DOI: https://doi.org/10.54393/pjhs.v5i02.1290

PAKISTAN JOURNAL OF HEALTH SCIENCES
https://thejas.com.pk/index.php/pjhs
ISSN (P): 2790-9352, (E): 2790-9344
Volume 5, Issue 2 (February 2024)

Original Article

Maximum Phonation Time of School-Aged Children in Pakistan: A Normative Study

Iqra Naeem[1], Raffa Mubeen[2], Syed Aftab Haider Shah[3], Sumaiyah Obaid[2] and Ghulam Saqulain[4*]

[1]Benazir Bhutto Hospital, Rawalpindi, Pakistan
[2]Riphah International University, Islamabad, Pakistan
[3]AMF, PAC, Kamra, Attock, Pakistan
[4]Capital Hospital, Post-Graduate Medical Institute, Islamabad, Pakistan

ARTICLE INFO

Keywords:
Acoustic Measurement, Glottal Efficiency, Maximum Phonation Time

How to Cite:
Naeem, I., Mubeen, R., Shah, S. A. H., Obaid, S., & Saqulain, G. (2024). Maximum Phonation Time of School-Aged Children in Pakistan: A Normative Study : Maximum Phonation Time of School-Aged Children . Pakistan Journal of Health Sciences, 5(02). https://doi.org/10.54393/pjhs.v5i02.1290

***Corresponding Author:**
Ghulam Saqulain
Capital Hospital, Post-Graduate Medical Institute, Islamabad, Pakistan
ghulam_saqulain@yahoo.com

Received Date: 24th January, 2024
Acceptance Date: 13th February, 2024
Published Date: 29th February, 2024

ABSTRACT

Maximum phonation time (MPT) evaluates maximum vocal capabilities and can be used to assess the effectiveness of behavioral and medical therapy interventions. There is a literature gap regarding MPT normalcy data for Pakistani children. **Objective:** To determine the Maximum Phonation Time of School Aged Children in Pakistan and its association with participant variables and impact of the 6-minute walk test on participant vitals. **Methods:** This cross-sectional survey was conducted in Rawalpindi and Islamabad on typical healthy school-aged children from August 2021 to January 2022. The sample included both genders, aged 6-13 years having normal language. Tools used included a basic demographic sheet, token test, stopwatch, growth chart, sphygmomanometer, pulse oximeter, and 6-minute walk test. Blood Pressure, oxygen saturation, heart rate, and MPT were calculated before and after the six-minute walk test (6-MWT). Data were analyzed by using SPSS version 21.0. **Results:** Results show MPT of 13.11 ± 3.93 seconds. Scores were significantly ($p=0.000$) higher for higher age groups. 6-MWT revealed a significantly ($p=0.000$) higher post walk SPO2 (99.16 ± 0.89 Vs.97.82 ± 1.45), HR (105.94 ± 14.53 vs 92.94 ± 14.79). systolic (112.46±13.40 vs. 107.25 ± 13.66) and diastolic blood pressure (79.07 ± 8.17 Vs.73.84 ± 8.50) compared to pre walk. A significantly ($p<0.001$) strong positive correlation was noted for age(r=.515), weight (r=.460), height (r=.491) and distance (r=.281). **Conclusions:** MPT of Pakistani 6-13 years children is 13.11 ± 3.93 seconds with significantly higher MPT for higher age groups. MPT has a strong positive correlation with age, weight, height and distance and increases after walking. MPT values for boys were slightly higher than for girls.

INTRODUCTION

Maximum Phonation Time (MPT) is an important measurement since it gives an idea of respiratory support and phonatory function. MPT is the individual's ability to control the respiratory, aerodynamic, and myoelastic forces of the larynx during phonation. It represents the longest period of phonation in which an individual can sustain /a/ sound in a single deep breath. It is a non-invasive, fast, and objective method [1]. MPT is the most common objective assessment clinical tool that examines acoustics measurement of glottal efficiency used by speech therapists for voice evaluation and represents a good criterion for the general quality of the voice. Researchers also recommended the use of maximum phonation for assessing vocal quality [2]. The maximum phonation time is defined as the duration that a person takes to maintain a sound during exhalation with maximal inspiration by sustaining speech sounds i.e. /a/, /s/, /z/, /i/. Lung function is linked to voice production. The significance of maximum phonation time (MPT) is that a speech therapist uses it as an assessment tool to evaluate the phonatory and respiratory systems [3]. When MPT is measured through trials, this measure reveals laryngeal-

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valving methods for maintaining phonation to the maximum level possible [4]. MPT is the easiest way to use in the clinic to diagnose the abnormality in vocal folds. The presence of laryngeal diseases causes a reduction in glottic efficiency, resulting in a lower MPT [5]. MPT depicts the capacity of the vocal cords to close efficiently and measures glottal efficiency when they vibrate through rapid opening and closing of vocal cords. It's a practical clinical test for determining the phonatory part of speech, and it can give a rough estimation of a person's respiratory reserves [6]. MPT evaluates maximum vocal capabilities and is one of the aerodynamic measurements that can be used to assess the effectiveness of behavioral and medical therapy interventions. It maintains the proper dynamic way between the three sublevels of vocal production i.e., respiratory, phonation, and resonant/articulatory. Vocal nodules, hypernasality, articulation difficulties, voice abnormalities, respiratory disease, and pulmonary ailments can improve by using aerodynamic data to help diagnose, evaluate, and treat complicated problems [7]. Maximum Phonation Time (MPT) measures respiratory support and glottal efficiency, as well as the aerodynamic and neuromuscular control of an individual's vocal production. As a result, a persistent emission can indicate and evaluate the relationship between mucosal waves of the vocal folds and the muscle activity, as well as the lungs' air flow, showing physical and functional status [8]. Maximum Phonation Time is used by speech-language pathologists, singing teachers, and oto-rhino-laryngologists. Despite the speed with which organic and physiological changes occur in children, voice specialists i.e. SLP/T, teachers, and oto-rhino-laryngologists must closely check the progress of participants to achieve better results [9]. A study revealed a significant increase in the second instant of emission of maximum phonation time values when instructions were given by the researcher to control airflow on vowel emissions, however, other researchers did not confirm this. A previous study of children found that the guidance of visual support given by the speech therapist caused the MPT values higher as compared to the children who didn't receive the visual support [10]. However, researchers disagree about the length of maximum phonation time. Researchers indicated that typical people should be able to sustain vowels for at least fifteen seconds [2]. Voice is a multifaceted and complex phenomenon. Aerodynamic measurements are part of the European Laryngological Society's comprehensive voice assessment. Maximum phonation time is a non-invasive, quick, objective, and low-cost measurement that is commonly used in clinics. Several researchers proposed norms for Maximum Phonation Time, as they found variations in MPT for children in consonants. Some researchers reported that a child should easily sustain a phonation with a normal voice for 20 or longer after a few trials [11]. Several variables/ factors affect MPT as age, sex, weight, height, vital capacity, phonation volume, air flow rate, vocal pitch, and intensity [11]. Keeping in view that the voice-disordered population had significantly shorter phonation, normative values are essentially required for different populations [12].

Hence, keeping in view the need for research due to contradictory evidence as regards MPT and the gap as regards data in a Pakistani context, current study was conducted to determine the Maximum Phonation Time of school aged children in Pakistan and its correlation with participant variables and impact of 6-minute walk test on participant vitals. Current research is important since it would fill the gap in local literature and be helpful for speech professionals in better managing their patients.

METHODS

This cross-sectional survey was conducted over a period of 6 months from 01.08 2021 to 31st January 2022. The study was commenced following ethical approval of research from Research Ethics Committee, Riphah International University vide registration # RIPHAH/RCRS/REC/Letter-01111 and consent of participants or their parents. Utilizing convenient sampling, a sample of N=102 participants was recruited from Islamabad and Rawalpindi [13]. The sample included school children aged 6-13 years, of both genders, with normal receptive and expressive language, who did not have any airway infection at the time of study. Children with any history of neurological, psychiatric, or gastric disease and laryngeal surgery were excluded from the study. Tools used included a basic demographic sheet, token test, stopwatch, growth chart, sphygmomanometer, pulse oximeter, and 6-minute walk test as follows: Stop stopwatch was used to measure the maximum phonation time of the children for vowel /a/. Three readings were obtained and the maximum value among three readings was taken as maximum phonation time of the children. The 6-Minute Walk Test (6-MWT) is a sub-maximal exercise test used to assess aerobic capacity and endurance [14]. The distance covered on a straight 30-meter track over a time of 6 minutes was used to compare changes in performance capacity. 6-MWT is an appropriate method for assessing functional submaximal levels of exercise capacity in adults as well as children and is the self-paced 6-minute walk test. The pre- and post-measures of Blood Pressure (BP), Oxygen Saturation (SPO_2), Heart Rate (HR), RPE, and distance walked were provided by 6-MWT. The test was conducted on a 10-meter track, with laps counted. The blood pressure (BP) equipment was used to measure the patient's blood pressure i.e. sphygmometer. The pulse rate and oxygen saturation levels were measured using a pulse

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oximeter [14]. Token Test was used to measure the reception of children [15]. Token test is a test of receptive language functions and linguistic properties of the commands. Token tests include 20 tokens with different sizes (large and small), colors, and shapes (squares and circles) [16]. Demographic data were obtained from children's parents and legal guardians and the children were screened using Token test for inclusion to ensure that selected ones were able to understand the instructions. Token test measured receptive language functions and linguistic properties of the commands. After researcher trained 6-MWT from a physiotherapist, pre-and post-BP measurements were obtained followed by oxygen saturation level (SPO_2) using an oximeter and heart rate (HR). Children were asked to walk at a normal pace for six minutes on a ten-meter premeasured area with start and end points marked red and also marked at every 3 meters to record the precise distance of the previous lap. The test instructions were given to the children in great detail. A stopwatch was used to record the time as the walk began. After that the total laps were recorded, followed by an immediate measurement of the vitals that were taken at the start of the test, and MPT on vowel/a/ for longer duration was measured. Children were asked to take a deep breath and to sustain phoneme /a/ as long as they can. Researcher was given visual feedback to the children for best trials. After three trials, researcher measured actual three trials by using stopwatch. Phonation effort of children was recorded by researcher three times for average criteria. Maximum Phonation time for the vowel /a/ was taken as the maximum value of time sustained by a child among three trials. A growth chart was used to measure their present and past growth rate percentiles (height and weight) with their maximum phonation time. Data were documented analyzed by Statistical Software for Social Sciences (SPSS-21.0). Descriptive statistics were utilized. Paired sample t-test was utilized to determine the pre-post difference of MPT following 6-MWT; Anova statistics were utilized to assess difference of MPT for different age groups. Spearman's rho correlation test was used to see a correlation of MPT with gender, while Pearson's correlation determined the correlation of MPT with age, weight, height and distance. Maximum phonation time, and association of Maximum Phonation, $P<0.05$ was considered significant.

RESULTS

Current study sample N=102 revealed 54(52.9%) females and 48(47.1%)males(figure 1).

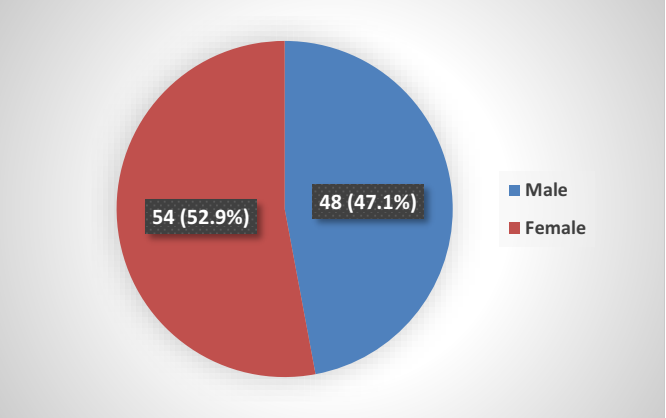

Figure 1: Gender Distribution of population(N=102)

Child characteristics revealed a mean age of 9.36±2.22 years, weight of 30.64±10.16 kg and height of 3.92±0.49 feet (table 1).

Table 1: Descriptive Statistics of Variables.

Variables	Score		
	Minimum	Maximum	Mean ± SD
Age in Years	6	13	9.36 ± 2.22
Weight in Kg	16	58	30.64 ± 10.16
Height (Feet)	3.05	5.05	3.92 ± 0.49
Distance (Metres)	360	1000	624.02 ± 111.56
Token Test score	28	36	33.93 ± 2.50

Table 2 reveals a Maximum Phonation Time (MPT) /a/ of 13.11±3.93 seconds. Scores were significantly (p=.0.000) higher for higher age group with highest scores for age group >10-13 years. Six-Minute Walk Test (6-MWT) revealed a significantly (p=0.000) higher post-walk oxygen saturation (99.16±0.89 Vs.97.82±1.45), heart rate (105.94±14.53 vs 92.94±14.79). systolic (112.46±13.40 vs. 107.25±13.66) and diastolic blood pressure (79.07±8.17 Vs.73.84±8.50)compared to pre walk(table 2).

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Table 2: Descriptive Statistics of Phonation Time and Six-Minute Walk Test

Variables		Minimum	Maximum	Mean ± SD	Sig.	
Paired Sample Correlation					T	p-value
Phonation Time	MPT of /a/ in seconds	7	27	13.11 ± 3.93	-	-
Vitals of Six-Minute Walk Test	Pre-Saturation level	88	99	97.82 ± 1.45	.621	0.000
	Post Saturation level	97	100	99.16 ± 0.89		
	Pre Heart rate	64	129	92.94 ± 14.79	.637	0.000
	Post Heart rate	78	146	105.94 ± 14.53		
	Pre Blood-Pressure Systolic	87	156	107.25 ± 13.66	.711	0.000
	Post Blood Pressure Systolic	76	145	112.46 ± 13.40		
	Pre Blood-Pressure Diastolic	50	96	73.84 ± 8.50	.521	0.000
	Post Blood Pressure Diastolic	56	98	79.07 ± 8.17		
ANOVA					F	p-value
Age (Years)	6-8 [40 (39.2%)]	7	18	10.55 ± 2.287	18.821	0.000
	>9-10 [29 (28.4%)]	9	27	14.69 ± 4.774		
	>10-13 [33 (32.4%)]	10	23	14.82 ± 3.015		

Correlation of Maximum Phonation Time with Participant variables, as shown in table 3, revealed that gender has a negative correlation (r=-0.078) with MPT (table 3), while a strong positive correlation was noted for age(r=.515) indicating that as a child grows older MPT increases, weight (r=.460) indicating that increase in weight increases MPT, height (r=.491) indicating increase increases in MPT with the height of the child and weaker positive correlation with distance(r=.281)which is also significant(p=0.004).

Table 3: Correlation of Maximum Phonation Time with Participant Variables(N=102)

Variables	Correlation Test	R	p-Value
Gender	Spearman's rho	-0.078	0.433
Age (Years)	Pearson	.515	0.000
Weight (Kilogram)	Pearson	.460	0.000
Height (Feet)	Pearson	.491	0.000
Distance (Meters)	Pearson	.281	0.004

DISCUSSION

Current study was focused on determining the Maximum Phonation Time of School Aged Children in Pakistan and its correlation with participant variables and impact of the 6-minute walk test on participant vitals. The Maximum Phonation Time is an acoustic measurement of voice It is a well-established procedure of measuring MPT by Speech-Language Pathologists by determining how long a vowel can be sustained for example "a" sound /a/ by a child. It can be used in research to monitor the progress of children [9]. In current research Maximum Phonation Time maximum value for vowel /a/ is 27s i.e. approximately near 30s. The minimum value of MPT is 7 and the maximum value is 27 with a mean and standard deviation of 13.11 ± 3.93. According to previous research, Maximum Phonation Time values vary for children for vowels over 30s and children should easily sustain a phonation with a normal voice for 20 or longer after a few trials [11]. In contrast, a study by Cielo and Cappellari reported an MPT of 7.42, 6. 35, and 7.19 seconds as age increases [17]. Current study revealed that values of MPT were higher in boys as compared to girls. Hence it has a negative correlation with MPT (r=-0.078, p=0.433). This is in compliance with available literature i.e., higher values of MPT in boys compared to girls [18]. In the present research age revealed a strong positive correlation (r=.515, p=0.000) with maximum phonation time, hence, MPT increases as the children get older and are significantly associated across age groups. This complies with literature and typical voice school-aged children should be able to sustain a sound for approximately 10 seconds. It is essential to analyze findings by age group to provide more accurate and practical comparisons for use in voice clinics [19]. Current study also revealed that as the height increases Maximum phonation time (MPT) also increases i.e. results show a very strong positive correlation (r = + 0.491, p=0.000). Similarly, a study by Fabron et al., revealed that not only age but also height, weight or physical growth, had a beneficial impact on MPT [20]. Present research demonstrated the findings on weight which increases with the rise of maximum phonation time values i.e. results show a statistically significant positive relationship of weight with MPT(r=.460, p=0.000). This complies with the study by Fabron et al [20]. However, in a study to examine the maximum phonation time in the participants with different body weights i.e., the effect of weight on MPT and fundamental frequency of voice. Participants sustained a vowel /a/ and MPT of the vowels was taken by using PRAAT software. It was concluded that the obese participants had lower MPT than 10-sec limit. The remaining participants showed higher average MPT compared to obese and overweight individuals [21]. This may be because the deposition of fat

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resulted in higher phonatory effort to reduce the increased subglottal force and pharyngeal resistance [22]. In the current study, Six-Minute Walk Test (6-MWT) revealed a significantly (p=0.000) higher post-walk PO2, HR, Systolic and Diastolic BP compared to pre-walk. MPT values increase with age and physical growth progression. The vital capacity increased significantly as a result of continuous physical growth during adult and adolescent stages. A variety of factors contribute to the increase and decrease of the MPT value, with physical growth in conjunction with age [20]. According to Issiki, other factors related to MPT include vital capacity, expiratory effort, glottal condition, inspiratory, and shape of the vocal tract. It was also possible that the longest phonation was limited by a layrngo-pulmonary reflex [23]. In current study three trials of MPT using vowel /a/ was used to elicit MPT which revealed that children exhibit longest phonation on /a/ vowel in third trial. A past study revealed an intra-subject reliability of second trial of MPT which was 2 seconds longer than the first and third. Analysis of three trials showed a strong correlation between them, which suggests that to use of several trials for MPT value and not just a single attempt [24]. Also, Cielo and Cappellari reported contrasting results compared to current study [17]. In current study, the researcher used modeling (visual support) for children so that they can understand the procedure. Previous research on children found that when the speech-language pathologist guidance was given with visual support, the MPT values were higher in comparison to the group of children who didn't receive this kind of support [10].

CONCLUSIONS

MPT of Pakistani 6-13 years children is 13.11±3.93 seconds with significantly higher MPT for higher age groups. 6-MWT revealed a significantly (p=0.000) higher post walk SPO2, HR. systolic and diastolic blood pressure compared to pre-walk. MPT has a strong positive correlation with age, weight, height and distance. MPT values for boys were slightly higher than for girls.

Authors Contribution

Conceptualization: RM
Methodology: IN, SAHS, SO
Formal analysis: IN
Writing-review and editing: GS

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

Source of Funding

The authors received no financial support for the research, authorship and/or publication of this article.

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