ORIGINAL ARTICLE

Acoustic Characteristics of Turkish Speaking Children Ages between 4 and 14 Years Old

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Purpose: The present study aims to establish and characterize the pediatric acoustic values of native Turkish-speaking children and the relationship of those measures with physical characteristics like height and weight.

Material and Methods: This study included 203 individuals aged between 4 to 14 years.

Results: It was found that despite the slight variations in the voice parameters of 4-to-14-year old children who had normal development, the principal change started after 8 years of age in boys and 10 years of age in girls, the fundamental frequency started to decrease in both sexes after those ages. Male and female children showed statistically significant levels of differentiation in voice characteristics beginning as of 13 years of age.

Discussion: It is considered that the normative data obtained from 4 to 14 years of age native Turkish speakers could be used to determine the voice disorders of children.

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Introduction

The complex structure of the human voice and the impact of personal characteristics demonstrate the importance of defining the standard normal voice. Ethnicity, environmental and cultural differences can influence the acoustic parameters of human voice and these acoustic characteristics may therefore vary from one population to another [1].

Clinicians often use indirect data when conducting studies on speech due to the problems related to direct evaluation of the larynx. This emphasizes the importance of voice laboratories designed to objectively analyze the various acoustic characteristics of voice samples. Acoustic measurements are analyzed to demonstrate their changes in vocal pathologies and with different laryngeal structures [2,3].

Values deviating from normal obtained from any evaluation of an abnormal voice should be compared with values that represent normal standard voice quality. Review of studies on normal voice quality provides a basis for the comparison of the values related to abnormal voice quality [4]. Ethnicity, gender and spoken language affect the fundamental frequency (F_0) and acoustic measures [5].

Children have different voice characteristics than adults. It is therefore important from a clinical perspective to demonstrate the voice development process to be able to determine deviations from normal. Acoustic measurements have previously been defined for English-speaking children, [6,7,8,9,10] English-speaking African-American and Caucasian children,[7,9,11] Arabic-speaking children[5] and Jordanian Arabic speaking children[12]. Acoustic values that are normal for one language may not be normal for another and the normative values therefore need to be determined separately for each language. So, this study was decided to conduct as the authors did not come across any previous definition of acoustic parameters in Turkish-speaking children.

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The aim of this study was to establish and characterize the pediatric acoustic measures of native Turkish-speaking children to produce a normative database.

Method

The present study was approved by the Hacettepe University Ethical Board (LUT 077/88).

Subjects

Two hundred and three native Turkish-speaking children with ages ranging between 4 and 14 years were the subjects of this study. Demographic data, including gender, age, height and weight were obtained for each subject before the analysis of voice (Table I). The distribution of age groups by gender is illustrated in Table 2. The subjects had normal otolaryngology examination findings, hearing[13] and development. The families and the teachers of the school age children gave information about the development of those children. Normal gross and fine motor development indicated by families and on time writing and reading skills development indicated by teachers regarded as normal development.

Apparatus

Voice samples for acoustic measures were recorded using the Computerized Speech Laboratory (CSL) 4300B (Kay Elemetrics) and a microphone (SHURE SM 48). The Multi-Dimensional Voice Program (MDVP) was used to evaluate the acoustic features of voice samples[14]. The MDVP can extract thirty-three different variables classified in six groups: (1) fundamental frequency information; (2) frequency perturbation; (3) amplitude perturbation; (4) noise and tremor evaluation; (5) voice break, sub-harmonic and voice irregularity; and (6) other.

Procedures

Data were obtained in the Voice Laboratory by recording the voice sample of the sustained /a/ vowel at a comfortable pitch and constant amplitude. All participants were given a practice trial for each task following the clinician's model, in order to assure the individual's best production. During the recording period, the participants were seated in an upright position and the microphone was placed 15 cm away from the participants' mouths. Recorded data were analyzed later.

Statistical Analysis

Statistical analysis was with the SPSS 15.0 package program. Student's t-test (Independent Samples t-test) was conducted in independent groups to set up a normative database and determine the difference between the genders. Pearson's correlation analysis was made to examine the relationship of F_0 with age, height, weight and gender. Covariance analysis was used to examine the effect of age, gender, height and weight on F_0.

Results

The F_0 means of the females and males aged between 4 and 14 years are illustrated in Figure 1.

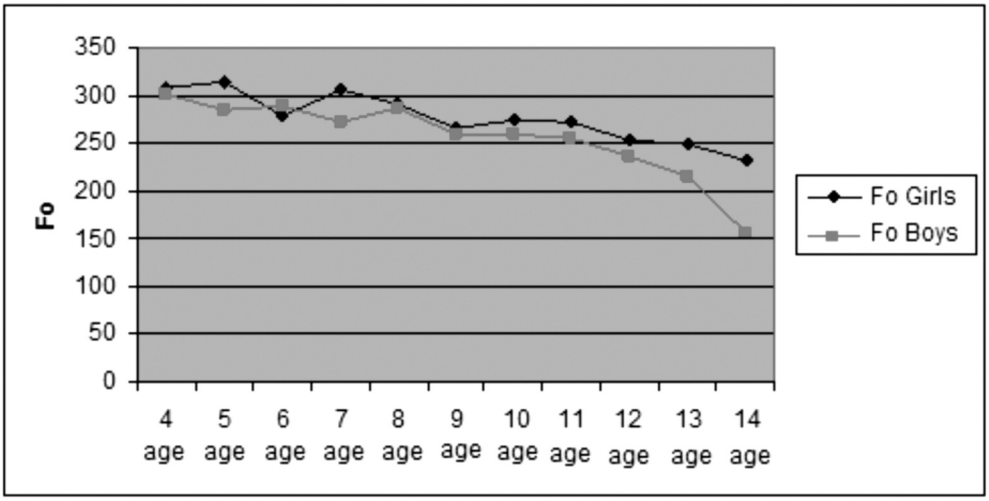

Figure 1. Fundamental Frequency by age and sex

Table 1. Demographic characteristics of the subjects

GENDER / AGE (years)		FEMALE N	FEMALE X±SD	FEMALE min-max	MALE N	MALE X±SD	MALE min-max
	Height		107,00±5,10	99-115		107,67±4,82	97-114
	Weight		18,67±2,55	15-23		17,44±1,33	15-19
4	Age range (y,m)	9	4,06±0,03	4,02-4,11	9	4.06±0,03	4,01-4,11
	Height		113,50±6,80	104- 127		116,00±3,87	110-124
	Weight	8	19,75±4,53	16-30	11	21,27±3,26	18-30
5	Age range (y,m)		5,06 ±0,03	5,03-5,11		5,05 ±0,03	5,02-5,11
	Height		121,00±4,75	115-127		116,08±5,35	106-122
	Weight	8	25,50±5,83	21-37	12	22,00±2,09	19-25
6	Age range (y,m)		6,07±0,04	6,00-6,11		6,05±0,02	6,02-6,09
	Height		122,22±3,77	116-129		123,33±5,72	111-132
	Weight	9	23,33±2,29	20-26	9	24,56±3,32	20-30
7	Age range (y,m)		7,06±0,03	7,00-7,10		7,05±0,03	7,02-7,11
	Height		130,89±4,51	124-136		134,78±5,61	129-145
	Weight	9	29,00±6,08	21-43	9	34,56±4,59	28-41
8	Age range (y,m)		8,07±0,03	8,00-8,11		8,05±0,03	8,00-8,10
	Height		132,91±4,76	124-140		139,00±7,54	124-150
	Weight	11	31,18±5,83	25-40	8	36,13±6,73	23-45
9	Age range (y,m)		9,07±0,04	9,01-9,11		9,06±0,03	9,03-9,11
	Height		145,00±8,03	136-158		139,22±6,04	128-147
	Weight	9	37,00±4,74	27-42	9	34,78±5,85	30-48
10	Age range (y,m)		10,05±0,03	10,01-10,10		10,05±0,02	10,03-10,07
	Height		151,82±6,40	145-167		149,30±7,53	132-160
	Weight	11	41,64±7,09	33-54	10	40,40±6,26	32-50
11	Age range (y,m)		11,06±0,03	11,00-11,10		11,06±0,02	11,03-11,09
	Height		159,56±7,67	147-170		153,78±8,97	140-165
	Weight	9	45,89±7,67	35-56	9	51,67±13,37	35-70
12	Age range (y,m)		12,06±0,02	12,03-12,09		12,07±0,02	12,04-12,11
	Height		161,89±5,13	155-169		160,00±5,61	150-166
	Weight	9	47,44±3,47	40-52	9	52,22±7,31	39-64
13	Age range (y,m)		13,06±0,02	13,02-13,08		13,06±0,02	13,03-13,08
	Height		163,00±4,92	155-170		168,13±5,08	163-178
14	Weight	8	49,88±4,02	43-54	8	62,25±12,52	44-80
	Age range (y,m)		14,06±0,04	14,00-14,11		14,08±0,03	14,02-14,11

Although there were small gender differences between the F_0 values, there was no statistically significant effect of age on F_0 ($p>0.05$) in the younger age groups (4-8 years). However, a noticeable change started afterwards with F_0 starting to decrease in boys after 8 years of age and in girls after 10 years of age although no statistically significant difference was observed between the genders in terms of age ($p>0.05$). While F_0 decreased at the same level in girls, it decreased again in boys at 13 years of age, creating a statistically significant difference ($p=0.000$) between the genders (Table II).

We found that the correlation between F_0 and height (min: -0,01; max: 0,53) and weight (min:-0,001; max: 0,65) in females and between F_0 and height (min :-0,54; max: 0,06) and weight (min: -0,59; max: 0,22) in males did not change with the age ($p>0.05$).

Table III presents the acoustic parameters data for Turkish-speaking, English-speaking, English-speaking Caucasian and English-speaking African-American, and Arabic-speaking children.

As illustrated in Table IV, V and VI, statistically significant differences of VTI measures were observed at age 7 (p=0,034), Fhi (p=0,016) and PER (p=0,003) measures at age 10, PER measures both at age 11 (p=0,037) and 13, (p=0,002), and lastly Fhi (p=0,001), Flo(p=0,000) and Jita (p=0,043) measures at age 14.

Discussion

Differences between male and female voices are an important aspect of gender identity. The main objective of this study was to determine the acoustic characteristics of Turkish-speaking children. The acoustic analyses of Turkish children's voices revealed findings similar to earlier studies. Kılıc et al.[19] reported mean F_0 values for Turkish-speaking adult males as Eguchi and Hirsh[20] found F_0 to be 270-300 Hz for preadolescent children. O'Neil et al.[5] reported a value of 279 Hz in girls and 281 Hz in boys,[5] while Campisi et al.[10] found a value of 279 Hz in both female and male children, indicating that girls of all ages and boys younger than 12 years old had the same vocal features[10]. The data from the current study suggest that there are no clear F_0 differences until the age of 13.

Fundamental frequency is based on vocal fold vibration and is determined by the mass and size of the vocal folds. Most acoustic studies of children's voice samples have shown little or no difference between genders under 13 years of age similar to our findings and it is apparent that vocal fold size does not increase significantly until puberty[5,21,22]. On the other hand, some authors[6,18,23,24] have reported that a significant F_0 difference between genders is observed at ages between 3 and 10 indicating that laryngeal structural change starts during that period.

Table 2. F_0 values of sustained /a/ regarding the ages and genders

AGE	F_0 (Hz) Females	Males	p
4	307,028±39,78	302,54±29,91	0,804
5	313,47±41,73	284,29±25,26	0,075
6	278,11±30,99	289,74±37,69	0,479
7	306,48±42,84	272,34±39,93	0,099
8	291,38±41,63	286,46±32,30	0,783
9	266,17±18,18	260,64±13,91	0,484
10	275,00±19,09	259,47±17,55	0,091
11	271,02±14,12	256,30±23,51	0,095
12	252,40±19,97	236,07±17,45	0,083
13	248,16±9,28	216,41±11,58	0,000**
14	232,51±9,00	156,87±15,67	0,000**

***p<0.05*

Table 3. Normative Values of Acoustic Parameters of the Child Voice Speaking Different Languages

Age (years)	Turkish-speaking		Arabic-speaking		African-American (English-speaking)		Caucasian (English-speaking Asian)		English-speaking	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
4	307	302							286f/232[b]	291[f]/224[b]
5	313	284	291[a]	281[a]			270[d]	270[d]	257[f]	262[f]
6	278	289	282[a]	281[a]	211[c]	220[c]	265[d]	265[d]	254[f]/242[g]	246[f]/248[g]
7	306	272	275[a]	287[a]			260[d]	260[d]	261[ı]	234[f]
8	291	286	279[a]	303[a]		230[e]	255[d]	250[d]	264[f]/234[g]/215[b]	235[f]/255[g]/217[b]
9	266	260	279[a]	-		217[e]	245[d]	240[d]	253[f]	230[f]
10	275	259	277[a]	278[a]		204[e]	245[d]	235[d]	247[f]-226[g]	228[f]-223[g]
11	271	256	291[a]	257[a]			227[d]	238[d]	221[h]	216[h]
12	252	236	-	-					213[b]	203[b]
13	248	216	-	-						
14	232	156	274[a]	214[a]			225[d]	175[d]		

a- O'Neil et al.[5] b- Perry et al. [8] c- Wheat and Hudson [7] d- - Wilson[15] e- Morris [16] f- Cummings[4] g- Whiteside and Hodgson [17] h- Bennett[6] ı- Hasek and Singh [18]

Kent[25] suggested that F_0 increases in the first 4 months in the postpartum period and remains stable during the subsequent 5 months. It then decreases sharply at around 1 year of age and gradually decreases between the ages of 3 and 11 with the difference between genders for F_0 unclear until 13 years of age, i.e. the beginning of puberty.

In this study, it is found that F_0, an important parameter in terms of laryngeal development, started to decrease after age 8 in boys and age 10 in girls, with a sharper decrease in boys at the age of 13 and older and the difference between genders was significant. Preadolescent girls had slightly higher F_0 values than boys. Similarly; Glaze et al.[26] and Whiteside and Hodgson[17] stated that F_0 decreases by age and girls have higher F_0 values than boys of the same age.

Andrews and Summers[27] found a significant relationship between F_0 and weight, gender and height. They stated height, gender and weight provided clearer information on maturation compared with age between the ages of 9.5 and 13, while Perry et al.[8] and Campisi et al.[10] suggested that this was the case after age 12. No relationship between neither F_0 and height nor weight were found in this study.

Fundamental frequency is influenced by language, ethnicity and age. It is suggested that Arabic-speaking children have higher F_0 values than English-speaking African-American children[5]. With this study it is shown that F_0 values of Turkish-speaking children were higher than English-speaking children but lower than Arabic-speaking children of the same age.

Regarding other MVDP parameters such as jitter, shimmer and NHR, Glaze et al. [26] found a mean shimmer value of 6.28and O'Neil et al.[5] found a mean shimmer value of 2.9 in Arabic-speaking children. In this study, jitter and shimmer values were higher than those reported by Campisi et al.[10] and O'Neil et al.[5] and a lower shimmer value than that of Glaze et al.[26]. Our NHR value is higher than that of Campisi et al.[10] but lower than that of O'Neil et al.[5] (Table III).

Stensapir et al.[11] stated that white children have a higher jitter value than black children**.** Colton and Woo[2] found the normal jitter value to be 1% in English-speaking individual sand it increases slightly in Arabic-speaking children[5]. The average jitter value in the present study was 1.29 in girls and 1.30 in boys. The shimmer value was found to be 4%, a normal value, in English-speaking Caucasians[26]. The shimmer value has been reported as 3.72 in Arabic-speaking girls and 3.11 in boys, increasing to as high as 8.24 in girls and 8.5 in boys[5]. A jitter value of 0.50 and shimmer value of 2.9 has previously been reported for Turkish-speaking males[19]. Our shimmer value was 4.72 and 4.65 in the girls and boys respectively.

Table 4. Acoustic measures of females

Age (years)	Fhi	Flo	Jita	Jitt	RAP	PPQ	sPPQ	vF0	Shim	APQ	sAPQ	vAm	NHR	VTI	SPI	PER
4	368,20±48,89	251,02±51,97	62,87±44,91	1,90±1,29	1,15±0,78	1,13±0,77	1,36±0,83	3,93±2,34	5,86±2,17	4,21±1,52	6,30±2,87	36,59±19,33	0,16±0,03	0,06±0,02	4,48±2.07	895,67±183,78
5	410,86±72,18	255,14±42,25	44,10±25,81	1,36±0,80	0,83±0,49	0,81±0,48	1,04±0,77	3,03±2,19	5,13±1,59	3,50±1,51	6,43±3,11	38,02±17,61	0,14±0,01	0,05±0,15	6,12±4.61	877,50±222,85
6	366,15±67,18	220,37±24,21	46,25±17,31	1,28±0,50	0,77±0,31	0,78±0,32	0,98±0,54	5,14±6,67	5,79±1,81	4,21±1,46	6,79±2,17	31,00±10,66	0,14±0,02	0,05±0,03	4,87±2,90	979,25±113,00
7	411,60±107,59	260,11±33,19	38,61±24,13	1,16±0,68	0,70±0,42	0,68±0,40	0,92±0,54	2,42±0,64	4,18±1,52	3,24±0,94	6,08±1,13	28,90±6,81	0,14±0,02	0,03±0,01	7,08±4,48	1090,22±140,90
8	352,36±63,21	214,67±63,77	40,94±17,88	1,16±0,47	0,70±0,28	0,62±0,34	0,97±0,54	5,34±6,32	4,26±1,82	3,17±1,37	5,93±1,94	31,71±12,61	0,14±0,03	0,05±0,02	11,42±7,51	1038,67±154,47
9	339,50±65,87	224,23±26,79	53,03±32,20	1,39±0,79	0,84±0,48	0,82±0,45	0,91±0,46	2,43±0,78	6,05±2,66	4,26±1,60	6,69±2,43	24,16±8,75	0,15±0,04	0,04±0,01	8,10±6,17	897,27±277,16
10	354,10±33,71	240,02±26,93	47,86±34,42	1,31±0,88	0,79±0,53	0,79±0,53	0,84±0,57	2,02±0,89	4,04±1,56	3,02±1,26	5,54±1,96	23,41±9,89	0,13±0,02	0,03±0,01	9,38±4,34	1061,11±91,03
11	360,20±63,95	238,71±15,35	42,15±16,96	1,14±0,46	0,69±0,28	0,69±0,28	0,81±0,33	2,19±0,85	4,51±0,77	3,42±0,72	6,42±2,58	26,50±15,26	0,15±0,06	0,05±0,02	11,11±5,88	997,27±53,78
12	316,04±26,56	203,18±49,05	46,23±29,72	1,15±0,71	0,69±0,43	0,71±0,46	1,06±1,22	3,49±4,01	3,83±1,86	2,87±0,78	5,89±2,02	19,61±5,64	0,13±0,02	0,04±0,01	12,32±5,14	928,78±94,58
13	308,41±49,40	213,61±29,07	50,63±30,67	1,30±0,80	0,78±0,48	0,80±0,48	0,87±0,48	1,76±0,84	4,18±1,66	3,03±1,06	5,70±1,73	30,22±15,57	0,13±0,02	0,03±0,01	16,95±4,70	942,11±48,46
14	267,88±27,76	214,61±16,58	45,30±17,45	1,05±0,40	0,63±0,24	0,63±0,23	0,76±0,28	1,72±0,67	3,93±1,10	2,84±0,78	5,62±1,06	29,12±13,44	0,12±0,22	0,04±0,01	15,73±4,16	664,38±209,95

Table 5. Acoustic measures of males

Age (years)	Fhi	Flo	Jita	Jitt	RAP	PPQ	sPPQ	vF0	Shim	APQ	sAPQ	vAm	NHR	VTI	SPI	PER
4	367,27±36,99	235,19±51,96	46,43±22,54	1,38±0,62	0,81±0,39	0,85±0,37	0,98±0,30	4,54±3,23	4,89±2,13	3,77±1,47	6,82±2,02	34,50±7,43	0,14±0,02	0,08±0,08	7,20±8,56	886,11±255,62
5	387,60±82,54	208,88±63,22	71,53±49,27	1,94±1,12	1,16±0,67	1,16±0,73	1,87±2,27	8,37±12,81	6,37±2,65	4,57±1,74	7,86±2,91	38,23±13,62	0,18±0,08	0,77±0,11	7,85±5,61	796,91±209,79
6	367,43±72,43	248,08±42,21	44,40±27,82	1,25±0,70	0,74±0,46	0,77±0,46	0,91±0,44	2,88±1,09	4,67±1,87	3,66±1,65	6,25±3,18	26,86±10,72	0,14±0,03	0,05±0,01	8,12±5,55	999,50±195,79
7	354,43±85,50	223,53±45,27	40,03±26,34	1,10±0,66	0,66±0,81	0,67±0,50	1,14±1,27	3,95±4,23	4,42±2,33	3,32±1,69	5,46±2,40	25,23±9,71	0,14±0,02	0,05±0,03	9,20±6,93	946,67±139,09
8	338,00±36,07	236,93±48,45	40,81±19,31	1,16±0,55	0,70±0,81	0,68±0,31	0,93±0,50	3,38±3,57	4,93±2,54	3,56±1,40	6,40±2,33	30,30±12,61	0,14±0,03	0,08±0,09	11,42±6,16	984,11±112,70
9	324,57±28,16	198,32±56,18	53,51±23,10	1,40±0,62	0,84±0,38	0,86±0,41	1,45±1,72	5,21±8,51	4,52±2,18	3,27±1,21	5,73±1,63	27,20±10,18	0,13±0,03	0,04±0,02	14,83±9,85	929,00±57,06
10	301,13±48,60	208,25±44,58	50,88±25,24	1,26±0,66	0,76±0,39	0,75±0,39	0,88±0,35	3,11±3,08	4,63±1,06	3,41±0,71	6,02±1,59	24,21±9,49	0,14±0,02	0,04±0,01	12,34±6,49	885,22±124,15
11	318,14±58,25	222,47±24,96	48,35±20,20	1,23±0,52	0,74±0,32	0,74±0,33	0,82±0,35	2,14±0,86	4,45±1,54	3,43±1,26	5,92±2,31	24,70±7,19	0,13±0,02	0,04±0,01	16,12±5,82	917,40±103,96
12	299,85±68,99	214,54±26,41	51,29±29,70	1,19±0,72	0,72±0,43	0,72±0,41	0,85±0,36	2,40±1,24	4,16±1,64	3,26±1,05	6,12±1,79	23,18±12,57	0,14±0,02	0,05±0,02	14,25±6,81	843,11±214,13
13	265,46±44,99	198,37±18,75	53,48±22,58	1,18±0,51	0,72±0,43	0,70±0,31	0,81±0,26	2,12±0,90	4,00±0,91	2,92±0,60	5,12±1,42	23,43±14,35	0,13±0,01	0,04±0,01	20,81±5,86	716,78±179,81
14	192,81±39,94	135,92±13,84	66,82±21,09	1,15±0,49	0,69±0,29	0,70±0,30	0,83±0,35	1,97±0,62	3,62±1,12	2,77±0,90	4,78±1,31	27,46±12,42	0,15±0,02	0,04±0,01	24,04±10,19	565,25±68,880

Table 6. p values of Acoustic measures

Age	Fhi	Flo	Jita	Jitt	RAP	PPQ	sPPQ	vF0	Shim	APQ	sAPQ	vAm	NHR	VTI	SPI	PER
4	0,964	0,527	0,341	0,291	0,262	0,33	0,215	0,654	0,354	0,536	0,668	0,766	0,236	0,543	0,369	0,929
5	0,532	0,091	0,17	0,234	0,246	0,256	0,338	0,263	0,256	0,179	0,319	0,978	0,239	0,481	0,485	0,432
6	0,969	0,112	0,869	0,901	0,867	0,97	0,756	0,261	0,2	0,457	0,683	0,408	0,821	0,857	0,148	0,795
7	0,23	0,068	0,907	0,883	0,874	0,962	0,618	0,299	0,797	0,902	0,495	0,367	0,788	0,034**	0,454	0,045
8	0,562	0,417	0,988	1.000	0,982	0,701	0,882	0,43	0,528	0,56	0,647	0,816	0,786	0,423	1	0,405
9	0,557	0,197	0,972	0,977	0,998	0,858	0,336	0,292	0,201	0,16	0,303	0,492	0,184	0,928	0,075	0,823
10	0,016**	0,085	0,836	0,894	0,903	0,85	0,981	0,321	0,36	0,439	0,568	0,864	0,658	0,18	0,272	0,003**
11	0,133	0,085	0,454	0,698	0,678	0,726	0,968	0,903	0,909	0,988	0,646	0,739	0,305	0,231	0,06	0,037**
12	0,521	0,55	0,722	0,906	0,901	0,959	0,614	0,448	0,633	0,387	0,798	0,449	0,465	0,209	0,517	0,288
13	0,072	0,205	0,825	0,688	0,684	0,629	0,758	0,393	0,778	0,799	0,448	0,35	0,404	0,113	0,143	0,002**
14	0,001**	0,000**	0,043**	0,658	0,649	0,625	0,652	0,435	0,586	0,872	0,18	0,801	0,006	0,791	0,051	0,225

*$p<0.05$

Children have lower values than adults. The differences in the values of the children speaking different languages may be the result of linguistic impact.

The difference between genders was found to be significant for F_0 as of 13 years of age, and for Fhi and Flo as of 14 years of age.

Conclusion

This study aimed to provide insight on the acoustic correlates of gender and the relative importance of these factors with development. The MDVP is an objective and noninvasive diagnostic tool that monitors functional voice modalities. The current results have provided normative values of acoustic measures for Turkish-speaking 4- to 14-year old children. Fundamental frequency, which is considered to be a criterion for voice change during preadolescence, was found to be statistically significant as of age 13. Normal acoustic reference ranges may be used to detect vocal fold pathologies and to monitor voice therapy outcomes. There will be better understanding of vocal samples of different languages as more studies are conducted in different languages and cultures.

References

1. Shoup JE, Lass NJ, Kuehn DP. Acoustics of speech. In: Lass NJ, McReynolds LV, Northern J L, Yoder DE, editors. Speech, language and hearing. Philadelphia: W.B. Saunders; 1982. p. 193-218.

2. Colton RH, Woo P. Measuring vocal fold function. In: Rubin S, Sataloff RT, Korovin GS, editors. Diagnosis and Treatment of Voice Disorders. Australia: Thomson Delmar Learning; 2003. p. 309-30.

3. Korovin GS, Rubin JS. Introduction to the laboratory diagnosis. In: Rubin S, Sataloff RT, Korovin GS, editors. Diagnosis and Treatment of Voice Disorders. Australia: Thomson Delmar Learning; 2003. p. 183-90.

4. Cummings MC. Normative acoustic and aerodynamic measures of voice production on 3, 4, and 5 year olds and voice quality following laryngotracheoplasty in children diagnosed with laryngotracheal stenosis. University of Cincinnati:Doctor of Philosophy dissertation; 1994. p. 1-358.

5. O'Neil EN, Jones GW, Chad N. Acoustic characteristics of children who speak Arabic. Int J Pediatr Otorhinolarygo 1997; 42:117-24.

6. Bennett S. A 3-year longitudinal study of school aged children's fundamental frequencies. J Speech Hear Res 1983; 26:137-42.

7. Wheat MC, Hudson AI. Spontaneous speaking fundamental frequency of 6 year old Black children. J Speech Hear Res 1988; 31:723-5.

8. Perry TL, Ohde RN, Ashmead DH. The acoustic bases for gender identification from children's voices. J Acoust Soc Am 2001; 109**:**2988-98.

9. Hollien H, Maclik E. Adolescent Voice Change in Southern Negro Males. Speech Monogr 1962; 29:53-8.

10. Campisi P, Tewfik TL, Manoukian JJ, Schloss MD, Pelland-Blais E, Sadeghi N. Computer-assisted voice analysis: Establishing a pediatric database. Arch Otolaryngol Head Neck Surg 2002; 128**:**156-60.

11. Steinsapir CD, Forner LL, Stemple JC. Voice characteristics among black and white children: Do differences exist? J Acoust Soc Am 1986; 80:58-62.

12. Natour YS, Wingate JM. Fundamental frequency characteristics of Jordanian Arabic speakers. J Voice 2009; 23:560-6.

13. Roeser RJ, Buckley KA, Stickney GS. Pure tone tests. In: Roeser RJ, Valente M, Hosford-Dunn H, editors. Audiology Diagnosis. New York:Thieme Medical Publishers; 2000. p. 227-51.

14. Traen RJ. Multi-dimensional voice program norms for aging female voices. Eastern Illinois University: Master Thesis; 2003. p.1-90

15. Wilson DK. Voice problems in children. 3rd ed. Baltimore: Williams & Wilkins; 1987. p. 1-400.

16. Morris RJ. Speaking fundamental frequency characteristics of 8- through 10 year old white and African- American boys. J Commun Disord 1997; 30:101-16.

17. Whiteside SP, Hodgson C. Some acoustic characteristics in the voice 6 to 10-year-old children and adults: comparative sex and developmental perspective. Logoped Phoniatr Vocol 2000; 25:122–32.

18. Hasek CS, Singh S. Acoustic attributes of preadolescent voices. J Acoust Soc Am. 1980; 68:1261-5.

19. Kılıç MA, Öğüt F, Dursun G, Okur E, Yıldırım I, Midilli R. The Effects of vowels on voice perturbation measures. J Voice 2004; 18:318–24.

20. Eguchi S, Hirsh I. Development of speech sounds in children. Acta Oto-laryngologica supplement 1969; 257:5–51.

21. Fairbanks G, Herbert E, Hammond J. An acoustical study of vocal pitch in 7 and 8 year old girls. Child Development 1949; 20:71–8.

22. Harries MLL, Walker JM, Williams DM, Hawkins S, Hughes IA. Changes in the male voice at puberty. Arch Dis Child 1997; 77**:**445-7.

23. Busby PA, Plant GL. Formant frequency values of vowels produced by preadolescent boys and girls. J Acous Soc Am 1995; 97:2603-6.

24. Sorenson DN. A fundamental frequency investigation of children ages 6-10 years. J Commun Disord 1989; 22:115-23.

25. Kent RD. Anatomic and neuromuscular maturation of the speech mechanism: Evidence from acoustic studies. J Speech Hear Res 1976; 19:421-47.

26. Glaze LE, Bless DM, Milenkovic P, Susser RD. acoustic characteristics of children's voices. J Voice 1988; 2**:**312-9.

27. Andrews ML, Summers AC. A clinical perspective: infants, toddlers and preschoolers. In: Andrews ML, Summers AC, editors. Voice treatment for children and adolescent. Canada: Singular Thomson Learning; 2002. p. 11-7.