



Science for Singers

A SERIES OF VOICE RESEARCH COLUMNS BY INGO R. TITZE, PhD

Critical Periods of Vocal Change: Puberty

This is the second part of a series of observations on critical periods of vocal change. The first part dealt with early childhood, and the last part will address advanced age. In this column, a few observations are made about puberty.

The most obvious vocal change in puberty is a dramatic pitch lowering, especially in males. A rapid and disproportionate growth in the larynx is responsible for this, brought about by an increase in release of the male hormone *testosterone*. This disproportionate growth is primarily in the thyroid cartilage, and therewith in the membranous vocal fold length, resulting in a protruding "Adam's apple" (Kahane, 1978). Membranous length L_m is defined as the distance from the tips of the vocal processes to the anterior commissure of the glottis (Figure 1a). This is the vibrating portion of the vocal folds. On average, a significant lowering in F_0 occurs for males between the years 10 to 16, as shown in Figure 2. Note that F_0 reduces from about 300 Hz to less than 200 Hz. In those same years, L_m changes from about 9 mm to about 13 mm. For a given individual, this downturn in F_0 is more abrupt (usually within one to two years), but since the growth spurt occurs at different ages for different individuals, the curve is smoothed out in the figure.

An increase in the bulk of the thyroarytenoid muscle is also a mark of puberty. This thickens the vocal fold as shown in Figure 1(b). There has been speculation about the effect of vocal fold thickness on fundamental frequency. Thickness in and of itself is not a major factor in determining F_0 . It does increase the overall mass of the vocal folds, but as mass is added, stiffness is added in proportion. Since F_0 depends on the ratio of stiffness to mass, there is no theoretical ground for assuming that thicker vocal folds have a lower fundamental frequency.

What, then, is the acoustic consequence of the enlarged thyroarytenoid muscle? It produces a register shift, an abrupt change in vocal quality. The bottom of the vocal fold bulges out medially, making the glottis more rectangular than wedge-shaped (Figure 1b). During vibration, glottal closure can then be obtained over a greater portion of the cycle, and more of the body of the vocal fold can be set into vibration (greater overall amplitude of vibration). The result is a voice of richer timbre, which we call *chest* or *modal* voice.

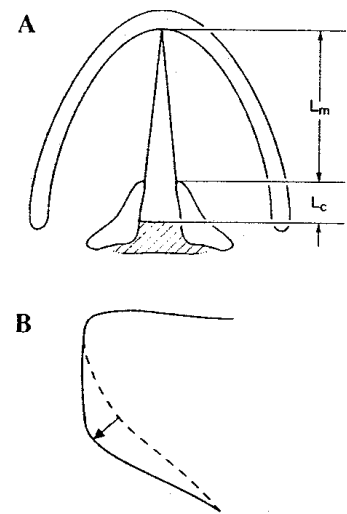


Figure 1. (a) Illustration of membranous vocal fold length L_m , the portion of the vocal fold that vibrates. L_c is the cartilaginous glottis. (b) Thickening of the vocal fold during puberty; right vocal fold is shown in frontal section.

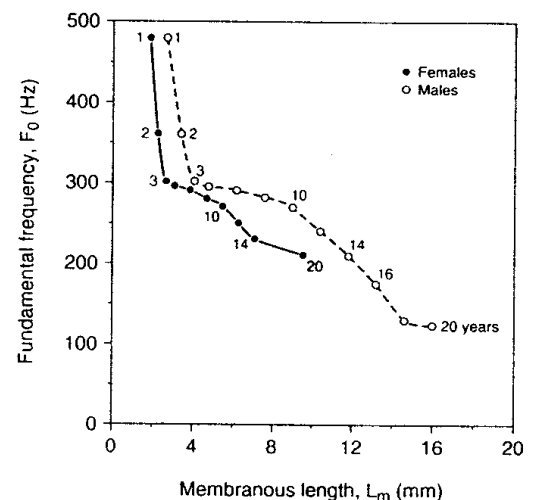


Figure 2. Fundamental frequency F_0 versus membranous vocal fold length L_m . Data points and numbers represent growth years.

During the growth spurt, adolescent boys find it difficult to control register. They often flip back and forth between their child voice and their new adult voice. This is understandable because vocal fold oscillation is critically dependent on the shape of the vocal folds (Titze, 1988). As the folds become thicker and more rectangular, different muscle patterns need to be developed to control the modes of vibration. It is basically a trial and error process, with the auditory system constituting the biofeedback loop.

Classification of voices in the adolescent years is fraught with difficulty, primarily because changes can occur so rapidly. In school choral groups, for example, a director may have a boy soprano at the beginning of the year, an alto by Christmas, and a tenor by graduation. But even beyond the major growth spurt, development continues up to about age 20.

This concludes the brief comments about puberty. In the next issue, some changes with advanced age will be highlighted.

References:

Titze, I. (1988). The physics of small-amplitude oscillation of the vocal folds. Journal of the Acoustical Society of America, 83(4), 1536-1552.

Kahane, J. (1978). A morphological study of the human prepubertal and pubertal larynx. American Journal of Anatomy, 15(1), 11-20.

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