Aerodynamic Measurements: Normative Data for Children Ages 15-17 Years

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Abstract. This paper mainly selects three teenagers aged 15-17 as research subjects.Study the various parameters of the airflow and air pressure during the obstruction and de-blocking phases of the aspirated stops and non-aspirated stops of this age group.It mainly collects the expiratory airflow duration,peak air pressure,expiratory volume,peak expiratory airflow to compare the aspirated and non-aspirated stops at different articulations.The results show that (1) the obstruction phase: the duration of the aspiration stops of the same place of articulation is longer than the duration of the non-aspirated stops ;the duration of the obstruction of the lip and the tip of the tongue is greater than the duration of the obstruction of the tongue;the air pressure value of the aspirated stops is slightly higher than the non-aspirated stops.(2) De-blocking stage: The expiratory airflow duration, expiratory volume,peak expiratory airflow of the aspiration stops are larger than the non-aspirated stops , and the expiratory airflow duration is proportional to the peak airflow and expiratory volume.

Keywords: Aerodynamics, expiratory volume, teenagers.

1. Introduction

Aerodynamics began in the 1950s with a focus on the amount of vital capacity, the level of subglottic pressure, and changes in airflow rate during human pronunciation [1]. The Rothenburg mask, designed by Rothenberg, M. in 1971, is of great significance for the use of airflow barometers for speech physiology research, and also allows humans to redefine the invisible airflow and air pressure during vocalization. Emanuel and Counihan (1970) and Isshiki, Ringerl (1964) studied the airflow mechanism of consonant of adults and found there is relatively better stability in airflow volumes of voiceless consonants compared with the voiced ones [2][3]. In recent years, there have been many foreign countries with airflow pressures of different age groups. For example, Beth Ann Salz (2003) explored the aerodynamic test of children aged 6-10 years. The experimental results show that the maximum airflow deviation rate of children increases with age. Richard and Zaick (2011) used PAS6600 to establish a database of adult (18-60) airflow parameters. It is believed that PAS6600 has great clinical significance for the evaluation and treatment of patients with vocal diseases. Barbara Weinrich (2012) explored the similarities and differences of airflow and pressure signals among children of different genders and ages by dividing 60 children into three age groups, and found that gender had the greatest impact on exhaled airflow. In the domestic experimental phonetics research, for example, Wang (1994) made a “spectral analysis of the voice of adolescents” to 126 students, and found that there is a significant difference between the fundamental frequency and the formant of the 13-17 year old adolescents[4].Zhang (2001) analyzed the acoustic parameters of children's voices in 4-8 years old, which showed that there was no difference in all parameters between normal preschool children and school age. There were significant differences between normal children and children with vocal cord nodules and other diseases of the throat [5]. Hu (2010) discovered the consonant pronunciation process and the acoustic characteristics of consonants such as VOT and gap, and the maximum airflow, maximum air pressure, maximum airflow to maximum air pressure by extracting signals from Chinese mandarin consonant airflow, acoustics, glottal impedance, and nasal flow. The duration, the position of the airflow to the distance between the highest peaks of the air pressure have a corresponding relationship, and the length of the maximum airflow to the maximum air pressure is proportional to the VOT [6]. Lv (2012) analyzed the airflow signals and parameters of the stop and the squeaky sounds. It was found that the airflow signals of the squeak and the squeaky sound were greatly affected by the pronunciation method. The size of the resistance and the sounding position caused different airflow speeds [7].

This paper mainly studies the characteristics and changes of airflow and air pressure in the 15-17-year-old adolescents who pronounce Chinese-speaking aspirated and non-aspirated stops. Mainly because this stage of the population is in an important turning point in adolescence, both physical and psychological changes have taken place. Especially in the adolescent boys, the physiological structure of their throats changed, the cartilage of the throat developed rapidly, especially the thyroid cartilage grew fastest, and the larynx was bulged forward, and the anteroposterior diameter of the larynx increased rapidly. The throat cavity becomes larger. The boys and girls in the vocal cords during adolescence are also slightly different. The vocal cords of boys will grow 5-10mm after puberty. The vocal cords of girls will grow 4-8mm after puberty, so the voice of boys is more generous and the voice of girls is clearer. And the adolescent period is the most energetic stage, and the vocal cords are also better.

2. Experimental Explanation

2.1 Experimental Materials

In this paper, non-aspirated stops b[p], d[t], g[k] and aspirated stops p[p^h], t[t^h], k[k^h] are selected. The relevant tuning organ is completely closed when the sound is blocked, and the airflow cannot pass, forming a blockage. This stage is the obstruction section of the stop sound; when the airflow breaks the blockage and makes a voice, it is the de-blocking. The stage between the two is the holding segment. The stop sound can also be divided into aspirated and non-aspirated stops according to the size of the air flow when the resistance is removed. In order to make it clearer that the stop sound is blocked and the block is removed, the above consonants are matched with the vowel [a]. In order to avoid the influence of different tones on the experimental data, all the syllables are 55 tone.

2.2 Participants

The main speakers are two men and one-woman, standard Mandarin, without any throat disease, and good vocal cord conditions. All the speakers were trained in pronunciation before the experiment, and they were asked to read each tone five times according to the pronunciation table. At the same time, the mask should be placed close to the face as much as possible. The mouthpiece is used to hold the air pressure tube and adjust the position of the air pressure tube according to the difference of the sounding resistance. Otherwise, the air pressure and airflow data will be affected, because the data collection of the air pressure is easy to deviate.

2.3 Instruments

This experiment used the Phonatory Aerodynamic System 6600 of the American KAY company. Since the pronunciation process of the consonant is a dynamic process, it is divided into three parts: resistance, holding, and removal. The occlusion period (GAP) and the vocal onset time (VOT) are two important parameters of the acoustic characteristics of the syllabary [8]. At the obstruction stage of the stop sound, the tongue position reaches the resistance point. At this time, the air pressure in the oral cavity also reaches a peak value, and then the blasting starts, and the airflow in the oral cavity breaks through the obstacle to achieve the stability of the airflow section.

The aerodynamic parameters selected in this paper are mainly:

(1) Expiratory Airflow Duration (EAD): Expiratory Airflow Duration (EAD) refers to the time length of the whole articulating process, from the airflow starting point (ST) to the end of articulation (ET).

(2) Peak Air-pressure (PAP): Refers to the maximum pressure in the oral air pressure before the deblocking.

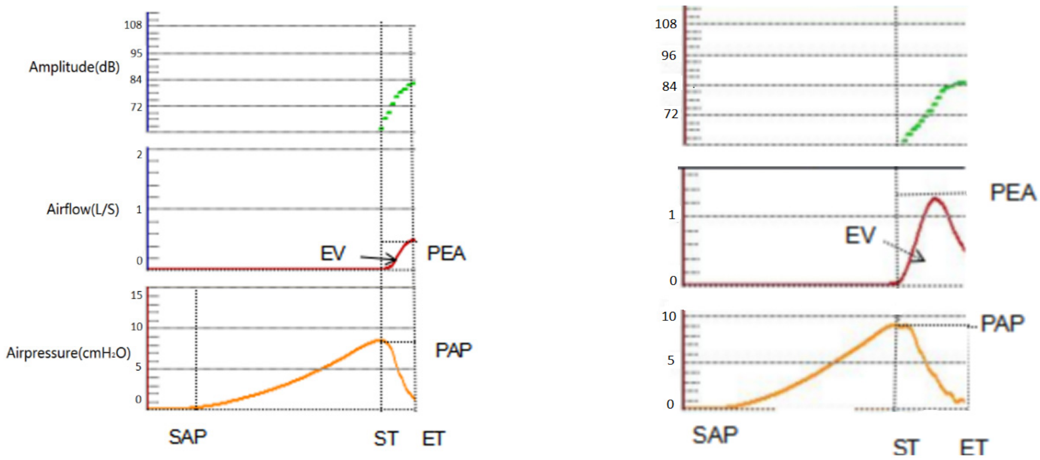
(3) Expiratory Volume (EV): Expiratory Volume is the amount of airflow exhaled during the consonant articulation.

(4) Peak Expiratory Airflow (PEA): The airflow signal is the volumetric velocity of the airflow as a function of time. The peak velocity of the airflow is the maximum value of the airflow signal during the consonant pronunciation.

3. Experimental Results

3.1 Aerodynamic Characteristics of the Stop

The difference in the pronunciation part of the consonant determines the size and shape of the resonance cavity. The difference in the pronunciation method determines the difference of the airflow removal mode. Comparing the airflow pressure signal diagrams of Fig. 1 non-aspirated stops [p] and aspirating stops [p^h]. It can be clearly and intuitively seen that the air flow of the air supply stops is significantly larger than that of the airless stops.



[p] [p^h]

Figure 1. [p] and [p^h].

Fig. 1 [p] shows the airflow pressure signal of the airless stops. The pronunciation physiological process is mainly as follows:

In the stage of obstruction and resistance, the air generated by the lungs is transported through the glottis to the oral cavity, and the resistance is blocked at the point of formation. Therefore, the air pressure in the mouth continues to increase from zero. When the ST position is marked, the air pressure in the mouth reaches the maximum value PAP. There is no airflow or sound pressure in this section. In the de-blocking stage, the airflow breaks through, the air pressure in the mouth drops rapidly, the airflow rate rises rapidly from zero, the sound pressure also rises rapidly, and the transient noise formed, ET is the peak point of the airflow signal, at which time the airflow speed reaches the peak PEA. Both the sound pressure and the air pressure signal tend to be stable, the consonant ends, and the area covered by the airflow signal and the abscissa axis is the consonant airflow EV. The aerodynamic characteristics of adolescents who non-aspirated sound are mainly characterized by a relatively long resistance period of about 80ms-130ms.The duration of the blasting phase is about 40ms-50ms.The peak pressure is about 7cmH2O~9cmH2O.Due to the short blasting time, the airflow signal of the stop sound is relatively small, and the peak value of the airflow is between 0.3 L/s and 0.5 L/s, and the air flow rate is small.

Fig. 1 [p^h] is a gas pressure signal diagram of the air supply plug sound. The air supply plug sound is basically the same as the stop sound before the stop sound is blasted, and the pressure in the mouth reaches the maximum value.

During the de-blocking phase, the airflow breaks through, the air pressure in the mouth drops rapidly, the airflow rate rises rapidly from zero, and the sound pressure also rises rapidly, forming transient noise.

During the aspiration phase, a large amount of airflow emerges directly from the lungs through the open glottis, and the sound pressure and airflow signals successively reach a peak. The air pressure quickly drops to a lower value. Since then, both the sound pressure and the airflow rate have begun to slowly decrease.

Finally, during the falling of the airflow and air pressure signals, the sound pressure signal first reaches the minimum value, and then the sound pressure gradually rises due to the influence of the vowel, and the sound pressure gradually stabilizes at the ET position, and the consonant ends.

The difference between the air supply plug and the airless plug sound is that during the air supply phase, the air supply plug has a large opening degree, and the air flow is greatly discharged from the oral cavity, and the air flow speed and the sound pressure reach a maximum at this stage.

The air supply duration of adolescents is about 90ms-170ms, and the peak airflow is about 0.96L/S~1.09L/S, and the airflow is between 0.06L-0.11L [9][10].

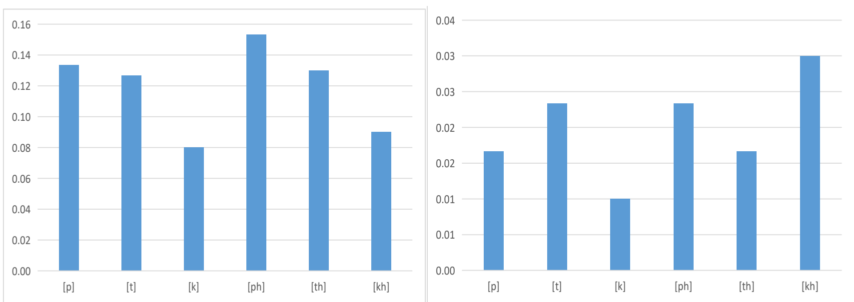
3.2 Analysis of the Resistance Segment

It mainly analyzes four sets of data of six Chinese vocals in Chinese Mandarin: expiratory airflow duration, expiratory volume, peak expiratory airflow, peak air pressure. The collected three speakers will average the four sets of data of the six stop sounds, and the average results are as follows:

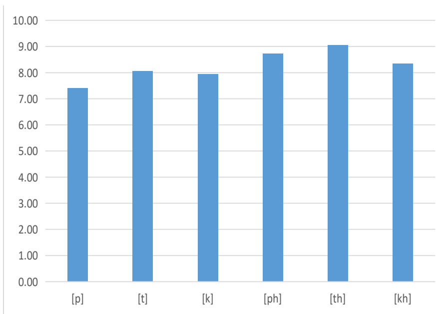
Table 1. Resistance segment parameter.

Parameter	**[p]**	**[t]**	**[k]**	**$[p^h]$**	**$[t^h]$**	**$[k^h]$**
Expiratory Airflow Duration (Sec)	0.13	0.13	0.08	0.15	0.12	0.09
Peak Expiratory Airflow (Lit/Sec)	0.02	0.02	0.03	0.02	0.02	0.01
Peak Air Pressure(cm H_2O)	7.42	8.05	7.94	8.72	9.05	8.35

Since the oral airflow in the obstructing section is not blasted, the airflow barometer does not detect the airflow, so the data in the expiratory volume row is displayed as 0. The airflow and pressure data of the above table is plotted as a histogram, as follows:



Expiratory Airflow Duration (Sec) Peak Expiratory Airflow(Lit/Sec)



Peak Air Pressure (cm H_2O)

Figure 2. Resistance segment parameter histogram.

According to Figure 2, we can analyze:

From the point of view of expiratory airflow duration of blocking sound, the length of the aspiration stop of the same pronunciation part is longer than that of the non-aspirated stop. This is mainly because the air flow of the aspiration stop is large, and it is necessary to collect more airflow, so it is long when the resistance is blocked. The duration of the blocking of the lip and the tip of the tongue is longer than the duration of the tongue plug. The main reason is that the mouth of the tongue is lower, and the cavity for storing the airflow is smaller, so the length of the resistance is shorter.

From the point of view of the peak air flow of blocking sound, whether the gas flow or the air supply is not small, even close to zero, this is mainly because the gas flow has not been blasted in the resistance phase, so the air pressure barometer does not detect more air flow.

From the point of view of the peak air pressure of blocking sound, the air pressure value of the aspiration stop is slightly higher than the non-aspirated stop, mainly because the aspiration stop will generate more airflow from the lungs, and the more air flow accumulated in the oral cavity, the greater the air pressure value. This is in line with the principle of speech aerodynamics.

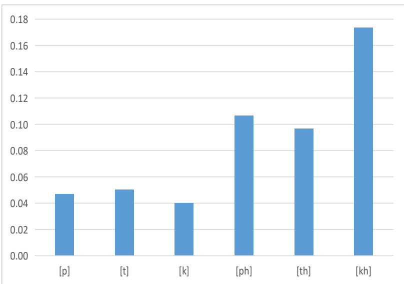
3.3 Analysis of the Destruction Segment

Since the peak pressure is reached at the end of the resistance, the peak pressure is not used as a research parameter in the deblocking phase. The three sets of data collected by the three speakers are divided into three groups of data, and the average results are as follows:

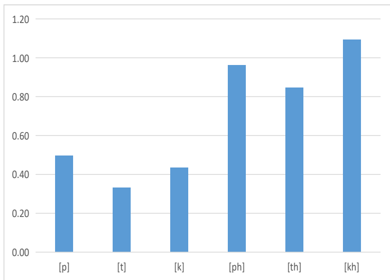
Table 2. Destruction segment parameter.

Parameter	[p]	[t]	[k]	[p^h]	[t^h]	[k^h]
Expiratory Airflow Duration (Sec)	0.05	0.05	0.04	0.11	0.10	0.17
Peak Expiratory Airflow(Lit/Sec)	0.50	0.33	0.43	0.96	0.85	1.09
Expiratory Volume(Lit)	0.01	0.01	0.01	0.11	0.06	0.11

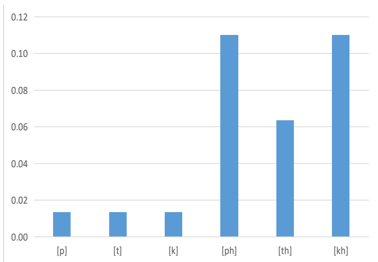
Draw the line graphs of the airflows in the above table as follows:



Expiratory Airflow Duration (Sec)



Peak Expiratory Airflow (Lit/Sec)



Expiratory Volume (Lit)

Figure 3. Destruction segment parameter histogram.

According to Figure 3, we can analyze:

From the expiratory airflow duration of deblocking sound, the average length of the deblocking section of the [p], [t], [k] is ≤ 0.05,the average length of the deblocking section of the [p^h], [t^h], [k^h]

is ≥0.1.It is also apparent from the histogram that there is a small increase in the average duration of the [p], [t], [k] to[p^h], [t^h], [k^h].

From the peak airflow of deblocking sound, the average airflow peak of the de-blocking section of [p], [t], [k] is ≤0.5, and the average airflow peak of the de-blocking section of [p^h], [t^h], [k^h] is ≥0.85, from the columnar shape. It can also be seen from the figure 3 that there is a large increase in the peak flow of the de-blocking from [p], [t], [k] to [p^h], [t^h], [k^h].

From the point of view of expiratory volume, the average gas flow rate of the de-blocking section of [p], [t], [k] is ≤0.01, and the average gas flow of the de-blocking section of [p^h], [t^h], [k^h] is ≥0.06, from the columnar shape. It can also be seen from the graph that there is a small increase in the average gas flow rate from [p], [t], [k] to[p^h], [t^h], [k^h].

It can also be seen that the average peak airflow and the average airflow of the non-supply plug [t] are smaller than [p], [k]; the average peak airflow and the average airflow of [t^h] are both smaller than [p^h], [k^h], which Mainly because of the different resistance sites, the obstruction sites of [p] and[p^h] are lips, the obstruction sites of [k] and [k^h] are tongue roots, and the obstruction sites of [t] and [t^h] are tongue tips. Before, and the tongue position is high, the resonance chambers of [t] and [t^h] are small, and the average peak airflow and average airflow are small.

In summary, the expiratory airflow duration, peak expiratory airflow, and expiratory volume of the destruction segment are related to the aspirated stops. The expiratory airflow duration, peak expiratory airflow, and expiratory volume of the aspirated stops de-blocking section are greater than the pronunciation of the non-aspirated stops. Duration, peak airflow, airflow, and the length of the pronunciation is proportional to the peak airflow and airflow.

4. Conclusion

This paper studies the gas flow and air pressure parameters of the 15-17-year-old Chinese Mandarin Chinese aspirator and non-aeration stops. It is found that the obstruction duration of the aspirator is slightly longer than that of the non-aeration stops, and the air pressure peak of the aspirator is also larger than the non-aeration stops; the air flow and the air flow peak of the aeration stops in the removal stage are greater than the elimination phase.

The difference between the aeration stops and the non-aeration stops can be clearly seen through the air pressure and air pressure device, and it can be intuitively found that the air flow pressure has a certain relationship with the difference of the resistance portion. This is a good evidence for the study of linguistic and non-aspirating vocalization of theoretical linguistics from the perspective of speech aerodynamics, and provides a good example for the study of aspirating and non-aspirating vocalization in young Chinese as a second language teaching study. Because in the Indo-European language, the singer does not have the distinguishing feature of aspiration and non-aspiration. Therefore, there is a certain resistance in learning. Through the airflow and air pressure equipment, the learner can clearly understand the difference between the two. This article only selects three speakers in this age group, cannot give the standard of air pressure parameters of adolescents, and needs to make more in-depth research in the future.

Acknowledgments

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