Voice Mutation During Adolescence in Mangalore, India: Implications for the Assessment and Management of Mutational Voice Disorders

Radish Kumar Balasubramaniam and Nikhita N, *Mangalore, Karnataka, India*

Summary: Background. The knowledge of vocal mutation is important for speech pathologists in the diagnosis and management of individuals with mutational voice disorders. However, data on vocal mutation in the Indian population are scarce and hence the present study was planned to investigate the age of attainment of vocal mutation in boys and girls from Mangalore, India, in the age range of 8–18 years.

Methods. A total of 600 participants in the age range of 8–18 years were divided into 10 groups with a 1-year interval. Sustained phonation /a/ and a narration were recorded. Two-way analysis of variance was used to obtain significant difference between the means across age and gender for the fundamental frequency and formant frequency measures.

Results. There was significant main effect of groups for fundamental frequency measure in boys, with post hoc tests revealing statistically significant differences from 14 years of age onward. However, the cutoff criteria of 140 Hz in boys and 240 Hz in girls were attained only by 16 years of age in boys and 15 years in girls, indicating that 16 and 15 years as the ages of onset of vocal mutation in boys and girls, respectively. Results also revealed that first formant frequency undergoes changes from 13 years onward. However, F2 changes from 16 years of age, with no significance observed in F3.

Conclusion. The results of the present study are useful in the assessment and management of individuals with mutational voice disorders.

Key Words: Vocal mutation–Fundamental frequency–Formant frequency–Mutational voice disorders–Acoustic analysis.

INTRODUCTION

Puberty is an event in life during which boys and girls undergo many bodily changes that will make them sexually mature for reproduction. It is a gradual and variable process during adolescence and usually happens between the ages of 10 and 14 years for girls and between the ages of 12 and 16 years for boys. It is caused by the secretion of hormones in the body. These hormones are essential for the changes to take place in the body during puberty. Puberty usually starts when the hypothalamus releases gonadotropin-releasing hormone, which informs the pituitary gland to release follicle-stimulating hormone and the luteinizing hormone. These hormones are majorly important for the sexual development for both boys and girls. When these hormones are released, puberty starts by various bodily changes in both boys and girls. Girls undergo a menstruation period,[1,2] which makes them aware of puberty. However, there is no clear onset of puberty, such as menstruation, for boys necessitating the use of secondary characteristics and biomarker testing. Traditional measures of male puberty markers consist of the age at peak height velocity,[2,3] testicular volume,[4,5] Tanner stages of genital and pubic hair development,[2,4] and endocrine biomarkers (eg, dehydroepiandrosterone sulfate and testosterone).[6,7] However, these measures are not reliable.[2,8–10]

A number of physical and hormonal changes take place in both boys and girls that will influence the transition from a prepubescent voice to a mature, adultlike voice and subsequently impact on communication, social interaction, personality, and artistic expression.[11] Testosterone is responsible for producing male voice, whereas progesterone and estrogen help to shape a female voice. The androgen hormones also help the larynx to grow bigger in both genders. During the pubertal development, the male larynx grows in the anterior posterior direction, leading to the development of a prominent thyroid notch in adult males. The thyroid angle shifts from 120° to 90° with the thickening of the muscular and mucosal layers of vocal folds.[12] As a result, vocal folds lengthen and widen in males. However, in females thyroid cartilage shows little development, with the slight thickening of the mucosal and muscular layers. In general, the female larynx increases in size with respect to height than the width.[12] Weiss observed that the principal differences between the male and female larynx play a major role in the perceptual differences between males and females.[13]

Due to these differences, the pitch of speaking fundamental frequency (F0) is quite different for males and females. During puberty, a male's voice decreases by one octave in pitch[11] and the female voice by a few semitones.[11] Hence, pitch of the speaking F0 can be used as an indicator for voice development, especially in males.[14] Fundamental frequency, which changes significantly during adolescence in boys,[3,15–17] is an underutilized male pubertal marker and would be a useful marker of male pubertal development as it impacts social interaction, and communication. Research indicates that a lower voice in males and a higher pitch in females impacts social perceptions, including assessments of age and gender,[18,19] and size.[18,19] The perceptual experience of a "low"-pitched voice in males and a

Accepted for publication November 28, 2016.

From the Department of Audiology and Speech Language Pathology, Kasturba Medical College (Manipal University), Mangalore, Karnataka 575001, India.

Address correspondence and reprint requests to Radish Kumar Balasubramaniam, Department of Audiology and Speech Language Pathology, Kasturba Medical College (Manipal University), Mangalore, Karnataka 57500, India. E-mail: radheesh_b@yahoo.co.in

Journal of Voice, Vol. 31, No. 4, pp. 511.e29–511.e33

0892-1997

http://dx.doi.org/10.1016/j.jvoice.2016.11.019

high-pitched voice in females is the product of two acoustic components, which is the fundamental frequency (a perceptual correlate of "pitch," F0) and formant structure.[20,21] F0 is a product of the length, tension, and cross-sectional area of the vocal folds, such that larger vocal folds produce lower F0,[16,22] whereas formant frequency is the result of changes in the dimensions of vocal tract cavities due to puberty. A longer vocal tract in adult males produces lower and closely spaced formants in comparison to the formants of prepubertal boys.[23]

These pubertal changes vary across a number of factors, such as nutrition, overweight or obesity, or exposure to endocrine disruptors and environmental factors. These factors have either improved or declined over a period of time. From the late 19th to the mid-20th century, a gradual decline in the onset of puberty in girls has been reported based on the start of menstruation.[24] However, in males, no such characteristic event exists apart from the development of secondary sexual characteristics and vocal mutation. Hence, it is difficult to ascertain the exact age of attainment of puberty in males. Yet the vocal mutation and the development of secondary sexual characteristics are observed to be advanced even in males.

These observations are raising the issues of timing of puberty in relation to ethnic, geographic, environmental, and socioeconomic backgrounds.[1–3,24–27] Also, the knowledge of vocal mutation is very important for speech pathologists in the diagnosis and management of individuals with mutational voice disorders. But the vocal mutation in the Indian population is not studied so far. Moreover, the results of the western population cannot be generalized to the Indian population. Hence, the present study was attempted to identify the age of vocal mutation in Indian boys and girls. The objective of the present study was to identify the age-related changes in fundamental frequency and formant frequency across adolescents in the age range of 8–18 years.

METHODS

Participants

A comparative cross-sectional study design was used for the present study. A total of 600 participants in the age range of 8–18 years were divided into 10 groups with a 1-year interval. Each group consisted of 60 participants (30 males and 30 females). All the participants had normal hearing and adequate speech and language development. The normal voice quality was ensured among the participants with Grade, Roughness, Breathiness, Asthenia, Strain (GRBAS) ratings. Participants with a history of vocal abuse or misuse, smoking, and reflux symptoms were excluded based on the detailed history. The present study was approved by the institutional human ethics committee at our institution. An informed consent was obtained from all the participants.

Instrumentation

The voice samples were recorded through a sensitive dynamic microphone that was connected to a laptop computer (Lenovo G550) (Lenovo Group Ltd, Beijing, China) and recorded through *Praat* software (version 5.1.43) (University of Amsterdam, Amsterdam, Netherlands) at a 44.1-kHz sampling frequency. *Praat* software was used for voice analysis from the recorded voice samples.

Procedure

Each participant was seated comfortably on a chair. Sustained phonation was recorded through a sensitive dynamic microphone kept at a constant distance of 10 cm from the participant's mouth in a quiet room. All the voice samples were directly recorded into the *Praat* software. Before the actual recording, the participants were instructed to sustain a vowel /a/ at the most comfortable pitch and loudness for at least 5 seconds. They were also asked to narrate about the topic "home." Two-way analysis of variance was employed to obtain the significant difference between the means across age and gender.

Analysis

Fundamental frequency was extracted from the sustained phonation sample, whereas the formant frequencies were extracted from vowel /a/ belonging to the word home (/mane/).

RESULTS

The aim of the present study was to determine when vocal mutation occurs in Indian adolescents. Descriptive statistics was employed to obtain the mean and the standard deviation of the fundamental frequency and formant frequencies among the Indian adolescents. The results are as follows.

From Table 1, it is observed that fundamental frequency decreases with an increase in age in adolescent boys. Conversely, F0 decreases only by a few hertz with an increase in age in adolescent girls. However, the cutoff criteria of 140 Hz in boys[28] and 240 Hz in girls[28] is attained by 16 years in boys and 15 years in girls, respectively.

TABLE 1.
Mean and SD of Fundamental Frequency Across Age Groups and Gender

Group	Gender	Mean	SD
8–8.11 y	Male	241.36	36.30
	Female	256.76	21.38
9–9.11 y	Male	262.54	41.93
	Female	267.71	34.24
10–10.11 y	Male	267.19	30.82
	Female	271.51	29.61
11–11.11 y	Male	246.15	26.84
	Female	241.52	19.27
12–12.11 y	Male	238.65	21.36
	Female	245.82	42.02
13–13.11 y	Male	248.00	33.31
	Female	232.61	20.24
14–14.11 y	Male	200.40	52.54
	Female	242.64	29.32
15–15.11 y	Male	163.78	38.47
	Female	239.88	25.22
16–16.11 y	Male	140.05	34.75
	Female	213.93	27.49
17–17.11 y	Male	131.78	25.21
	Female	226.77	29.90

Abbreviation: SD, standard deviation.