"TO COMPARE BETWEEN OBJECTIVE EVALUATION OF NASALITY USING NASOMETER AND PERCEPTUAL EVALUATION OF NASALITY AMONG CHILDREN AND ADULTS WITH CLEFT PALATE: A PRELIMINARY STUDY"

BY

AFIQAH IYLIA BINTI KAMARUDDIN

Dissertation submitted in partial fulfillment of the requirements for the Degree of Bachelor of Health Sciences (Speech Pathology)

School of Health Sciences

Universiti Sains Malaysia

Health Campus

16150 Kubang Kerian Kelantan

Malaysia

2012

First and foremost, I want to thank God for giving me the opportunity to learn to become a Speech Language Pathologist. Also for the strengths I get during my time to finish this study. All praise is due to Allah.

A special thank you to my supervisors Miss Nurul Hidayah Dean Kamarudin, Speech Pathology Program Lecturer of School of Health Science and Dr. Khoo Teng Lye, Medical Doctor of HUSM who gave me their very best efforts and feedbacks to help me with my first time study. I am very grateful to have them as my supervisors.

I also want to thank the head of SOPD department, head of Audiology and Speech Pathology unit in HUSM and head of ORL department in HRPZ II for their cooperation and not to forget the staffs for the good services and cooperation during the data collection process.

Sincere thanks to Pn. Azmawanie, Pn. Analiza Anis and Pn. Fadhilah for listening to the speech samples and giving me thoughts and ideas to help me with my research. Not to forget, thanks to Pn. Azlinda and Pn. Norhaniza for being there giving their time and efforts throughout the timeline to finish my study.

My personal thank you to Yew Wei Ching, Angela, and Muhammad Nur Hilmi bin Che Hassan for guiding me with my data analysis. My study is possible especially because of them. To my fellow course mates; thank you for all your time and nonstop supports to help me with my study.

To my beloved family and loved ones, the strengths and supports they gave to me could never be repaid by a simple 'thank you'. Still I could only show my deepest gratitude towards them. Thank you for all this while.

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LIST OF ABBREVIATIONS

CLP	Cleft lip and palate
CP	Cleft palate
NOHS	National Oral Health Surveys
SLP	Speech Language Pathologist
TONAR II	The Oral Nasal Ratiometer
NS	Nasalance score
SD	Standard deviation
HUSM	Hospital Universiti Sains Malaysia
SOPD	Surgery Out-Patient Department
SPSS	Statistical Package for Social Sciences
VPI	Velopharyngeal Incompetence
HRPZ II	Hospital Raja Perempuan Zainab II

One of the most common birth defect and congenital defect of the craniofacial is cleft lip and palate. The speech characteristic commonly associated with cleft palate population is hypernasality. Traditionally, Speech Language Pathologists (SLPs) used perceptual evaluation to evaluate the nasality of one's speech. As technology is advancing, a number of instruments are now available to be used as an objective evaluation to evaluate nasality for example, Nasometer. A cross sectional study on nasometry analysis was conducted to investigate the effectiveness of Nasometer as an objective evaluation for nasality among cleft palate population. The participants were 8 repaired cleft palate patients from Surgery Out-Patient Department (SOPD) in HUSM. Kay Nasometer model 6400 was used as an objective evaluation to obtain the mean nasalance scores for each participant. Three reading stimuli in Bahasa Melayu constructed by Abdul Wahab et al. (2004) were used to measure the mean nasalance scores. Three SLPs listened to the audio recordings and rate the severity of the hypernasality using seven-point equal-appearing interval scale. The results showed mean nasalance scores of 75.68% for nasal passage, 67.38% for oral passage, and 67.75% for oronasal passage. There was a good intra-rater reliability and moderate to good inter-rater reliability. There was no correlation between objective evaluation using Nasometer and perceptual evaluation using seven-point equal-appearing interval scale. The results found in this study showed that Nasometer is effective to be used as an objective evaluation of nasality among children and adults with repaired cleft palate.

Key words: cleft lip and palate, speech, hypernasality,nasometer, nasalance.

Salah satu kecacatan muka yang biasa ialah sumbing pada bibir dan lelangit. Salah satu ciri pertuturan dalam kalangan populasi sumbing lelangit ialah sengau. Pegawai terapi pertuturan lazimnya akan menggunakan penilaian secara subjektif untuk menilai tahap kesengauan seseorang pesakit. Pelbagai instrumentasi yang digunakan untuk menilai tahap kesengauan dan salah satunya ialah Nasometer. Satu kajian rentas analisis nasometri dijalankan bertujuan untuk menguji keberkesanan Nasometer sebagai penilaian objektif untuk kesengauan dalam kalangan kanak-kanak dan orang dewasa yang sudah dibaiki sumbing lelangit. Seramai 8 orang subjek sumbing lelangit yang sudah dibaiki dipilih dari Surgery Out-Patient Department (SOPD) di HUSM. Kay Nasometer model 6400 telah digunakan sebagai penilaian objektif dan purata skor nasalan dihasilkan. Tiga stimulus dalam Bahasa Melayu yang direka oleh kajian Abdul Wahab et al. (2004) telah digunakan untuk mengukur purata skor nasalan. Tiga pegawai terapi pertuturan membuat penilaian secara subjektif menggunakan skala tujuh-mata dengan mendengar rakaman audio. Hasil kajian ini menunjukkan purata skor nasalan 75.68% untuk ayat nasal, 67.38% untuk ayat oral dan 67.75% untuk ayat oronasal. Terdapat nilai kebolehpercayaan intra-rater yang baik manakala nilai kebolehpercayaan inter-rater yang sederhana ke baik. Tiada korelasi yang dijumpai antara penilaian objektif menggunakan Nasometer dengan penilaian subjektif menggunakan skala tujuh-mata. Hasil kajian menunjukkan bahawa Nasometer mempunyai keberkesanan sebagai penilaian objektif untuk kesengauan dalam kalangan kanak-kanak dan orang dewasa yang sudah dibaiki sumbing lelangit.

Kata kunci: sumbing bibir dan lelangit, pertuturan, kesengauan, nasometer, nasalan.

1.1 Introduction of the study

One of the most common birth defect and congenital defect of the craniofacial are cleft lip and palate (CLP). Abdul Wahab et al. (2004) stated that every 500 – 1000 births worldwide will be affected by cleft lip and palate (CLP) deformity. That, the National Oral Health Surveys (NOHS) also indicated an increased incidence of CLP from 1 in 1006 to 1 in 941 live birth in Malaysia (Normastura et al, 2008). A study regarding the population-based of birth defects in Malaysia by Thong et al. (2005) stated that 11.9% from 17 720 births had cleft lip and palate with the prevalence of 1 in 591 births and incidence of 1.69 in 1000 births.

A cleft is an abnormal opening in an anatomical structure which can occur for lip or palate or both (Kummer, 2008). In nature cleft palate can occur either primary or secondary. Primary cleft palate or also called as prepalate or intermaxillary segment occurs anterior to the incisive foramen including lip and alveolus (Kummer, 2008), while secondary cleft palate occurs posterior to the incisive foramen including hard and soft palate (Kummer, 2008; Shprintzen & Bardach, 1995). Cleft palate can affect the velopharyngeal closure of individuals if it happens at the posterior of the incisive foramen. Velopharyngeal closure happens when soft palate moves up to make contact with the posterior and lateral pharyngeal walls which move inward and upward to make the closure possible.

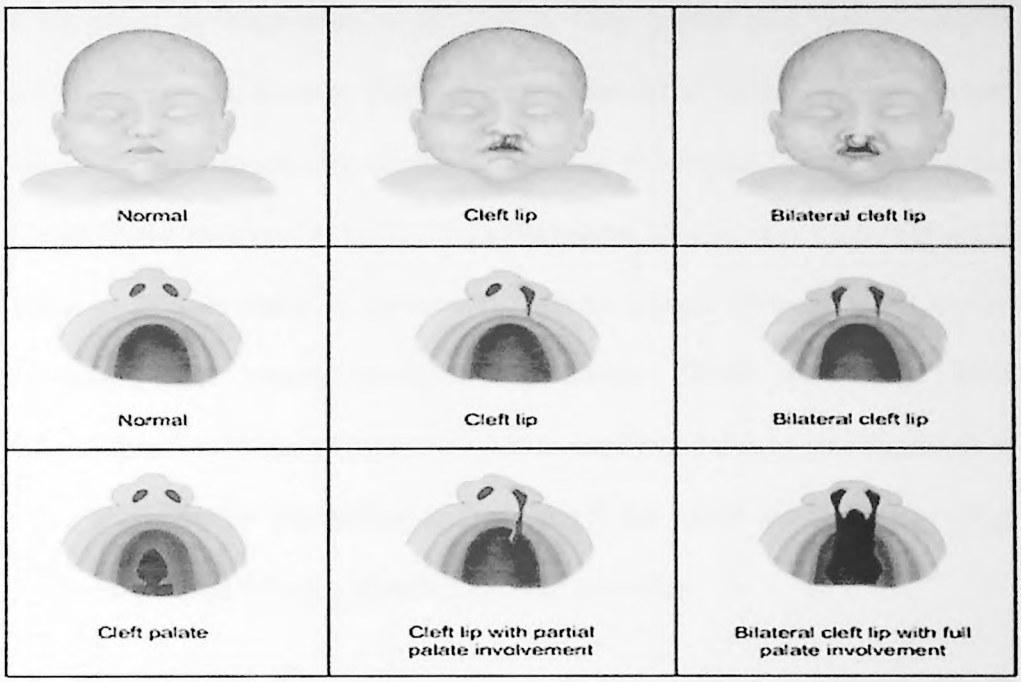

Figure 1.0 Cleft lip and palate

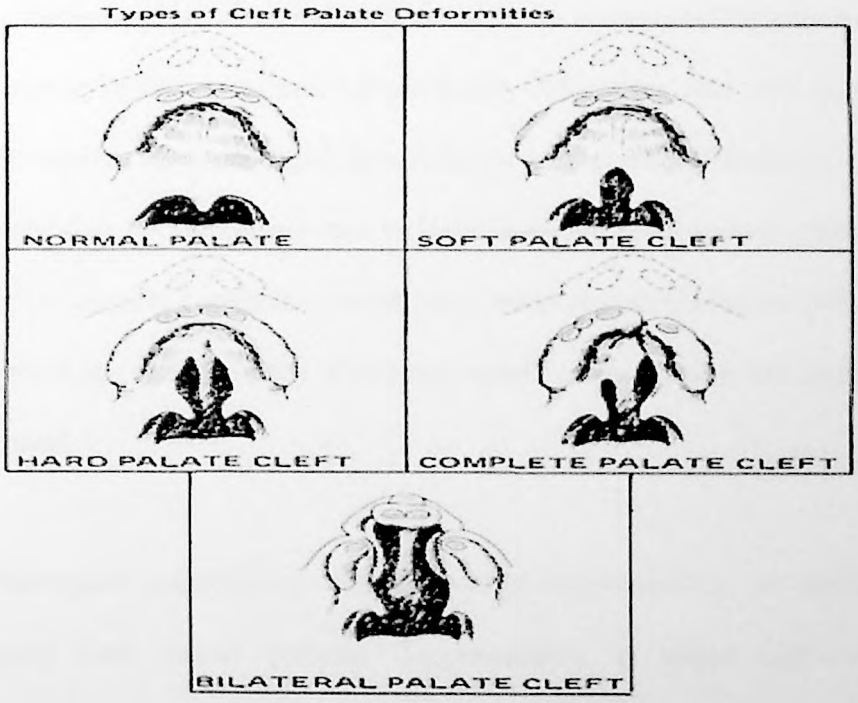

Figure 1.1 Types of cleft palate

In the study by Shprintzen et al. (1975), they quoted that velopharyngeal closure is a sphincteric mechanism. They added description of velopharyngeal closure as the postero-superior movement of the velum and the medial movement of the lateral aspects of the pharyngeal walls. Velopharyngeal closure will close the nasal cavity during speech in order to prevent the air to escape through nasal cavity especially during oral sounds production. Kummer (2008) explained about velopharyngeal function followed by speech which is affected due to abnormalities in velum structure. He stated that velum will close off the nasal cavity by elevating against the pharyngeal wall during speech and other activities.

Velopharyngeal dysfunction can be in two types which are velopharyngeal insufficiency which later will lead to velopharyngeal mislearning and velopharyngeal incompetence. Velopharyngeal insufficiency is cause by anatomical defects such as cleft palate. Kummer (2008) stated that approximately 20% of patients with history of cleft palate will exhibit velopharyngeal insufficiency after repaired. Kummer (2008) continued to state that the factors are due to learned and adapted speech patterns of articulation before surgical correction. Incomplete velopharyngeal closure will affect the speech mechanism which is the resonance specifically causing the speech to become hypernasal.

Velopharyngeal insufficiency often leads to hypernasality of speech as observed among cleft palate patients. Hypernasality, a major cleft speech characteristic is one type of resonance disorders. Resonance is the modification of the sound generated by larynx by enhancement of certain frequencies. Changes of the length or shape of resonating cavities will give effect to the quality of voice.

Abnormal resonance can happen due to any form of obstruction, oronasal fistula or velopharyngeal dysfunction (Kummer, 2008). Three major resonance disorders are hypernasality, hyponasality and cul de sac. Shprintzen & Bardach (1995) stated in their book, that hypernasality oftenly associated with cleft palate. Kummer (2008) defined hypernasality as resonance disorder in which there is abnormal sharing of acoustic energy from the oral and nasal cavities during speech. When there is too much sound resonating in the nasal cavity during speech, hypernasality will occur and production of voiced oral consonants will be affected.

In managing resonance disorder among cleft palate patients, nasality must be measured first. Traditionally, perceptual assessment by Speech Language Pathologists (SLPs) is used to evaluate the nasality. The issues with perceptual judgment are experienced and reliability. SLPs need to address the inter-rater and intra-rater reliability for perceptual judgment of nasality. Lee et al. (2005) stated that perceptual judgment of hypernasality affected by listeners' and speakers' language. Some other factors that can affect perceptual judgment are the articulation, resonance, voice and also facial expression.

Nowadays, as technology is advancing, instrument that can be use as objective evaluation is increasing and one of it is Nasometer. Although a lot of choices available, researchers choose Nasometer as the instrument of their studies (Abdul Wahab et al., 2004; Bressmann et al., 2006; Brunnegard & Van Doorn, 2009; Prathanee et al., 2003; Sarac et al., 2011; Sweeney & Sell, 2008, Hirschberg et al., 2006; Van der Heijden et al., 2011) probably due to its noninvasive method of collecting data. Nasometer measures oral and nasal acoustic sound signals by

producing a score of energy ratio between the two signals (Fletcher et al., 1989 as cited in Sweeney & Sell, 2008). Nasometer is reported to be reliable to identify the presence or absence of hypernasality with high sensitivity and specificity. The high value of sensitivity and specificity of the Nasometer makes it reliable to be used together with perceptual judgments.

Researchers often use three types of passages when using Nasometer for evaluation of hypernasality. The passages are Zoo Passage, Rainbow Passage and Nasal Sentences (Bressmann et al., 2006). The used of the three Passages are to assess the extent of subjects' effect velopharyngeal closure and to assess denasality (Dalston et al., 1991) In order to get a normal data for nasalance scores, researchers tend to use passages in their native language to avoid biases. There are a numbers of researches that use passages in their language to produce normative nasalance scores (Abdul Wahab et al., 2004; Bressmann et al., 2006; Brunnegard & Van Doorn, 2009; Hirschberg et al., 2006 & Prathanee et al., 2003). In Malaysia, Abdul Wahab et al. (2004) constructed three stimulus texts to be used when evaluating hypernasality using Nasometer. The stimulus texts are Oral Text, Nasal Text and Oronasal Text.

Using the three texts, Abdul Wahab et al. (2004) conducted a study to produce normative nasalance scores for normal and in repaired cleft lip and palate children. The results showed significant difference in nasalance scores between normal and cleft palate children for oral and oronasal texts but not in nasal texts which is consistent with other researches. The study by Abdul Wahab et al. (2004) is the only study that in Malaysia considering the use of Nasometer. Further study need to be done to evaluate the effectiveness of the Nasometer evaluating hypernasality in

comparison to perceptual judgment. Also the stimulus texts constructed by Abdul Wahab et al. (2004) need to be tested in terms of effectiveness in providing objective evaluation on nasality.

1.2 Research statement

Hypernasality is a common resonance disorder often observed among cleft palate patients. Even after surgical correction of the velum structure, individuals often still exhibit hypernasality because of habituation and auditory feedback loop that still perceive as 'normal' as before the surgical correction. Speech Language Pathologist (SLP) plays very important roles in managing hypernasality among patients with cleft palate. For that matter, SLPs usually opt for perceptual evaluation when assessing severity of hypernasality. It is only recently SLP in Malaysia started using objective evaluation. Perceptual evaluation of hypernasality is a valid assessment when done by experienced SLP. As speech and language therapy is still developing in Malaysia, the number of SLP experienced in assessing and managing cleft palate patient are still fairly limited. Furthermore, perceptual evaluation can give rise to different opinion between SLPs as the perception of one is influenced by experience and the number of resonance cases they managed.

The Nasometer is currently the most commonly used instrument for nasalance analysis in clinical settings. Nasometer is an objective evaluation and produce 'nasalance score'. The score is the isolation and filtration of the oral and nasal acoustic speech signals (Nasalance = Nasal / [Nasal + Oral] x 100) according to Watterson et al. (2005). There are contradicting reports regarding the reliability rating of correspondence between objective evaluation using Nasometer (nasalance scores) and

perceptual evaluation of hypernasality when conducted by experienced clinician. Reports suggested that the passage used in the evaluation have an effect on effectiveness of the evaluation (Paynter et al., 1991 & Dalston et al., 1991b). In 2004, Abdul Wahab et al. (2004) did a study using Nasometer for Malaysian population and constructed 3 stimulus texts to be used for evaluation of nasality.

This study aims to compare between objective findings of nasality using Nasometer and subjective findings of nasality through perceptual evaluation, describe the inter-rater and intra-rater reliability of perceptual judgment, and determine the mean nasalance scores produce by Nasometer and also to investigate the correlation between perceptual evaluation and objective evaluation.

1.3 Significance of the study

This study is conducted to know the effectiveness of Nasometer as an objective evaluation of nasality in children and adults with cleft palate. To date, most SLP are using perceptual evaluation using rating scale as gold standard in assessing nasality of cleft palate patient. The use of Nasometer will be useful to inexperienced and new SLP in effectively evaluating and managing cases of nasality as it can give biofeedback.

Furthermore, this study can be guidelines to further study in other region in Malaysia and further investigate other factors that can influence perceptual evaluation and objective evaluation for better evaluation and management cases of nasality.

1.4 Research questions

1. What is the correlation between mean nasalance scores of nasality using Nasometer and severity rating of nasality using Seven-point equal-appearing interval scale?
2. What are the inter-rater and intra-rater reliability of perceptual evaluation of nasality using Seven-point equal-appearing interval scale by Speech Language Pathologists?
3. What are the mean nasalance scores and range of nasalance scores of Nasometer for nasality?

1.5 Research objectives

1.5.1 General objective:

1. To compare between objective findings of nasality using Nasometer and subjective findings of nasality through perceptual evaluation.

1.5.2 Specific objectives:

1. To investigate the correlation between mean nasalance scores of nasality using Nasometer and severity rating of nasality using Seven-point equal-appearing interval scale.
2. To describe the inter-rater and intra-rater reliability of perceptual evaluation of nasality using Seven-point equal-appearing interval scale by Speech Language Pathologists (SLPs).
3. To determine the mean nasalance scores and range of nasalance scores of Nasometer for nasality.

"Intelligibility is a general judgment of speech that refers to how well a listener understands it." (Shprintzen & Bardach, 1995). Shprintzen & Bardach (1995) added that one of the factor influence the intelligibility is resonance. Hypernasality and articulation will decrease intelligibility and ratings of intelligibility depending on perceptual judgment. Due to the effect of the hypernasality on intelligibility of speech, rating scales has been used by speech language pathologist (SLP) in classifying patients with hypernasality. Over the years, perceptual analysis based on listening and variety of assessment has been done to rate the hypernasality.

Nasality can be rated reliably by panels of pre-trained judges under experimental conditions which includes used of recorded speech samples (Lintz & Sherman, 1961 as cited in Bradford et al., 1964). Under controlled conditions, single judges are also reliable (Weiss, 1954 as cited in Bradford et al., 1964). However no studies been found for reliability of nasality rating in clinical settings (Bradford et al., 1964). Bradford et al (1964) found out in their study, neither experienced nor experienced judges able to rate hypernasality reliably under clinical environments. Plus, another researcher stated that "the standard baseline for perceptual judgments are unstable and undependable for repeated comparisons over time or for comparisons between patients" and adding to that there are difficulties to compare results from different clinicians due to flaw in identifying basic parameters (Fletcher, 1970 as cited in Karling et al., 1993).

Van Lierde et al. (2007) stated in their study that currently no internationally accepted perceptual judgment protocol available for resonance disorder. They continued stating that most studies used ordinal scale. Dalston et al. (1991) used 6-

point equal-appearing interval scale to rate the nasality while Van Lierde et al. (2002) used nominal scale of 4 categories. On the other hand, Abdul Wahab et al. (2004) use seven-point equal-appearing interval scale to rate the nasality. Hirschberg et al. (2006) use three-point scale to rate the degree of nasality. Meanwhile, Sweeney & Sell (2008) used Temple Street Scale to rate hypernasality in their study. Different protocol used can cause biases to the reliability of the perceptual judgments. If another study will be done in the same state, same protocol should be adapted for efficient comparison between studies.

Perceptual judgments of nasality need agreement between listeners and therefore inter-rater and intra-rater reliability must be good. Bressmann et al. (2005) use only one rater in their study but intra-rater reliability was not considered. Bradford et al. (1964) compared the reliability of experienced and inexperienced judges and found that the judgments of the inexperienced judges were somewhat reliable. The inter-rater and intra-rater reliability was poor, but they stated that the conditions should be take into consideration which is inexperienced judges has no pre-training and clinical setting also put some impact. Karling et al. (1993) showed 42% inter-listener reliability and 58% intra-listener reliability. The findings are not so strong in terms of reliability and thus need to be taking into consideration if further study to be conducted.

A number of instrumental devices arise in order to complement perceptual judgments of nasality. Some of the instruments are The Oral Nasal Ratiometer (TONAR II) (Dalston & Warren, 1986) which is a system used to calculate the ratios of acoustic energy between oral and nasal signals expressed as 'nasalance

percentage'; that is now being called as Nasometer, The NasalView that calculates the nasalance scores like Nasometer but based on whole frequency spectrum with no bandpass filtering being used, and also The OroNasal system that measure nasalance like the previous two but with different setup. Out of the three, Nasometer seems to gather much attention from researchers to be used for nasalance analysis as it allows clinician to quantify clinical judgments of nasality, making it favorable tool to be used (Hardin et al., 1992).

A number of articles reported about the usefulness of Nasometer in providing information regarding the speech of patients with velopharyngeal inadequacy (Dalston et al., 1991a as cited in Dalston & Seaver, 1992) and upper airway impairment (Dalston et al., 1991b as cited in Dalston & Seaver, 1992) since 1986. Research by Dalston et al. (1991) stated that individuals with less than complete velopharyngeal closure and being judged as hypernasal should produce high nasalance scores as Nasometer, and human ear should be sensitive to speech with vowels generated with increased nasal resonance. As mentioned earlier, Dalston et al. (1991) stated the sensitivity and the specificity of the Nasometer in correctly identifying subjects with more than mild hypernasality are 0.89 and 0.95 respectively while Hardin et al. (1992) showed sensitivity and specificity of the Nasometer for correctly identifying the presence or absence of hypernasality was 0.87 and 0.93 respectively. The insignificant difference between the studies making Nasometer as suitable instrument in assessing patients with suspected of having velopharyngeal impairment.

A lot of research had produced normative nasalance scores in different languages such as Swedish, Dutch, Thai, Hungarian and Malay (Brunnegard & Van Doorn, 2009; Van der Heijden et al., 2011; Prathanee et al., 2003; Hirschberg et al., 2006 & Abdul Wahab et al., 2004). The results of the research can be viewed in Table 1. Researchers aim to produce normative nasalance scores for their language for clinical use. SLP especially need a norm for nasality in order to produce reliable diagnosis and to facilitate intervention.

Table 2.0 Nasalance scores (NS) in other languages

Researcher(s)	**Language**	**NS % (SD) Oral Stimulus**	**NS % (SD) Nasal Stimulus**
Brunnegard & Van Doorn 2009	Swedish	12.7 (5.6)	56.5 (6.4)
Van der Heijden et al. 2011	Dutch	11 (4)	-
Prathanee et al. 2003	Thai	14.3 (5.8)	51.1 (6.4)
Hirschberg et al. 2006	Hungarian	11.0	50.6
Abdul Wahab et al. 2004	Malay	17.7 (6.31)	59.3 (5.65)

Apart from studies to develop normative nasalance scores, many researchers use Nasometer to compare nasalance scores of normal children with cleft lip and palate children (Sweeney & Sell, 2008; Hardin et al., 1992; Abdul Wahab et al., 2004; Van Lierde et al., 2002; Van Lierde et al., 2007). One of the study which is from Van Lierde et al. (2002) stated that significant nasalance difference found between normal children and cleft children. Besides comparing the two groups, Nasometer