular index is an angular value showing the slope of the acetabular roof on an antero-posterior pelvic radiograph (Fig. 1). Tönnis defined and published the mean and standard deviation (SD) values of this angle according to age, sex

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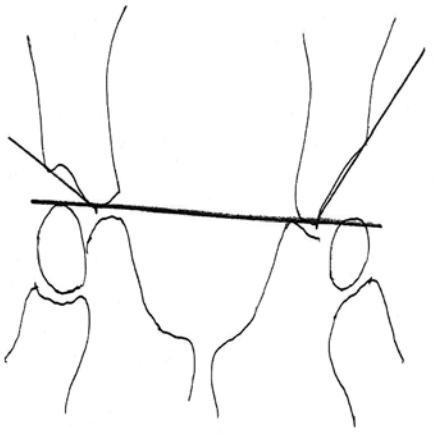

Fig. 1. Acetabular index angle.

and side. After clinical follow-up, Tönnis also outlined angular values of mild (index values between 1 SD and 2 SD's above mean) and severe dysplasia (index values higher than 2SD above mean).[3]

Previous studies on acetabular index mean values and standard deviations utilized local data at different age groups in Turkey.[4,5]

Our aim was to define mean acetabular index values based on age, sex and side and to outline mild-severe dysplasia values of Turkish children aged between 6 months and 8 years.

Materials and methods

The records from the data pool gathered for the project "Prevalence of untreated hip dislocation at Turkish children aged between 6 months and 14 years" which was supported by Turkish Society of Orthopedics and Traumatology was used. Pelvis and lower abdominal radiographs taken for non-hip dysplasia related causes were evaluated. Population of country was distributed into 12 regions according to NUTS1 (Nomenclature of units for territorial statistics) and number of radiographs to be collected from this regions were determined. A total 4956 radiographs were collected from 19 cities and 2788 measurable radiographs of children aged between 6 months and 8 years were evaluated.

The measurement was performed with MB.Ruler 4.0 software on 2196 radiographs available on digital media, while manual measurement was performed with a goniometer on the remaining 571 conventional analogue radiographs.

Statistical analysis was performed using SPSS 15.0 (SPSS, Inc., Chicago, Illinois, USA) software. Acetabular index values were reported as mean ± standard deviation. Relation between age and acetabular index was defined by Pearson correlation coefficient and linear regression analysis. The index values between 1 standard deviation and 2 standard deviation above mean were taken as mild dysplasia, while the values more than 2 standard deviations above mean were considered as severe dysplasia. Mild-severe dysplasia values obtained and mild- severe dysplasia values defined by Tönnis were compared using marginal homogeneity test and McNemar test.

Results

Amongst 2788 radiographs thirty-three hips of 21 radiographs revealed subluxation or dislocation (0.75%). After exclusion of these radiographs, the remaining 2767 radiographs gathered from 19 cities of

Table 1. Distribution of acetabular index angle mean values according to sex, age and side (in degrees).

	Male						Female					
	Right			Left			Right			Left		
Age (yrs.)	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
6 mo.–1 yr.	260	20.4	3.9	260	21.6	4.1	196	23.0	4.7	196	24.1	4.8
2	219	18.9	3.8	219	19.2	3.9	192	20.4	4.1	192	21.7	4.5
3	212	16.9	3.7	212	17.2	3.9	170	18.6	4.2	170	18.9	3.7
4	177	15.6	4.0	177	16.0	4.2	131	16.8	3.9	131	17.6	3.8
5	156	15.3	3.4	156	15.2	3.7	157	15.9	3.6	157	16.4	3.6
6	158	14.1	3.6	158	14.2	3.8	148	15.7	3.9	148	15.9	3.7
7	155	14.1	3.6	155	14.2	3.4	154	14.4	3.7	154	14.4	3.7
8	146	13.8	3.5	146	13.8	3.5	136	14.1	4.2	136	14.2	4.4
Total	1483	16.6	4.4	1483	17.0	4.7	1284	17.7	5.1	1284	18.3	5.3

N: number, SD: standard deviation

Table 2. Distribution of acetabular index angle limits for mild and severe dysplasia according to sex, age and side (in degrees).

	Male						Female					
	Right			Left			Right			Left		
Age (yrs.)	N	Mild dys.	Severe dys.	N	Mild dys.	Severe dys.	N	Mild dys.	Severe dys.	N	Mild dys.	Severe dys.
6 mo.–1 yr	<24	24-28	>28	<26	26-30	>30	<28	28-32	>32	<29	29-34	>34
2	<23	23-27	>27	<23	23-27	>27	<25	25-29	>29	<26	26-31	>31
3	<21	21-24	>24	<21	21-25	>25	<23	23-27	>27	<23	23-26	>26
4	<20	20-24	>24	<20	20-24	>24	<21	21-25	>25	<21	21-25	>25
5	<19	19-22	>22	<19	19-23	>23	<20	20-23	>23	<20	20-24	>24
6	<18	18-21	>21	<18	18-22	>22	<20	20-24	>24	<20	20-23	>23
7	<18	18-21	>21	<18	18-21	>21	<18	18-22	>22	<18	18-22	>22
8	<17	17-21	>21	<17	17-21	>21	<18	18-23	>23	<19	19-23	>23

N: normal, dys.: dysplasia

12 regions according to NUTS1 were found to be homogenous regarding to age and sex distribution.

Acetabular index mean values and standard deviation values based on age and sex distribution is listed in Table 1. Limits for normal, mild and severe dysplasia values is summarized in Table 2.

Comparison of mild and severe dysplasia cases of study group with mild and severe dysplasia cases of Tönnis' data is summarized in Table 3. Since Tönnis didn't defined index values for age 8, study cases between 6 months and 7 years (4990 hips of 2495 cases) were evaluated for comparison. In our study, 723 hips (13%) of 493 children were found to be between mild dysplasia limits. Severe dysplasia was found in 147 hips (2.65 %) of 118 children (4.3%). When Tönnis' limits for dysplasia were used, 1070 hips (21.4%) of 604 children (24.2%) would be evaluated as mild dysplastic whereas 192 hips (3.8%) of 159 children (6.4%) are found to be severely dysplastic. Comparison of both data revealed that mild dysplasia limit for all ages except age 3 are significantly different than mild dysplasia limits of Tönnis, whereas severe dysplasia limits are significantly different only for ages 1 and 2 (Table 3).

Acetabular index values were found to decrease with age (Pearson correlation coefficient, right r=0.545, regression equivalence: AI=21.658 – 1.096 × age; left r= 0.572 , regression equivalence AI= 22.732 – 1.243 × age) (Fig. 2).

Table 3. Comparison of distribution of cases with mild and severe dysplasia evaluated according to study values and criteria of Tönnis for hip dysplasia by age and p-values.

	Study values				Tönnis				p	p (Mild)	p (Severe)
	Mild dysplasia rate		Severe dysplasia rate		Mild dysplasia rate		Severe dysplasia rate				
Age (yrs.)	N	Rate (%)	N	Rate (%)	N	Rate (%)	N	Rate (%)			
1	89	19.6	18	3.9	125	27.4	43	9.4	<0.001	<0.001	<0.001
2	63	15.3	20	4.9	107	26.1	45	10.9	<0.001	<0.001	<0.001
3	65	17	18	4.7	56	14.7	20	5.2	0.336	0.108	0.687
4	46	14.9	16	5.2	92	29.9	21	6.8	<0.001	<0.001	0.125
5	60	19.1	13	4.2	77	24.6	8	2.6	0.250	0.035	0.125
6	66	21.6	12	3.9	81	26.4	14	4.6	<0.001	<0.001	0.754
7	52	16.8	13	4.2	66	21.3	8	2.6	0.414	0.007	0.180
8	52	18.5	8	2.8							
Total	493	17.8	118	4.3	604	24.3	159	6.4	<0.001	<0.001	<0.001

N: number

Discussion

Acetabular index is one of the radiological parameters used for diagnosis, treatment planning and follow up of developmental dysplasia of the hip. Children aged between 6 months to 8 years were included for evaluation in our study, because radiological landmarks of acetabular roof and triradiate cartilage are clearly visible and measurable at this age group. It has been reported in previous studies that the inter- and intra-observer reliability of AI measurements were high. Moreover, the reliability of AI measurements was shown to be higher in non-dysplastic hips. Therefore, reliability tests were not performed for the current data.[6-8]

Acetabular index values based on age, sex and side reported by radiological and clinical follow up studies of Tönnis were accepted as reference values for hip dysplasia. These values have been widely used worldwide as well as our country in treatment and follow up of DDH. Tönnis stated that, every value between 1 and 2 SD above mean should be accepted as mild dysplasia and values 2 and more SD above mean as severe dysplasia. Due to genetic characteristics and environmental differences during child development, AI normal values may show differences amongst countries. Based on this idea, we planned to define the normal AI values for Turkish children aged between 6 months and 8 years and evaluated 5534 hips of 2767 children.

Acetabular index is the most commonly used measurements for evaluation of acetabular dysplasia.[9] Although it has been commonly used, there is no consensus on the management of patients with acetabular index values at the upper limits. Ömeroğlu et al. defined acetabular index measurement as the most reliable method for evaluation of hip dysplasia. This study also reported lack of agreement between surgeons on the indication for treatment in patients at the upper limits.[9] Primary debate concentrates on the management of the children with stable, non-subluxated hips with high acetabular index. Although there is a strong need for long term follow up studies to answer the question "Is treatment for the stable hip with high acetabular index is necessary?", the current study will contribute to the debate by defininning the normal, mild and severe dysplasia limits of acetabular index in Turkish children aged between 6 months and 8 years.

As we started the study to evaluate the prevalence of hip dislocation of children aged between 6 months and 8 years in Turkey, we found out that the acetabular index values of study group was usually higher from the acetabular index values defined by Tönnis. When study

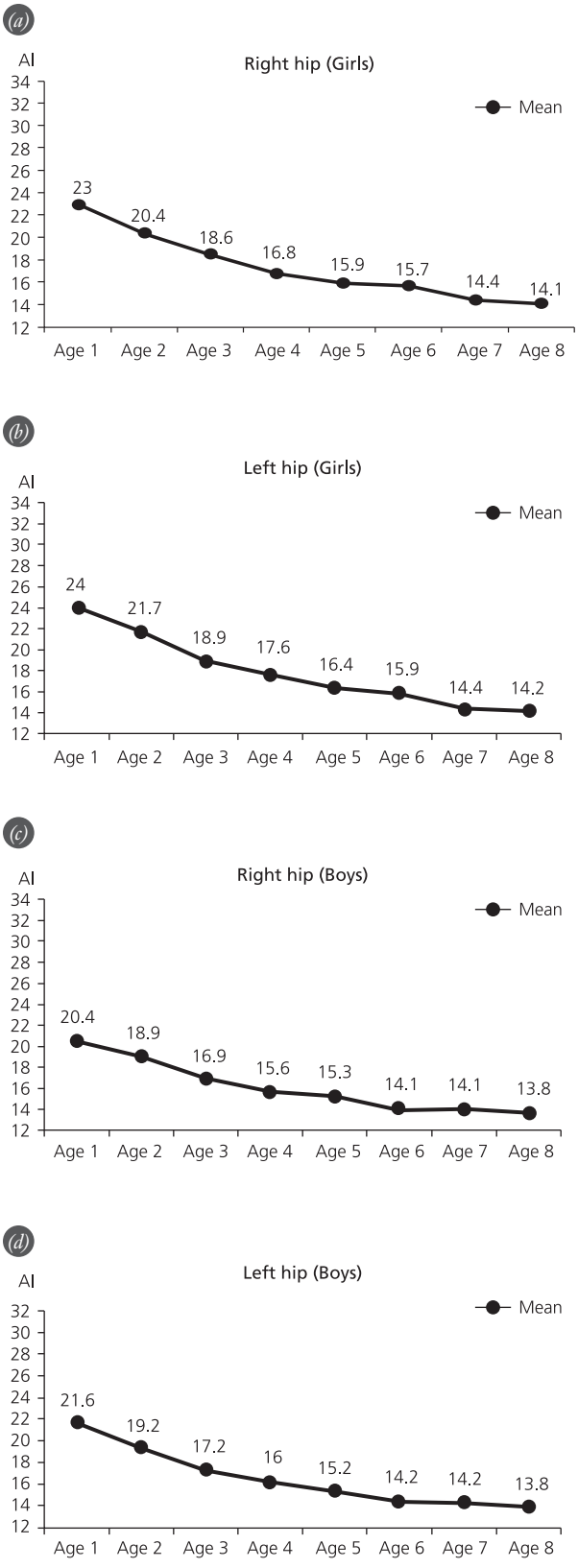

Fig. 2. **(a-d)** The distribution of the mean acetabular index value based on age, sex and side.

data was evaluated according to Tönnis' limits for dysplasia, prevalence of mild dysplasia for all study group increases from 17.8% to 24.3% (Table 3). Severe dysplasia cases with AI values 2 SD above mean were found to be more frequent in children aged 2 or younger. When criteria of Tönnis were used for evaluation, prevalence of severe dysplasia increases from 4.9% to 10.9% (Table 3).

Evaluations of Turkish children until age 8 years using criteria of Tönnis may result in the overdiagnosis of mild hip dysplasia and may necessitate unnecessary clinical and radiological follow up. Similarly. when the Tönnis' criteria were applied, the number of the patients diagnosed with severe dysplasia increases under age 2 which may cause unnecessary surgeries. Therefore definition of normal AI limits of the population gains importance. In our clinical practice, we take into consideration of both the AI and other radiological parameters while making the diagnosis of acetabular dysplasia and deciding the follow up regime. We prefer to follow the cases of mild dysplasia according to criteria of Tönnis when other radiological parameters are normal.

When compared according to sex, first 6 years (with the exception of 5 years of age and right hip) AI values of girls were found to be higher than AI values of boys. Similarly, +1 SD and +2 SD limits were found to be different in boys and girls. Similar AI values were measured at ages 7 and 8. These differences between boys and girls must be considered in evaluation of AI under 7 and it must be kept in mind that girls less than 7 years old have higher AI values.

In our study normal acetabular index values of Turkish population aging between 6 months and 8 years were determined and mild and severe dysplasia limits were defined. Together with other radiological parameters, AI values representing normal Turkish population will be helpful not only for management of hip dysplasia cases, but also will develop a common language between researchers studying hip dysplasia.

Conflicts of Interest: No conflicts declared.

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