DOCTOR OF PHILOSOPHY

Bimaxillary Protrusion in Trinidad and Tobago Population
Prevalence, Features and Management

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Bimaxillary Protrusion in Trinidad and Tobago Population: Prevalence, Features and Management

by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

ABO	American Board of Orthodontics
ANB	A point- Nasion- B point angle
ANS	Anterior nasal spine
Co-ANS	Condylion to Anterior nasal spine (Maxillary length)
Col-Sn-UL	Nasiolabial angle
Co- Pog	Condylion to pogonion (Mandibular length)
E-Plane	Aesthetic plane
GN	Gnathion
Go	Gonion
GRADE	Grading of Recommendations, Assessment, Development and Evaluation
ICW	Intercanine width
ICP	Intercuspal position
IPW.	Interpremolar width
IMW	Inter molar width
IOTN	The Index of Orthodontic Treatment Need
JBI	Joanna Briggs Institute
LAFH	Lower anterior face height
LAFH/TAFH	Lower anterior face height to Total anterior face height
L1 to Apo	Lower incisor to A-pogonion line (Lower incisor protrusion)
L1 to MnP	Lower incisor to mandibular plane
LIT	Lower incisor tip
M	Menton

MMPA.	Maxillomandibular planes angle
Mx	Maxilla
MxIA	Maxilla incisor apex
MIA	Mandibular incisor apex
Md	Mandibular
N	Naison
N-ANS	Nasion to Anterior nasal spine (Upper face height)
NA- Apo.	Nasion to point A, to Point A to pogonion (Convexity angle)
O	Orbitale
OJ	Overjet
OB	Overbite
P	Porion
PAR	Peer assessment Review
PFH/AFH	Posterior face height to anterior face height
PICO	Population Intervention Comparator Outcome
PNS	Posterior nasal spine
Pog	Pogonion
PP-MP	Palatal plane to mandibular plane
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCT	Randomized Clinical Trial
S	Sella
SN-Ar	Sella Nasion- Articulare angle (Saddle/Sella angle)
SNA	Sella -nasion – A point angle

SNB	Sella- nasion- B point angle
SOF	Summary of findings table
SN-PP	Sella nasion line to palatal plane
STROBE	Strengthening the reporting of Observational studies in Epidemiology
TADs	Temporary anchorage devices
UIT	Upper incisor tip
U1 to MxP	Upper incisor to maxillary plane
U1 to L1	Interincisal angle

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DECLARATION

I hereby declare that this thesis has been compiled by me, that this is a record of work completed by myself under the direct supervision of Professor Bearn and Professor Mossey, and that it has not previously been accepted for a higher degree at this University or any other institution of learning.

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ABSTRACT

Aim: To study Bimaxillary Protrusion in the Trinidad and Tobago population; its prevalence, features and management.

Design: Two systematic reviews and meta - analyses, three cross sectional surveys, a clinical study and a retrospective study.

Subjects and Methods: The cross- sectional surveys were conducted on 672, 972 and 975 11 to 12 year old subjects. One orthodontist (T.H.) examined the students which were selected from some of the 141 public high schools which gave permission to conduct the research, located across the twin island republic, representing both rural and urban populations. The retrospective study was conducted using 109 standardised lateral cephalometric radiographs from patients receiving orthodontic treatment at the University of The West Indies dental hospital between September 2015 to March 2019.These patients gave consent for their records to be used.

Results: Prevalence of bimaxillary protrusion varies greatly among populations. Bimaxillary prognathism has a prevalence of 64.4% and bimaxillary proclination has a prevalence of 68.8% in Trinidad and Tobago. The overall prevalence of fractured incisors in Trinidad and Tobago is 4.72%. The overall prevalence of habits is 93%. 68.6% of subjects presented with more than one oral habit.

The use of Temporary Anchorage Devices (TADs) showed shorter treatment time in bimaxillary protrusion cases. There is however low quality evidence that TADs could be the preferred method for anchorage for bimaxillary protrusion cases.

The cephalometric norms for this population were unique compared to other bimaxillary protrusion societies. Higher ANB and MMPA were demonstrated in this society compared to Caucasians and Chinese populations with bimaxillary protrusion. The lower incisors were more protrusive compared to Nigerian populations

Conclusions:

1. Bimaxillary protrusion and certain oral habits are more prevalent in the Trinidad and Tobago population.
2. Bimaxillary protrusion is accompanied by unique dental and facial features.
3. Optimum treatment for bimaxillary protrusion will be dictated by presenting features, habits and tailored to cephalometric values.
4. More high quality research is required in the area of bimaxillary protrusion.

CHAPTER 1 - INTRODUCTION

1.1 Background

Anthropological evidence shows normal occlusion tends to occur in genetically homogenous populations and in heterogenous populations jaw discrepancies and occlusal disharmonies are significantly greater (Mossey 1999). Mossey in this article also pointed to the polygenic theory for craniofacial and dental morphogenesis. Polygenic inheritance suggests there can be environmental modification and this has been proven in familial twin studies (Mossey 1999).

Malocclusion can be defined as an appreciable deviation from normal occlusion (Houston and Tulley,1992). Malocclusions can be classified as Class 1(the lower incisal edge lies on or below the cingulum plateau of the palatal surface of the upper incisors) Class 2 division 1 (the lower incisor edges lie palatal to the cingulum plateau of the upper incisors; upper incisors are proclined or of average inclination with an increase overjet), Class 2 division 2 (the lower incisor edges lie palatal to the cingulum plateau of the upper incisors; upper incisors and usually lowers are retroclined, with minimal overjet although it may be increased) and Class 3 (the lower incisal edges lie anterior to the cingulum plateau of the palatal surface of the upper incisors) (British Standards Institutes, 1983). The incidences in the British population are Class1 incisors 60%, Class 2 division1 20%, Class2 division2 10-18% and Class3 5% (Todd and Ladder 1988).

Prevention and stable correction of occlusal discrepancies requires an understanding of the aetiology of malocclusion. The aetiology of malocclusions is multifactorial with a combination of genetic and environmental influences. Proffit (1986) stated that 95% of malocclusions are due to a variation of normal development and 5% of malocclusions have an identifiable cause. Genetics include ethnicity and skeletal pattern both vertically and antero-posteriorly and dental hard tissue. Environment influences tooth position, but both act synergistically to create malocclusion (Lundstrom, 1984, Dibbets, 1996). Environmental factors include the soft tissues (Proffit, 1978), particularly the lips and tongue, pathology and habits (Bowden, 1966). The relative importance of genetic and environmental influence depends on the trait under examination.

1.2 Bimaxillary Protrusion

In 1897 the term Bimaxillary Protrusion was coined by Calvin Case (Case 1921) describing “a condition in which the entire dentures of both jaws are protruded in relation to the mandible and other bones of the skull”, and that “this deformity is always aggravated by a receding chin” (Lewis, 1943). Another definition describes bimaxillary protrusion as “a condition characterised by protrusive and proclined upper and lower incisors and an increased procumbency of the lips” (Bills et al., 2005).

1.2.1 Classification

In bimaxillary protrusion the upper and lower incisors are proclined (bimaxillary proclination, Figure 1.1). In cephalometric analysis the upper incisor to maxillary plane is 109º± 5º and the lower incisor to mandibular plane is 93º± 6 º. Therefore, a proclined upper incisor is any degree above 114º and lower incisor is any degree above 99º. Therefore, in bimaxillary protrusion the upper and lower incisors will be above 114º and 99º respectively.

Severity of bimaxillary protrusion can also be classified by the interincisal angle. The normal Caucasian interincisal angle is 135º ± 10º, therefore an interincisal angle less than 125 º is considered mild bimaxillary protrusion.

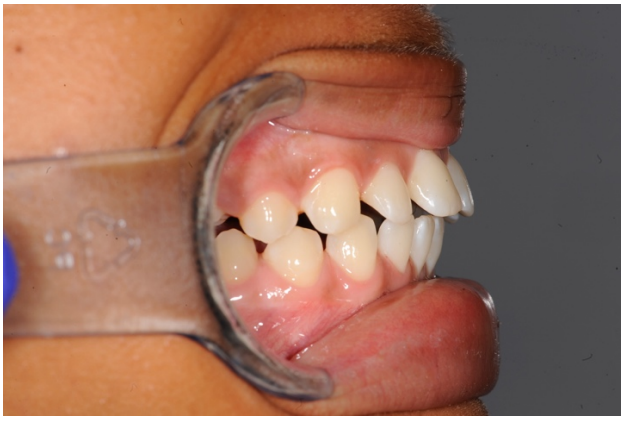


Figure 1.1: Intraoral presentation of bimaxillary protrusion showing proclined upper and lower incisors

1.2.2 Skeletal Pattern

Studies have shown that in bimaxillary protrusion the skeletal pattern displays a skeletal bimaxillary prognathism, increased ANB angle due to greater maxillary prognathism, divergent facial planes, smaller upper and posterior face height, larger dental arch, and a steeper mandibular plane angle (Keating, 1986, Carter and Slattery, 1988) (Figure 1.2). The antero-posterior dimensions of the maxilla and mandible are larger in bimaxillary protrusion patients and the vertical ramus is broader (Enlow et al., 1982). (Consent was obtained from the participant for use of her picture).

Figure 1.2: Showing extraoral profile with bimaxillary prognathism

1.2.3 Dental

The presence of large incisors may exacerbate the facial appearance of bimaxillary protrusion. Two authors (Lavelle, 1974, Keene, 1979) showed teeth to be larger in these subjects compared to Caucasians. Bimaxillary protrusion can have superimposed crowding or spacing. It has been suggested that crowding may exacerbate Bimaxillary

proclination (Ballard, 1963). Upper and lower incisors are proclined, the proclined lower labial segment compensating for the ANB difference (Carter and Slattery, 1988).The dental arch length is also increased.

Some authors report in bimaxillary protrusion the teeth are in normal molar relationship and there is a relatively normal overbite and overjet (Keating, 1986, Carter and Slattery, 1988). However, there can also be an anterior open bite in these cases.

1.2.4 Environmental Factors

Primary forces on the teeth are intrinsically from the tongue and lips and extrinsically from habits.

Proffit (1978) wrote on the equilibrium theory of tooth position. Equilibrium is said to exist when a body at rest is subjected to forces in various directions but is not accelerated. Proffit (1978) stated that the teeth are in equilibrium position because the forces are equal on them from all directions over time. This was regardless of the muscle applying the force.

The lips, cheek and tongue are the most important determinants of tooth position (Di Fazio et al., 2011). The forces from the tongue have been shown to be greater than the lips (Proffit, 1978). In bimaxillary protrusion there is also lip incompetence, a gummy smile and mentalis strain (Chu et al., 2009).

1.2.5 Tongue

1.2.5.1 Tongue Volume

Lamberton et al. (1980) stated that an increased tongue volume was part of the multifactorial aetiology of bimaxillary protrusion. Other authors reported tongue volume and tongue pressure (Bills et al., 2005, Adesina et al., 2013) as key aetiological factors in bimaxillary protrusion.

1.2.6 Lips

Lips have been shown to be slightly longer in subjects of African descent with bimaxillary protrusion than in Caucasians (Connor and Moshiri, 1985). The lips are much more protrusive in women of African descent than in Caucasian women, on average they were 7mm in front of the N-Po line (Fonseca and Klein, 1978). Noteworthy, is that the soft tissues overlying points A, B and Pogonion showed no difference in thickness. Labial protrusion seen is partly due to Bimaxillary Protrusion and partly eversion of the longer lips of people of African descent rather than thicker soft tissues (Carter and Slattery, 1988). Carter and Slattery also stated that this reveals there is more lip tissue between upper and lower vermillion borders and explains why the nasolabial angle is smaller in people of African descent. The nasal tip was found to be less prominent in people of African descent than Caucasians. This combined with protrusive lips gives a convex facial form in bimaxillary protrusive patients (Connor and Moshiri, 1985). Naini and Gill (2008) reported in bimaxillary protrusive patients the lips are full, loose, and everted and the tongue acts to mould the dental arches forward as they erupt in this malocclusion.

The lip line is also low (Keating, 1985). Fonseca and Klein (1978) reported lips were more protrusive in females of African descent compared to Caucasians

1.2.6.1 Lip Forces and Malocclusion- absence of class 2 division 2 incisors

In bimaxillary protrusion the incisor relationship can be Class 1, 2 or 3 (Chu et al., 2009). Of interest is the absence of Class 2 division 2 malocclusions in bimaxillary protrusion cases. Genetics as part of the aetiology of Class 2 division 2 malocclusion has been demonstrated (Markovic, 1992). Mossey (1999) described Class 2 division 2 as a syndrome. He said it comprises of a deep overbite, retroclined incisors, Class 2 skeletal discrepancy, high lip line with strap like activity of the lower lip, and active mentalis muscle.

Tomes (1873) said “the teeth are like a plastic material which cannot fail to be moulded by the tongue and lips to produce all the various arrangements which we see’’. In Class 2 division 2 malocclusion a ‘strap-like’ lower lip is present and may retrocline the maxillary

and mandibular incisors, resulting in bimaxillary retroclination (Lapatki et al., 2002). Lapatki also reported that high resting lip pressure against maxillary incisors causes the retroclination.

In contrast in bimaxillary protrusion the pressure from the tongue is thought to be the dominant force and there is a low lip line which leads to the bimaxillary proclination (Keating, 1985). Also, maximum lip forces were found to be slightly smaller in bimaxillary protrusion cases compared to Caucasians (Mitchell and Williamson, 1978). This difference however was not statistically significant. In contrast Posen (1976) found subjects with bimaxillary protrusion had low lip strength, compared with Class1 and Class 2 division 2 patients.

1.2.7 Habits

1.2.7.1 Tongue Thrust

1.2.7.1.1 Definition

Tongue thrust is a condition in which the tongue makes contact with the teeth anterior to the molars during swallowing (Singaraju and Kumar 2009). The tongue thrust habit is related to the persistence of an infantile swallow pattern during childhood and adolescence and thereby produces an open bite and protrusion of the anterior segments (Singaraju and Kumar 2009).

1.2.7.1.2 **Tongue Thrust Classification** (Brauer and Holt, 1965)

Type 1- Non deforming tongue thrust

Type 2- Deforming anterior tongue thrust

Subgroup1- Anterior open bite

Subgroup2- Associated procumbency of anterior teeth

Subgroup3- Associated posterior crossbite

Type 3- Deforming lateral tongue thrust

Subgroup1- Posterior Open Bite

Subgroup 2- Posterior Crossbite

Subgroup 3- Deep Overbite

Type 4- Deforming anterior and lateral tongue thrust

Subgroup1 -Anterior and posterior open bite

Subgroup2- Associated procumbency of anterior teeth

Subgroup3- Associated posterior crossbite

Brauer and Holt (1965) stated with Type 2 subgroup 2 (Associated procumbency of the anterior teeth) the associate deformity may be bimaxillary protrusion.

Sassouni (1969) in classifying skeletal facial types, suggested that with skeletal open bite there is a tongue thrusting tendency. A narrow palatal vault exists and the vault is constricted because of inadequate development of the posterior face. This leads to a disproportional development which causes a tongue thrust which leads to bimaxillary protrusion.

1.2.7.2 Digit sucking habit

A digit sucking habit acts locally to alter the resting forces on teeth (Bowden (1966). Occlusal effects include formation of an asymmetrical anterior open bite, proclined incisors, increased overjet and a unilateral buccal crossbite. A digit sucking habit can lead to a tongue thrust habit.

1.2.8 Susceptibility to Dental trauma

Reported predisposing factors for dental trauma include proclined incisors, increased overjet, incompetent lips, and accident proneness (Juneja et al., 2018, Burden, 1995,

Baccetti et al., 2011). Bimaxillary protrusion subjects might therefore have an increased risk of dental trauma (Barsi et al., 2013).

1.3 Prevalence of Bimaxillary Protrusion

It has long been reported that bimaxillary protrusion is prevalent in the African American (Fonseca and Klein, 1978) and Afro-Caribbean populations (Farrow, 1993). It is also common among Arab groups (Hussein, 2007) and Asians (Lamberton et al., 1980, Tan, 1996) and is less prevalent in Caucasian populations (Keating, 1985).

The twin island republic of Trinidad and Tobago is a cosmopolitan country and the last census in 2011 reported the total population at 1,328,019.

According to the Trinidad and Tobago census people of East Indian descent make up 36.43% of the population and African descent 34.2%. The mixed ethnicity population was the third largest making up 22.8% of the population (Figure 1.3).

The prevalence and occlusal features of bimaxillary protrusion in the Trinidad and Tobago population is unknown.

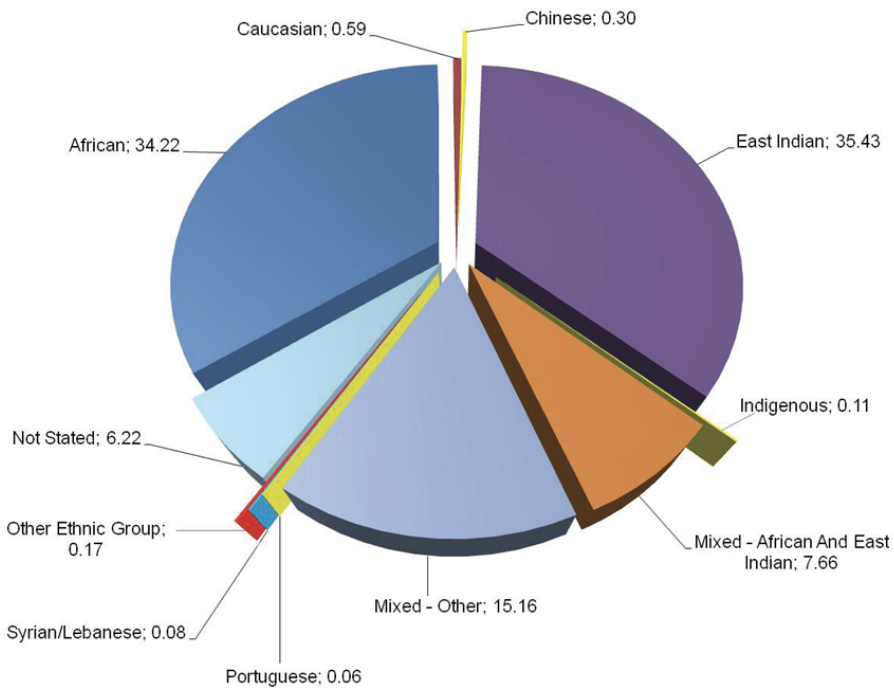


Figure 1.3: Percentage Distribution of Total Population by Ethnic Group, 2011 population census Trinidad and Tobago

1.4 Consequences of Bimaxillary Protrusion

1.4.1 Human health and wellbeing

The World Health Organisation defines health as a state of complete physical, mental, and social well-being. In today's society facial aesthetics is an important concern (Kiekens et al., 2005). Pleasant aesthetics is an important factor for psychosocial wellbeing (Shaw, 1981, Shaw et al., 1985, Birkeland et al., 2000). In order to document the prevalence and severity of a malocclusion in a society, measuring of malocclusion is required. This can be qualitative (Tang and Wei, 1993) or quantitative (Van Kirk, 1959, Grainger, 1967, Summers, 1971, Brook and Shaw, 1989, Daniels and Richmond, 2000). Use of indices aid in prioritising treatment and assessing treatment need or outcome. When there is limited access to dental care as occurs in developing countries, treatment is unevenly spread, and priority should then be given to patients with the greatest need.

1.4.2 Aesthetics and dental health

1.4.2.1 Facial aesthetics

Improvement of facial aesthetics and dental appearance are the main reasons patients with bimaxillary protrusion seek orthodontic treatment. This agrees with most studies (Birkeland et al., 2000, Kiyak, 2000, Trulsson et al., 2002). In bimaxillary protrusion there is unacceptable circumoral convexity of the facial profile despite in most cases a Class1 molar relationship. This negatively impacts on the individual's psychological wellbeing and they seek orthodontic treatment for improvement (Bills et al., 2005). But the existing occusal and facial indices are not sensitive to profile alterations (Sundareswaran and Ramakrishnan, 2016). Little effort has been made to prioritise, categorise and identify patients according to soft tissue treatment needs even though soft tissue patterns in treatment planning are important. In the UK and Europe, the Index for Orthodontic Treatment Need (IOTN) has been widely used in research to quantify malocclusions. It has also been used as a screening tool to ascertain which patient on hospital waiting lists recieve treatment (Dawjee et al., 2002). Dawjee et al (2002), also pointed out a shortfall for the use of the IOTN index in bimaxillary protrusion cases, that is the index ignores occlusal traits common to patients with bimaxillary protrusion.

1.4.2.2 Dental Health- susceptibility to trauma

Proffit et al. (2013) stated that malocclusion, particularly protruding maxillary incisors, can increase the likelihood of injury to teeth. Carter and Slattery (1988) described the reasons for treating bimaxillary protrusion as to flatten the profile, reduce overjet and enable lip competence. With the IOTN the Dental Health Component (DHC) classifies malocclusion into five grades determined by the potential harm that a particular malocclusion can have on the longevity of the dentition. In Class1 incisal relationship in bimaxillary protrusion because of the proclination of the incisors there is an increase in overjet approximately 5mm with or without incompetent lips. With the IOTN DHC this would fall into Grade 3 which is a borderline need for treatment. Proclined incisors, increased overjet and incompetent lips make bimaxillary protrusion subjects at a greater

risk for trauma and therefore there is a greater need for treatment. Therefore, the IOTN which only has five grades would not rank bimaxillary protrusion as a great need for treatment

1.5 Treatment Aims and Treatment Planning

Aims of treatment are mainly to improve facial aesthetics and flatten the profile (Carter and Slattery, 1988). Levelling and alignment of teeth, complete retraction of maxillary and mandibular incisors with reduction of procumbency of lips and incisors, establishment of a positive overbite and overjet and reduction of facial convexity are the usual treatment aims for bimaxillary protrusive patients. Treatment planning will include creation of space most commonly by extraction of first premolars and complete retraction of anterior teeth with maximum anchorage (Bills et al., 2005).

1.6 Fixed Appliance Systems

Bimaxillary Protrusion can be treated using different mechanics including the Begg lightwire technique (Lew, 1989), edgewise appliance (Caplan and Shivapuja, 1997) and predjusted edgewise appliances (Sharma, 2010).

1.6.1 Begg appliance

The Begg appliance has excellent anchorage control derived totally intraorally and offers great potential in the treatment of bimaxillary protrusion. Lew (1989) reported this treatment resulted in:

1. Upper incisors were retracted by 5.6 ± 0.8mm and lower incisors by 4.4 ± 0.8mm;
2. The nasolabial angle became more obtuse increasing from 80.7º to 90.7 º;
3. The upper lip and lower lip lengthened by 1.9mm and 1.2mm;
4. The lower lip to E line reduced from 7.5mm to 3.7mm;
5. The upper lip to upper incisor retraction was 1:2.2 while the lower lip to lower incisor retraction was 1:1.4; and
6. Reduction in bimaxillary protrusion and improvement in the soft tissue profile.

1.6.2 Edgewise preadjusted appliance- self-ligating vs conventional ligation

Stolzenberg (1935), described the first self-ligating bracket, the Russell attachment in the 1930's. At that time because of scepticism or lack of promotion, it did not gain much popularity (Chen et al., 2010). There has been a resurgence of interest in the self-ligating bracket over the last thirty years. One of the reported advantages of these brackets is reduced friction, with the passive design creating less friction than the active design (Chen et al., 2010, Kim et al., 2008). It is proposed that self-ligating brackets with reduced friction require less force to achieve tooth movement (Berger, 2008, Pizzoni et al., 1998, Sims et al., 1993, Kim et al., 2008). Other proposed advantages of self-ligating brackets include reduces chairside time (faster archwire removal and ligation), less anchorage requirements, less chairside assistance, more efficient levelling, more certain full archwire engagement, patient comfort and minimal force (Damon, 1998, Turnbull, 2007, Berger, 2008).

There have been several systematic reviews of the treatment effects of conventional and self-ligated bracket systems published in recent years (Celar et al., 2013, Ehsani et al., 2009), but none of these looked at the use of these systems in bimaxillary protrusion patients. We therefore do not currently know if the proposed advantages of self-ligating brackets translate to being better in a bimaxillary protrusive population compared with conventionally ligated brackets.

The treatment efficiency of self-ligating versus conventional ligating systems has only been studied in predominantly Caucasian populations where the prevalence of bimaxillary protrusion is low. Therefore, it is unknown whether the same advantages reported in these populations hold for a population where bimaxillary protrusion is prevalent.

1.7 Treatment Mechanics

Carter and Slattery (1988) stated that for creation of space premolar extractions are appropriate for crowded cases but avoid extractions for incisor retraction alone as relapse is likely and extraction spaces can reopen. Extraction of four premolars can be used to decrease procumbency (Bills et al., 2005). En masse retraction is preferred to two step

retraction of the anterior teeth in bimaxillary protrusion cases since it is aesthetically more acceptable (Felemban et al., 2013).

1.7.1 Type of anchorage

Upadhyay et al. (2008) conducted a randomised clinical trial on bimaxillary protrusion patients and compared mini-implants as anchorage devices with conventional anchorage techniques in these subjects. Chopra et al. (2017) also conducted a prospective clinical trial comparing mini-implants and conventional anchorage devices. Upadhyay concluded that mini- implants provided absolute anchorage for en masse retraction of anterior teeth. Chopra et al (2017) also concluded there was less anchorage loss with mini-implants. The treatment time with mini-implants was less though not statistically significant in both studies. Chopra et al. (2017) showed that the soft tissue response was variable and that lower lip protrusion, nasolabial angle and facial convexity angle, showed greater changes in the mini-implant group. Liu et al. (2009) compared the use of mini-implants with transpalatal arches in patients with bimaxillary protrusion and found mini-implants achieved better dental, skeletal and soft tissue changes and mini-implants should be routinely recommended in bimaxillary protrusion cases. Chen et al. (2015) compared the use of extra-oral anchorage (headgear) with mini-implants and showed superior control in anterior posterior and vertical dimensions with mini-implants compared with headgear.

1.7.2 Elastics

Intermaxillary elastics are often used to support anchorage in bimaxillary protrusion treatment. Intermaxillary elastics have an inherent vertical force vector (Hanes, 1959, Bien, 1951). This force may cause incisors to extrude and lead to an opening rotation of the mandible compromising the overbite in bimaxillary protrusive cases (Kanter, 1956, Bien, 1951).

1.7.3 Glossectomy

There is low quality evidence for the use of glossectomy in treating bimaxillary protrusion (Silbermann et al., 1972, Egyedi, 1965, Swanson and Murray, 1969). Glossectomy is recommended in cases involving speech problems or psychological indications.

1.7.4 Orthognathic surgery

In severe bimaxillary protrusion cases orthognathic surgery is required. In the adult patient bimaxillary protrusion may be complicated by periodontal problems, large diastemas, vertical maxillary excess, symmetrical or asymmetrical transverse deviations, mandibular dentoalveolar vertical hyperplasia or any saggital skeletal discrepancy (Jacobs and Bell, 1983). Correction includes subapical osteotomies with or without extraction and or genioplasty. Chu et al. (2009) reported extraction of premolars and anterior subapical osteotomies can correct saggital excess. When there is vertical maxillary excess and an exaggerated curve of Spee segmental maxillary osteotomies is the recommended form of treatment. Anterior open bite treatment can include differential intrusion of maxillary segments or the maxilla with clockwise rotation of the occlusal plane.

1.8 Cephalometric Norms

Cephalometric radiography is a standardised and reproducible method to take x-rays of the cranial vault and facial skeleton. It was developed in 1930's by Broadbent in the USA (Broadbent, 1937) and Hofrath in Germany. Cephalometric analysis is used in diagnosis and treatment planning (Isaacson, 2015). It is also used during active treatment, towards the end of treatment, during retention, in research (Bjork, 1954) growth prediction, to assess treatment progress and craniofacial growth (Broadbent, 1937).

Various studies have been conducted to establish cephalometric norms of different ethnic and racial groups. These studies show that norms for one group are not necessarily appropriate for another group. Each racial group must be treated according to its own characteristics (Ajayi, 2005). Accurate diagnosis is dependent upon comparing patient's

cephalometric findings with norms in their ethnic group as patients tend to seek a treatment plan based on norms for their racial group (Miyajima et al., 1996).

Hard tissue norms for common angular values are shown in Table 1.1

Table 1.1: Hard tissue norms for common angular measurement in three racial groups

	Caucasian	Chinese	Afro-American
SNA	81 º	84 º	88 º
SNB	78 º	80 º	84 º
ANB	3 º	4 º	4 º
MMPA	27 º	28 º	28 º
U1 to MxP	109 º	113 º	118 º
L1 to MnP	93 º	98 º	101 º

(Proffit et al., 2013, Fonseca and Klein, 1978, Chan, 1972)

With soft tissue norms lateral cephalograms need to be carefully interpreted due to errors due to identification of points, posturing and variable muscle tone. Errors in cephalometric radiography can be systematic (when a measurement is consistently under/overestimated) or random (variable error with no pattern) (Houston, 1983).

Errors can be reduced by employing one of several methods, duplicating measurements, good quality film and standardisation, care when interpreting results, careful selection of analysis, clear understanding of point definition, error calculation, (Houston, 1983, Houston et al., 1986) and automated computerised x-ray identification of landmarks (Rudolph et al., 1998).

There are no established cephalometric norms for the Trinidad and Tobago population. Therefore, orthodontic diagnosis and treatment planning in this population is not ideal.

1.9 Stability in Bimaxillary Protrusion Cases

Ballard (1963) stated that retraction of maxillary to mandibular incisors in bimaxillary protrusion cases is stable once in control of the lower lip. Long term stability in bimaxillary protrusion cases is therefore unpredictable and depends on lip pattern adapting to incisor retraction (Keating, 1986). The rest position of the lips determines stability as it determines the tooth position (Carter and Slattery, 1988). In a Caucasian bimaxillary protrusion sample the interincisal angle relapsed by twenty percent (Keating, 1985).

In this thesis I plan to look at not just prevalence of bimaxillary protrusion in Trinidad and Tobago but to systematically review reported prevalence of bimaxillary protrusion. I will also be investigating prevalence of oral habits and fractured incisors in this population as well as the cephalometric norms and tongue pressure. I will perform a systematic review on orthodontic treatment of bimaxillary protrusion and present a protocol and interim report of a randomised clinical trial to compare the use of self-ligating versus conventional bracket in this population.

CHAPTER 2 - AIMS AND OBJECTIVES

2.1 Aims

The aim of this study is to examine bimaxillary protrusion in Trinidad and Tobago population. The study will look at prevalence, features and management of this malocclusion.

2.2 Objectives

- Conduct a systematic review of prevalence of bimaxillary protrusion
- Investigate the prevalence of bimaxillary protrusion in the Trinidad and Tobago population
- Investigate the prevalence of fractured incisors in Trinidad and Tobago population and its association with bimaxillary protrusion
- Investigate the prevalence of oral habits in Trinidad and Tobago population and its association with bimaxillary protrusion
- Conduct a systematic review of treatment of bimaxillary protrusion
- Develop a protocol and provide an interim report on a study to compare self-ligating and conventional brackets in the treatment of bimaxillary protrusion
- A prospective study to ascertain cephalometric norms for the Trinidad and Tobago population

CHAPTER 3 - PREVALENCE OF BIMAXILLARY PROTRUSION: A SYSTEMATIC REVIEW AND META-ANALYSIS

3.1 Introduction

In 1897 the term bimaxillary protrusion was coined by Calvin Case (Case, 1921) describing “a condition in which the entire dentures of both jaws are protruded in relation to the mandible and other bones of the skull”, and that “this deformity is always aggravated by a receding chin”(Lewis, 1943). Another definition describes bimaxillary protrusion as “a condition characterized by protrusive and proclined upper and lower incisors and an increased procumbency of the lips” (Bills et al., 2005).

For the purpose of this systematic review bimaxillary protrusion will be defined as a form of malocclusion characterized by protrusion of both upper and lower jaws with proclination of the incisors and usually without disharmony between the arches. Many articles have described this condition as being present in African American (Fonseca and Klein, 1978), Asian (Lamberton et al., 1980), Trinidad and Tobago (Hoyte et al., 2018) and, in fact, almost every ethnic group to some extent (Hussein and Abu Mois 2007, Hassanali, 2006, Hassan, 2006, Keating,1985, Behbehani et al., 2006, Shehata, 1982).

In most countries there is a negative aesthetic perception of a protrusive dentition and protrusive lips and this leads patients with bimaxillary protrusion to seek orthodontic treatment. Some of these societies have recorded a marked increase in orthodontic patients attending requesting a reduction in their protrusive profile (Hussein and Abu Mois, 2007). While bimaxillary protrusion has been reported as occurring in many populations there appears to be a shortage of data on its actual prevalence and studies reporting prevalence have a wide variation in sample size.

Despite increasing data on prevalence there has been no previous attempt to consolidate this information and there has been no attempt to undertake a systematic review of the prevalence of bimaxillary protrusion among different populations. Understanding of the prevalence of this condition in different populations is important for health policy making as the demand for orthodontic treatment of patients with bimaxillary protrusion is increasing in most countries and publicly funded healthcare systems will have to introduce methods to prioritize treatment based on appropriate objective measures of need.

3.2 Materials and Methods

This review was undertaken according to the Joanna Briggs Institute (JBI) reviewers' manual for systematic review of prevalence and incidence data (The Joanna Briggs Institute, 2014).

3.2.1 Eligibility criteria

The following selection criteria were applied by two reviewers for initial identification and screening of potential published abstracts.

1. Type of Publication: Only published articles from scientific journals were selected. Excluded were thesis, letters, abstracts, editorials, letters.
2. Type of Study: Only observational studies were included. Case control studies, case reports, clinical trials, and retrospective studies were excluded.
3. Population: No restrictions were placed on population.
4. Context: General population; no selection was made by context
5. Condition: Bimaxillary protrusion including the presence of prognathic upper and lower jaws, or proclined upper and lower incisors or both.
6. Exclusion criteria: Studies evaluating convenience samples were excluded. Studies not published in English language were excluded.

3.2.2 Search strategy

To identify all the studies on prevalence of bimaxillary protrusion a literature search was performed in the following electronic databases: PubMed, Medline, Scopus, Google Scholar and the Cochrane Library up to 5th February 2019. The MeSH headings Bimaxillary Proclination or Bimaxillary Protrusion or Bimaxillary dentoalveolar protrusion or Bidental or Bialveolar Protrusion or Biprotrusion or Bimaxillary Prognathism or Bimax* or Bimaxillary* and Prevalence were used in conjunction with keywords.

3.2.3 Selection and assessment of relevance

Selection of articles was determined independently by two authors using the criteria above and any discrepancy between the authors was resolved through discussion. All article abstracts that met the selection criteria were selected and full articles retrieved, extraction of data was performed independently and in duplicate by two investigators (T.H and D.B) who were not blinded to the authors or the results of the research.

3.2.4 Assessment of methodological quality

The methodologic soundness of each article was assessed using the critical appraisal tool for studies reporting prevalence from the JBI (The Joanna Briggs Institute, 2014).

The following ten questions were asked to critically appraise the study:

1. Was the sample representative of the target population?
2. Were study participants recruited in an appropriate way?
3. Was the sample size adequate?
4. Were the study subjects and setting described in detail?
5. Was the data analysis conducted with sufficient coverage of the identified sample?
6. Were objective standard criteria used for the measurement of the condition?
7. Was the condition measured reliably?
8. Was there appropriate statistical analysis?
9. Are all important confounding factors/ subgroups/ differences identified and accounted for?
10. Were subpopulations identified using objective criteria?

The outcome from the overall assessment of quality (include, exclude or seek further information) was made for each study using the JBI critical appraisal tool. Studies with at least one criteria obtaining a 'no' in the first five questions from the critical appraisal checklist were regarded as having a high risk of bias and excluded from the meta-analysis. The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) methodology was used to assess the quality of the body of retrieved evidence (GRADEpro, version 20, McMaster University, 2014).

3.2.5 Analysis

A meta-analysis was performed by pooling the data using a random-effects model for bimaxillary protrusion using Comprehensive Meta-Analysis software (Version 3.3, Biostat, Englewood, NJ, USA). Heterogeneity was tested using I^2 test, and if enough studies were included was to be examined using the 'one study removed' sensitivity method. Subgroup analysis was planned by sex and ethnicity if appropriate data was available.

Forest plots displaying mean prevalence (together with 95% confidence interval) were generated.

3.3 Results

The outcome of the search and selection are shown in the PRISMA flow diagram (Figure 3.1). Pubmed identified 93 articles, Medline identified 39, Scopus 24, Google Scholar 1 and Cochrane Library identified none. After removal of duplicates, 94 articles were initially deemed potentially relevant to the review.

After initial screening, 13 were deemed applicable to the research question. Two were subsequently excluded because they did not satisfy the inclusion criteria. Of the final 11 full text articles assessed for eligibility eight were excluded, three of these were not observational studies but were interventional. Of the observational studies the sample was deemed not representative of the target population in four articles and because of this risk of bias these four were excluded from the systematic review (Table 3.1).

One of the remaining articles was excluded as the study participants were not recruited in an appropriate way with the sampling being from patients assessed as requiring orthognathic surgery. Of the three articles assessed as eligible for inclusion, all were cross-sectional studies.

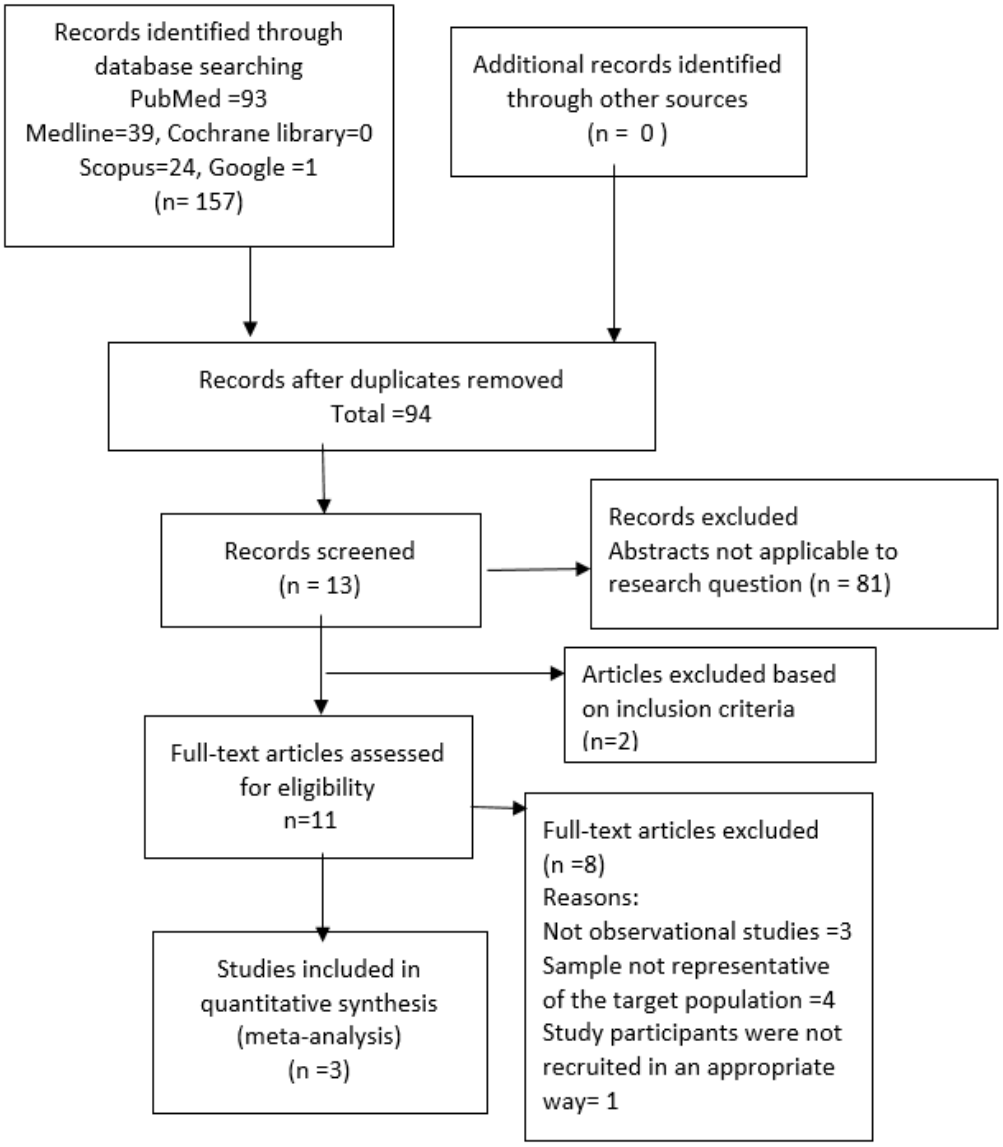


Figure 3.1: Prisma flow chart for article retrieval

Table 3.1: Observational Studies excluded from the Meta-analysis

Author	Year	Population	Sample Size	Prevalence	Condition	Reason for exclusion
Isiekwe, M	1990	Medical, dental students and armed forces of Nigeria	110	20%	Bimaxillary protrusion	Unclear if sample is representative of population
Bryan, Jones	1986	Saudi Arabia	132	No figure given	Bimaxillary proclination	The sample was not representative of the population; the participants were not recruited in an appropriate way. The study subjects and settings were not described in detail
Boeck, E et al	2011	Brazil	381	4.09%	Biprotrusion	Used patient with dentofacial deformities and required orthognathic surgery
Baeshen, H	2017	Saudi Arabia	300	8.3%	Bimaxillary protrusion	Did not sample from population but people seeking treatment. Sample was not representative of the target population and study participants were not recruited in an appropriate way

3.3.1 Included studies

Only three articles qualified for the final analysis, since they fulfilled the selection criteria and finally were included in this systematic review and meta-analysis. The study design of the three articles and the results are summarized in Table 3.2. The first included study was of 1028 subjects aged 11-18 years from four educational institutions in an urban city in northern Nigeria (Dacosta, 1999). The second included study was of 1024 randomly selected subjects aged 13-15 years residing in Jeddah City attending middle schools from different socioeconomic backgrounds (Murshid et al., 2010). The third included study was of 972 subjects aged 11-12 years old from high schools across Trinidad and Tobago (Hoyte et al., 2018). In all three studies the sample size was representative of the target

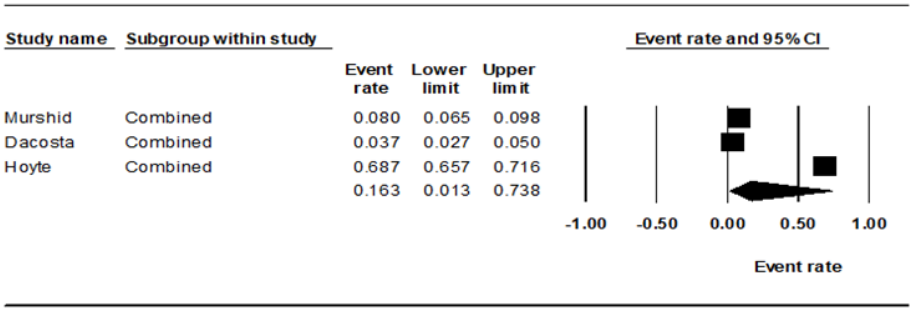
population, the participants were recruited in an appropriate way, the sample size was adequate and the study subjects and settings were described in detail. For two studies (Dacosta, 1999) (Murshid et al., 2010) objective, standard criteria were not used for the measurement of the condition and the condition was not measured reliably. The study by Dacosta (1999), reported a prevalence of 3.7%, Murshid et al. (2010) reported 8% and Hoyte et al. (2018) reported a 68.8% prevalence.

3.3.2 Meta-analysis

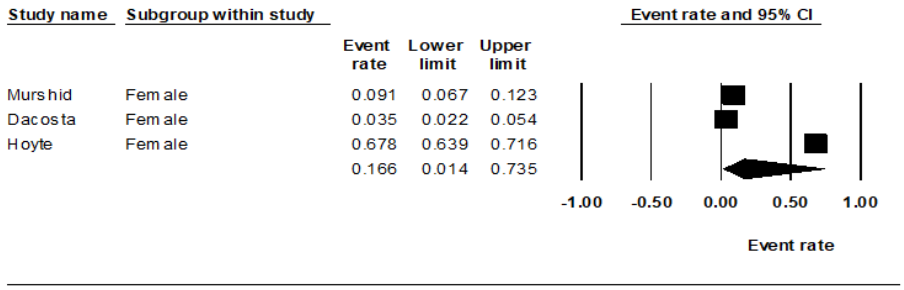
Quantitative data synthesis was undertaken for the three included studies and the results are shown in Figure 3.2 for the whole samples and for the subgroup analysis by sex. Because it was not reported directly, the authors of the third study were contacted for prevalence by sex for inclusion in the meta-analysis sub-group analysis. I^2 tests for homogeneity were undertaken to quantify the extent of heterogeneity. The included studies showed an overall prevalence of 16.3% (95% CI: 1.3 - 73.8%) I^2 was 99.8%. Males had a prevalence of 16.4% (95% CI: 1.3- 74.5%) and I^2 was 99.5%. Females had a prevalence of 16.6% (95% CI: 1.4 - 73.5%) with I^2 at 99.5%. It was not possible to undertake subgroup analysis by ethnicity as this was not reported separately in two of the three studies.

Table 3.2: Studies included in the Meta-analysis

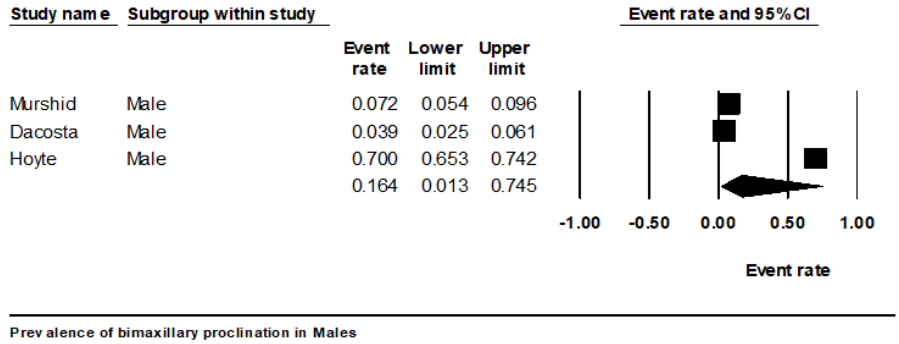
Author	Year	Population	Sample Size	Prevalence	Condition	Study design
Dacosta, Oluranti	1999	Northern Nigeria	1028	3.7%	Bimaxillary proclination	Epidemiological survey
Murshid et al	2010	Saudi Arabian	1024	8%	Bimaxillary protrusion	Cross-sectional study
Hoyte et al	2018	Trinidad and Tobago	972	68.8%	Bimaxillary protrusion	Epidemiological survey



$I^2 = 99.8$



$I^2 = 99.5$



$I^2 = 99.5$

Figure 3.2: Forest plots of prevalence for whole samples and subgroups by gende

3.3.3 GRADE

Overall evidence was also qualified using GRADE for the included observational studies. The GRADE tables are in Table 3.3

Table 3.3: GRADE table showing summary of evidence table for observational studies

Quality assessment							Summary of Findings		
Participants (studies) Follow up	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall quality of evidence	Study event rates (%)	Relative effect (95% CI)	Anticipated absolute effects
							With Control / With		Risk with Control / Risk difference with (95% CI)
Prevalence of Bimaxillary Protrusion (CRITICAL OUTCOME; Better indicated by lower values)									
3028 (3 studies)	no serious risk of bias	serious[2]	no serious indirectness	no serious imprecision	undetected		2535 / 493	-	The mean prevalence of bimaxillary protrusion in the intervention groups was **0 higher** (1.3 to 73.8 higher)

[1] 1.There was not objective, standard criteria used for measurement of the condition

[2] 2. Was the condition measured reliably

3.4 Discussion

This systematic review only identified a small number of studies that met the initial inclusion criteria, and only three studies were included for data synthesis including meta-analysis. Studies were excluded mainly because the sample was not representative of the population (Isiekwe, 1990, Jones, 1987), or were not observational studies and the study participants were not recruited in an appropriate way, but were selected from populations seeking treatment (Boeck et al., 2011, Baeshen, 2017). For inclusion in this review selection criterion had to be independent of specific context to minimize the number of confounding variables. This was because it is likely that the prevalence of bimaxillary protrusion in those seeking treatment, does not represent the prevalence in the general population. Therefore, more studies with representative samples and appropriate recruitment are needed to produce more robust data on prevalence of bimaxillary protrusion.

Analysis of reported prevalence data requires scrutiny of the sample and collection of data. Reliability of the prevalence data is affected by the quality of the diagnostic criteria for identifying the condition of bimaxillary protrusion which varied between the studies. There is a need for an agreed definition and diagnostic criteria for bimaxillary protrusion and bimaxillary prognathism. For example, the diagnostic tools used in the three included studies varied from extra oral clinical examination to intra oral clinical examination to use of the tooth inclination protractor (TIP).

The large variation in prevalence rates in the included studies are likely due to these and other methodological issues as well as a high level of variability across geographic areas and ethnicities. Trinidad and Tobago's population showed a high prevalence rate which confirms previous suggestions of high rates in Afro-Caribbean populations (Carter and Slattery, 1988). Prevalence in this ethnic group is significantly higher than that amongst other ethnic groups.

The meta-analysis showed very high levels of heterogeneity (I^2 was greater than 75% which indicates high heterogeneity). The pooled prevalence rates may therefore not be

valid. The differences in prevalence ranged from 3.7% to 68.8%, but with only three included studies it was not possible to undertake sensitivity analysis. This heterogeneity may be due to differences in geography, ethnicity or methodology for conducting the research. The impact that methodology, geography and ethnicity have on the reported prevalence may have caused prevalence rates to be over or underestimated.

Overall quality of evidence, as qualified by GRADE, was low. Thus further research will have an impact on our confidence in the estimate of effect and is likely to change the estimate (Atkins et al., 2004). A more robust protocol for reporting prevalence data is required to obtain meaningful rates and comparisons and an example of this is the STROBE guidelines.

The clinical significance of this research is that orthodontic treatment needs to provide treatment for any patient with functional or aesthetic problems. Bimaxillary protrusion patients can have functional problems such as speech, adaptive tongue thrust, anterior open bite and spacing. Aesthetically, these patients can have psychosocial problems and they are also entitled to treatment just the same as anyone with a functional problem. Excessive bimaxillary protrusion has been attributed to gingival recession as the unbalanced tooth arch relationship results in buccally prominent teeth enclosed by a thin or non-existent labial plate of bone and inadequate keratinized gingiva (Gowd et al., 2017).

However, given these limitations it is important to remember the need for prevalence data since more people with bimaxillary protrusion are seeking orthodontic treatment to improve facial aesthetics. Bimaxillary protrusion has now been identified in almost all ethnicities. Because it is realistically impossible to sample every population for a prevalence rate, it becomes very difficult to make generalised decisions on all populations. We can only make decisions on the available data until more information on sex, ethnicity and geographical variation in prevalence through further research is made available and it is likely that this would change our conclusions.

3.5 Conclusion

1. Prevalence of bimaxillary protrusion varies greatly among populations.
2. The Trinidad and Tobago population showed a high prevalence across all ethnicities.
3. Methodology, geography and ethnicity had a major impact on reported prevalence.
4. Further studies are required to better assess impact of factors affecting reported prevalence.

CHAPTER 4 - PREVALENCE OF BIMAXILLARY PROTRUSION AND OCCLUSAL FEATURES IN TRINIDAD AND TOBAGO

4.1 Introduction

In bimaxillary protrusion the characteristic facial profile may be a result of the prognathic maxilla and mandible (bimaxillary prognathism) and / or proclined upper and lower incisors (bimaxillary proclination) (Carter and Slattery, 1988). The face is convex and lips procumbent (Carter and Slattery, 1988, Bills et al., 2005, Hussein and Abu Mois, 2007). Bimaxillary protrusion has long been reported to be prevalent in Afro-Caribbean, African-American, Asian and other populations (Carter and Slattery, 1988, Bills et al., 2005, Hussein and Abu Mois, 2007, Dandajena and Nanda, 2003, Farrow et al., 1993, Keating, 1985, Onyeaso, 2004). It is not known how prevalent this condition is in ethnically diverse populations such as that found in Trinidad and Tobago. The central statistical office reports that three major ethnic groups can be recognised in Trinidad and Tobago, namely Afro-Trinidadian, Indo- Trinidadian and Mixed. Studies have shown that there is an increase in mixing of ethnicities across the Caribbean and worldwide. It is therefore important to identify if there is an increased proportion of bimaxillary protrusion in such populations and any associated factors.

This epidemiologic survey was conducted to obtain this prevalence data and so provide data on the need for orthodontic treatment due to bimaxillary protrusion in ethnically diverse populations. The demand for orthodontic treatment is increasing not just in Trinidad and Tobago but in most countries and publicly funded healthcare systems have introduced methods to prioritise treatment based on objective measures of need. One such measure widely used is the IOTN, but this was not developed for populations where bimaxillary protrusion is prevalent and may not be appropriate in these settings. Appropriate provision of orthodontic services for Trinidad and Tobago and other areas where this is increased prevalence of bimaxillary protrusion require such data to allocate and plan access to limited government health service resources, and inform manpower planning decisions in the public and private dental sector (Onyeaso, 2004, Thilander et al., 2001, Brook and Shaw, 1989, Borzabadi-Farahani and Eslamipour, 2010).

Therefore, the aim of this study was to identify the prevalence of bimaxillary protrusion and associated factors in the ethnically diverse population found in Trinidad and Tobago.

4.2 Methods

Ethical approval from The University of West Indies ethics committee was obtained for this epidemiological survey. Approval was then obtained from the Ministry of Education in Trinidad and Tobago to conduct this research in high schools across the country (Appendix 1). Principals of high schools were contacted for permission to conduct the research. In the schools that gave permission, consent forms were given out to the students in the first year of high school. Only students from whom consent was obtained from both parents and child were examined.

4.2.1 The sample

This epidemiological survey comprised 1000 high school children. A pilot study was conducted and the prevalence of bimaxillary protrusion calculated to be 40%. The sample size was therefore determined from this estimate of prevalence of 40% and a population of 20,000 to give a confidence level of 0.95 and precision of 2.5 to be 1006 (Epitools epidemiological calculators. Ausvet Pty Ltd. Available at: http://epitools.ausvet.com.au). One orthodontist (T.H.) examined the students which were selected from forty-one high schools out of 141 public high schools which gave permission to conduct the research, located across the twin island republic representing both rural and urban populations. Inclusion criteria included all ethnicities including the mixed race population, and all males and females aged 11or 12 years at the time of examination. Exclusion criteria included any craniofacial abnormality and current or previous orthodontic treatment.

4.2.2 Recording procedure

Data was collected on individual data collection forms including school attended, age, gender and self-reported ethnicity. The presence of any self-reported habits was also noted (digit sucking, tongue sucking, tongue thrusting, nail biting, lip licking or lip sucking).

The students were then examined at school in a well-lit area. The candidates were seated on a chair and placed in natural head position.

Extra-oral assessment included presence or absence of bimaxillary prognathism, the anterior posterior, vertical (lower face height and an estimate maxillo-mandibular planes angle) and transverse skeletal pattern. Intra-oral assessment included incisor classification (assessed using British Standards Institute 1983 definitions), overbite, overjet, canine and molar relationship, and incisor inclination.

Standardised extra-oral profile photographs and orthodontic intraoral photographs were taken. The intra-oral assessment was done with the use of a dental mirror and the incisor inclination was measured using the Tooth Inclination Protractor (TIP) (Richmond et al., 1998), shown in Figure 4.1.

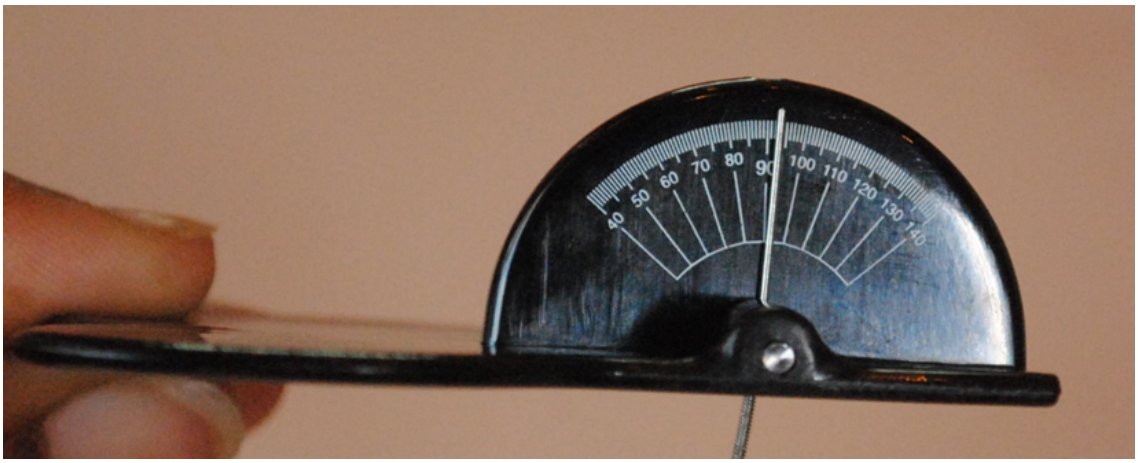


Figure 4.1: Tooth Inclination Protractor

The TIP has a plastic platform which was placed intraorally against the occlusal surfaces of the maxillary dentition. The platform has a stainless steel pin whose length can be adjusted and rests on the labial surface of the upper incisor. The upper right central incisor was used to measure the incisor inclination (Richmond et al., 1998, Daniels and Richmond, 2000, Ghahferokhi et al., 2002). The stainless steel pin was adjusted so that contact was made with the most convex portion of the incisor to record the incisor inclination. The other end of the steel pin rests on a graduated scale of the protractor (Daniels and Richmond, 2000, Ghahferokhi et al., 2002). In cephalometric analysis the normal value for the upper incisor to maxillary plane angle is 109º±5º. Therefore, any

degree above 114º would be considered proclined. The TIP has been shown to underscore the upper incisor to maxillary plane by 10.46 degrees (Richmond et al., 1998) . Therefore, using the TIP an incisor inclination greater than 105 degrees was considered proclined.

The data was coded, entered into a computer for analysis by a statistical package (IBM SPSS Statistics for Windows, version 22 (IBM Corp., Armonk, N.Y., USA)). The data was first cleaned. It was checked for any inclusion errors. Candidates outside the age range of 11-12 years were removed. In addition, based on ethnicity, there was one Chinese subject and this subject was also removed from the sample as it was not possible to include such a small group in the analysis. The final sample size was therefore 972. Any other missing data entry was completed by manually checking the clinical data recording sheet and checked against the clinical photographs by two investigators (T.H. & D.B.).

Two conditions were identified from the data:

1. Bimaxillary Prognathism. An extra-oral diagnosis of bimaxillary prognathism was made if all of the following features were present: lower face height and estimate of maxilla-mandibular planes angle average or increased, decreased nasolabial angle, lips full and everted and a convex profile (Carter and Slattery, 1988).

2. Bimaxillary Proclination. An intra-oral diagnosis of bimaxillary proclination was made if all the following features were present: proclined upper and lower incisors, overbite reduced or presence of an anterior open bite, incisor inclination of greater than 105º as measured by the TIP (Carter and Slattery, 1988, Richmond et al., 1998).

4.2.3 Statistical analysis

Descriptive analysis was undertaken. Pearson chi- square and z statistic was used to assess the distribution of bimaxillary prognathism and bimaxillary protrusion in the different ethnicities and p values of less than 0.05 were considered as statistically significant. A binary logistic regression analysis explored other explanatory variables alongside ethnicity to predict the diagnosis of bimaxillary prognathism.

4.3 Results

The sample included 58.2% female and 41.8% male subjects. Eleven year olds comprised 15.5% of the sample and twelve year olds 84.5%, with a mean age of 11.84 years. Afro-Trinidadians made up 46.4%, Indo-Trinidadians 35.3% and mixed subjects 18.3% of the sample. Bimaxillary prognathism diagnosis was made in 64.9% of subjects and bimaxillary proclination in 68.8%.

Table 4.1 shows the distribution of the presence of bimaxillary proclination and bimaxillary prognathism for the three ethnicity groups. Chi-squared for bimaxillary prognathism showed a statistically significant difference between ethnicity groups ($p=0.000$), but a non-significant difference in distribution for bimaxillary proclination ($p=0.208$). A z-test showed that for bimaxillary prognathism there was a statistically significant ($p<0.05$) difference between each of the three ethnicities.

Table 4.1: Association between Ethnicity and Bimaxillary Proclination and Prognathism

		Bimaxillary Proclination			Bimaxillary Prognathism		
		Present	Absent	Total	Present	Absent	Total
Ethnicity	Afro-Trinidadian	319	132	451	412	39	451
	Indo-Trinidadian	237	106	343	98	244	342
	Mixed	113	65	178	120	57	177
Total		669	303	972	630	340	970

In order to explore further the relationship between the presence of bimaxillary prognathism and the other variables recorded a forward stepwise logistic regression was undertaken, with bimaxillary prognathism as the independent variable and the following dependent variables: ethnicity, skeletal pattern, gender, lip sucking, digit sucking, lip licking, tongue sucking and tongue thrusting. The final model included ethnicity, nail biting, tongue thrusting, finger sucking, lip licking and lip sucking and had a R-squared value of 0.371. The details of the model are shown in Table 4.2 with a positive effect of Afro-Caribbean ethnicity (Ethnicity 1) and a negative effect of Indo-Caribbean ethnicity

(Ethnicity 2), and a negative effect for the absence of each of the oral habits included in the model. Neither gender nor skeletal pattern were included in the model.

Table 4.2: Logistic regression models (forward stepwise) for bimaxillary prognathism

	B	Standard Error	Wald	df	Sig	Exp(B)
Step 1 Ethnicity			260.115	2	.000	
Ethnicity (1)	1.613	.232	48.231	1	.000	5.018
Ethnicity (2)	-1.653	.200	67.938	1	.000	.192
Constant	.744	.161	21.416	1	.000	2.105
Step 2 Ethnicity			219.709	2	.000	
Ethnicity (1)	1.553	.241	41.527	1	.000	4.724
Ethnicity (2)	-1.555	.210	54.667	1	.000	.211
Tonguethrust(1)	-1.670	.224	55.639	1	.000	.188
Constant	1.056	.174	36.688	1	.000	2.876
Step 3 Ethnicity			211.875	2	.000	
Ethnicity (1)	1.551	.243	40.784	1	.000	4.715
Ethnicity (2)	-1.524	.213	51.462	1	.000	.218
Nailbiting(1)	-.635	.180	12.449	1	.000	.530
Tonguethrust(1)	-1.512	.228	44.009	1	.000	.220
Constant	1.377	.201	46.796	1	.000	3.961
Step 4 Ethnicity			201.664	2	.000	
Ethnicity (1)	1.515	.243	38.735	1	.000	4.551
Ethnicity (2)	1.505	.213	49.902	1	.000	.222
Nailbiting(1)	-.560	.183	9.364	1	.002	.571
Tonguethrust(1)	-1.418	.231	37.838	1	.000	.242
Liplicking(1)	-.561	.202	7.698	1	.006	.571
Constant	1.716	.239	51.443	1	.000	5.562
Step 5 Ethnicity			202.064	2	.000	
Ethnicity (1)	1.493	.245	37.179	1	.000	4.450
Ethnicity (2)	-1.561	.216	52.368	1	.000	.210
Nailbiting(1)	-.540	.184	8.617	1	.003	.583
Tonguethrust(1)	-1.483	.232	40.903	1	.000	.227
Digitsucking(1)	-.481	.196	6.025	1	.014	.618
Liplicking(1)	-.536	.204	6.915	1	.009	.585
Constant	2.065	.283	53.152	1	.000	7.882
Step 6 Ethnicity			203.112	2	.000	
Ethnicity (1)	1.517	2.46	37.998	1	.000	4.558
Ethnicity (2)	-1.567	.217	52.247	1	.000	.209
Nailbiting(1)	-.539	.184	8.548	1	.003	.583
Tonguethrust(1)	-1.544	.235	43.023	1	.000	.214
Digitsucking(1)	-.466	.197	5.619	1	.018	.627
Liplicking(1)	-.520	.205	6.462	1	.011	.594
Lipsucking(1)	-1.588	.742	4.584	1	.032	.204
Constant	3.614	.785	21.191	1	.000	37.121

Ethnicity (1) Afro-Caribbean
Ethnicity (2) Indo-Caribbean

Table 4.3 shows the association between ethnicity and oral habits. Chi-squared showed a significant difference between ethnicities for the presence of finger sucking (p = 0.035), tongue sucking (p=0.00) and tongue thrusting (p=0.00). Afro-Trinidadian subjects were more likely to have these habits and mixed ethnicity least likely to have a finger sucking habit. There was no association between these oral habits and bimaxillary proclination.

Table 4.3: Association between Ethnicity and Oral Habits

		Digit Sucking			Tongue Sucking			Tongue Thrusting		
		Absent	Present	Total	Absent	Present	Total	Absent	Present	Total
Ethnicity	Afro-Trinidadian	286	165	451	347	104	451	38	413	451
	Indo-Trinidadian	217	126	343	314	29	343	119	230	343
	Mixed	131	47	178	155	23	178	29	149	178
Total		634	338	972	816	156	972	180	792	972

We then looked at occlusal characteristics of the population. Table 4.4 shows 46.6% of the sample had Class 1 incisor relationship, 16.6% had Class 2 division 1 and 1% had Class 2 division 2 incisor relationship. Class 3 incisor relationship was present in 35.8% of the sample. 45.8% had an average overbite, 17.4% had increased overbite, 29.8% had decreased overbite and 6.7% had an open bite. Class 1 canine relationship was the most common canine relationship (41% right side, 47.1% left side), class 2 was less represented (38.4% right side and 32.8% left side) and class 3 was the least common canine relationship (12.8% right side, 11.6% left side).

Table 4.4: Incisor relationship

	Frequency	Percentage
Class 1	453	46.6
Class2 division 1	161	16.6
Class 2 division 2	10	1.0
Class 3	348	35.8
Total	972	100

4.4 Discussion

This study is the first to determine the prevalence of bimaxillary protrusion in a mixed ethnicity population such as found in Trinidad and Tobago. Several studies have shown that bimaxillary protrusion is present in various ethnicities (Carter and Slattery, 1988, Bills et al., 2005, Hussein and Abu Mois, 2007, Dandajena and Nanda, 2003, Farrow et al., 1993, Keating, 1985, Onyeaso, 2004, Lamberton et al., 1980). This study agrees with the findings of these studies in that bimaxillary protrusion was found in all ethnic groups in Trinidad and Tobago. The prevalence in this study however was much higher than those reported in other countries. The prevalence of bimaxillary protrusion has been reported between 4.09% to 20% (Boeck et al., 2011, Isiekwe, 1990) in other countries. The prevalence of bimaxillary proclination in a Nigerian study was reported to be 3.7% (Dacosta, 1999).

Associations were looked at because causations cannot be proven in cross-sectional studies. Both chi-squared and linear regression models showed ethnicity to be associated with bimaxillary prognathism, with Afro-Trinidadian ethnicity being a predictor for the presence of bimaxillary prognathism and Indo-Trinidadian ethnicity being a predictor for the absence of bimaxillary prognathism. A range of oral habits were also predictors of bimaxillary prognathism and were also associated with Afro-Trinidadian ethnicity. This study showed no association between bimaxillary proclination and oral habits. This was in contrast to oral habits being reported as an etiologic factor by one author (Hussein and Abu Mois, 2007).

The prevalence of Class 2 division 1 incisor relationship was lower than that reported in white Caucasian populations (Todd and Ladder, 1988). The prevalence of Class 3 incisors was a lot higher than reported by most authors (Todd and Ladder, 1988, Isiekwe, 1983, Haynes, 1970, Foster and Day, 1974). This is possibly a reflection of the high incidence of tongue sucking and tongue thrusting habits leading to proclination of the lower incisors. Class 2 division 2 prevalence was comparable to Isiekwe's findings in a West African population (Isiekwe, 1983), and Class 1 incisor relationship was the most prevalent but less common than reported in most populations (Todd and Ladder, 1988, Isiekwe, 1983,

Sclare, 1945). The decreased overbite in the population reported was higher than previously reported (Onyeaso, 2004). This increased prevalence of this occlusal feature is however expected in populations where bimaxillary proclination is prevalent (Carter and Slattery, 1988).

Use of lateral cephalometric radiographs is the most common method used to assess incisor inclination. Use of the TIP is a preferred non-invasive technique (Richmond et al., 1998, Ghahferokhi et al., 2002) and was shown to be effective for epidemiological surveys in this study. Lateral cephalometric radiographs have errors associated with landmark identification and measurement of angles (Baumrind and Frantz, 1971) and in addition, there is an increase in risk of mitotic changes with the radiation dose (Richmond et al., 1998, Wall and Kendall, 1983). The TIP has been shown to be valid, reliable, simple, inexpensive and non-invasive method to ascertain incisor inclination (Richmond et al., 1998, Ghahferokhi et al., 2002) and would therefore be the preferred method to use in this type of field research.

These findings have a profound impact on the manner in which care is planned in this and similar populations. The IOTN, used extensively in the UK and Europe would appear to not be a useful measure of treatment need in this setting. Both the Aesthetic Component and Dental Health Component of IOTN are skewed against scoring class 3 malocclusion, reduced overbite and anterior openbite or bimaxillary proclination as features in need of orthodontic treatment (Cousley, 2013, Brook and Shaw, 1989, Dawjee et al., 2002). The functional problems and occlusal loading found in Class 3 malocclusion are not considered in the index. In addition, the IOTN does not account for extra-oral features including bimaxillary prognathism, and other related soft tissue features (Cousley, 2013, Dawjee et al., 2002). Patients with these features present due to aesthetic concerns related to the bimaxillary protrusion and with functional problems associated with the combination of Class 3 and reduced overbite or openbite. In addition, there are also cultural differences in what is considered attractive. Africans and Caucasians have been shown to differ in their perceptions of dental aesthetics (Ngom et al., 2005). Ngom reported that Caucasian judges rated the dental aesthetics of African subjects lower than African judges in his study.

Therefore, we propose that IOTN is not a useful tool for planning allocation of resources in Trinidad and Tobago or similar mixed ethnicity populations where bimaxillary protrusion has a high prevalence. Ngom suggested that ICON was marginally better than IOTN for assessing treatment need (Ngom et al., 2005). Another alternative to IOTN is to conduct a full orthodontic diagnosis to assess treatment need, but this requires greater resources. Some authors have proposed a facial aesthetic index for subjects with bimaxillary protrusion (Sundareswaran and Ramakrishnan, 2016) and our findings would support this proposal as well as the use of ICON with an aesthetic component. Further research is required in this field.

4.5 Conclusion

- Bimaxillary prognathism has a prevalence of 64.4% and bimaxillary proclination has a prevalence of 68.8% in the Trinidad and Tobago population.
- The prevalence is much higher in Trinidad and Tobago than reported in other studies.
- There is evidence that there is an association between bimaxillary prognathism and ethnicity and a range of oral habits.
- There is no evidence that there is an association between bimaxillary proclination with ethnicity.
- There is an association between ethnicity and digit sucking, tongue sucking and tongue thrusting. Afro-Trinidadians were more likely to have all three habits.
- IOTN may not be the most appropriate tool for assessing treatment need in this and similar populations.

CHAPTER 5 - PREVALENCE OF FRACTURED INCISORS, AND ASSOCIATION WITH BIMAXILLARY PROCLINATION IN TRINIDAD AND TOBAGO

5.1 Introduction

Oral injuries are the fourth most common area of bodily injuries among 7-30 year old individuals (Juneja et al., 2018). Dental trauma (traumatic dental injury) results from an impact to the teeth and/or other hard and soft tissues within and around the vicinity of the mouth and oral cavity (Lam, 2016). These injuries are common in certain groups, no individual is ever at zero risk through their activities of daily living (Lam, 2016).

It is a serious condition among young children as dental injuries result in aesthetic problems and functional problems involving the mandible. Dental injuries can also cause psychological disturbances accompanied by great concern from the child, the parent and the dentist.

Most studies have examined the relationship between incisor fracture and single features like sex, age, overjet using univariate statistical methods.

Studies from other countries have presented variable data on the prevalence of dental trauma (Table 5.1).

Table 5.1: Reported prevalence of fractured incisors in different countries

Country	Age Group	Prevalence	Author
Malaysia	16 years	4.1%	(Nik-Hussein, 2001)
Syria	9-12 years	5%	(Marcenes et al., 1999)
South Africa	11-13 years	6.4%	(Naidoo et al., 2009)
Indore City, India	8-15 years	10.2%	(Juneja et al., 2018)
Jordan	7-12 years	10.5%	(Jamani and Fayyad, 1991)
Nigeria	12 years	12.8%	(Adekoya-Sofowora et al., 2009)
London, UK	14 years	17%	(Marcenes and Murray, 2002)
United States	6-20 years	18%	(Kaste et al., 1996)
Dominican Republic	7-14 years	18.1%	(Garcia-Godoy et al., 1981)
South Finland	9-11 years	19.8%	(Jarvinen, 1979)

Dental trauma presents a public health problem and in some countries where caries has decreased can be considered the major risk to the anterior teeth (Adekoya-Sofowora et al., 2009, Jarvinen, 1979).

The cost to the injured person and the community throughout the world has been substantial in terms of time and financial cost (Lam, 2016, Bastone et al., 2000, Borum and Andreasen, 2001). The average number of visits during one year due to sustaining dental trauma ranges from 1.9 to 9.1 (Glendor, 1998). It has also been discovered that in Australia that only one-third of the patients presented for dental treatment within 24 hours of the injury while the remainder delayed seeking treatment for varying times up to 1 year (Lam et al., 2008).

Currently there is little epidemiological data on dental trauma in Trinidad and Tobago. The aim of this study was to investigate the prevalence and occlusal risk factors for dental trauma in high school children in Trinidad and Tobago.

5.2 Patients and Methods

A cross-sectional survey was carried out on 672 high school children 11 to 12 years old in 141 public schools in the twin island republic of Trinidad and Tobago. These schools were located across the twin island republic representing both rural and urban populations.

The ethics committee of The University of the West Indies granted approval for this cross-sectional survey. Trinidad and Tobago Ministry of Education gave approval for the research to be conducted in high schools across the country. A letter was sent to school principals requesting permission to conduct the research. Another letter was sent to parents asking for permission for their children's participation.

Dental examination was carried out by a single dentist (T.H.) supported by a recorder. The students were seated on a chair in a well- lit area. Traumatic injuries to the incisors were recorded. Subjects who had already undergone previous orthodontic treatment were excluded from this cross-sectional survey so that orthodontic treatment for unknown reason as a confounding factor was removed.

The following data were recorded

- Patient demographics: Information included age, gender, ethnicity
- Trauma History: Trauma was recorded when there was
    - Fracture involving enamel
    - Fracture involving enamel and dentine
    - Fracture involving enamel and dentine and pulp
    - Discoloration of the crown as a result of traumatic injury (verified by an interview)
    - Presence of a restoration done on a tooth as a result of traumatic injury (verified by an interview)
- Skeletal Relationships: The patients were assessed in profile view into Class1, Class 11, Class 111.
- Morphologic malocclusion: The following were assessed with the subjects in centric occlusion.

    1. Overjet was measured with a millimetre ruler as from the incisal edge of the most labial maxillary central incisor to the most labial mandibular central incisor distance to the occlusal plane.

    2. Lip competence was evaluated with the lips in rest position and scored as competent once there was no strain. If lip strain was evident on closure the lips were scored as incompetent.

    3. Assessment of malocclusion was done with teeth in centric occlusion, the relationship between the upper and lower incisors were assessed (British Standards Institute 1983).

5.2.1 Statistical analysis

The data was analysed using IBM SPSS Statistics for Windows version 22 (IBM Corp., Armonk, N.Y., USA).

Descriptive analysis was undertaken and statistical associations for dental injuries with sex, ethnicity, incisal overjet, lip competence and skeletal pattern were calculated using Chi-square test and independent t-test. These analyses were used to test associations between occurrence of occlusal features and dental trauma. Binary logistic regression was then performed to estimate the predictive value of ethnicity, overjet and lip competence for the probability of incisor injury.

5.3 Results

672 children across high schools in Trinidad and Tobago aged 11-12 participated in this cross -sectional survey. There were more girls (n=356, 53%) than boys (n=316, 47%). The 672 participants had their 4 maxillary and mandibular incisors examined. There were 124 fractured upper incisors. There were 3 fractured lower incisors. Fracture of the upper incisors showed a prevalence of 4.61% and lower incisors 0.11%. More boys (9.49%) experienced fractured incisors than girls (7.58%), this difference was not statistically significant, p >0.05 (Table 5.2). Among the children who had experienced traumatic injuries to the teeth 86.3% presented with untreated damage.

Table 5.2: Gender and prevalence of fractured incisors

Gender	Fractured Incisor n (%)	No Fractured Incisor n (%)	Total n (%)
Girls	27 (7.58)	329 (92.42)	356 (53)
Boys	30 (9.49)	286 (90.51)	316 (47)
Total	57	615	672
Chi-squared. P= 0.585			

Afro-Trinidadian ethnicities had the highest prevalence of fractures at 11.0%, the Indo-Trinidadians ethnicity had a prevalence of 6.19% and the Mixed ethnicity had the lowest prevalence 5.93%. The differences in prevalence associated with ethnicity was not statistically significant (p=0.15) (Table 5.3).

Table 5.3: Prevalence of fractured incisors by ethnic group

Ethnicity	Fractured Incisor n (%)	No Fractured Incisor n (%)	Total
Afro-Trinidadian	36 (11)	291 (89)	327
Indo-Trinidadian	13 (6.19)	197 (93.81)	210
Mixed	8 (5.93)	127 (94.07)	135
Total	57	615	672
Chi-squared, P= 0.150			

18.62% of subjects with incompetent lips had fractured upper incisors compared with 8.54% with competent lips. This difference was statistically significant p=0.01, (Table 5.4).

Table 5.4: Relationship between fractured incisors and incompetent lips

	Lip Competence		Total
	Competence n (%)	Incompetence n (%)	
Fractured Incisors	45 (62.5)	27 (37.5)	72
Sound Incisors	482 (80.33)	118 (19.67)	600
Total	527	145	672
Chi-squared, P=0.01			

The mean overjet of subjects with fractured incisors was 4.2mm ± 2.1. The mean overjet of subjects in the non- fractured incisors group was 3.48mm ± 2.01. An independent sample T -test for equality of means showed the difference with overjet between fractured and sound incisors was statistically significant p=0.003, (Table 5.5).

Table 5.5: Relationship between fractured incisors and overjet

		N	Mean	Std. Deviation	Std. Error Mean
Mean Overjet	Fractured Incisor	72	4.22	2.11	0.249
	Sound	600	3.48	2.01	0.08
	Independent Samples Test				
P-value					
Mean Overjet	Equal variances assumed	0.003			
	Equal variances not assumed	0.006			

Children with a class 2 division 1 incisor relationship were more likely to have a fractured incisor compared with other malocclusions, (Table 5.6). The difference was statistically significant p=0.021.

Table 5.6: Relationship between malocclusion and fractured incisors

	Incisor Relationship				Total
	Class 1	Class 2 division 1	Class 2 division 2	Class 3	
Fractured Incisor	33(10.54%)	19(18.81%)	0	20 (7.97%)	72
Sound	280(89.46%)	82(81.19%)	7(100%)	231(92.03%)	600
Total	313	101	7	251	672
Chi-squared, P=0.021					

5.3.1 Overall significance of regression model

Table 5.7 shows the overall significance of regression model coefficients showing that the model is significant, which means it is better than guessing the most frequent category each time.

Table 5.7: Overall significance of regression model

	Chi-square	df	p-value
Step 1 Step Block Model	31.2444	4	0.000
	31.2444	4	0.00
	31.244	4	0.00

5.3.2 Classification table

The classification table showed that fractured incisor would be mis-classified in nearly all but 1.6 % fractured incisor patients Table 5.8.

Table 5.8: Classification Table showing predictive power of sample

Observed	Predicted		
			Percentage Correct
	No Fracture	Fracture	
No Fracture	542	3	99.4
Fracture	125	2	1.6
Overall Percentage			81.0

5.3.3 Binary logistic regression

Binary Logistic regression was suggestive of a relationship between fractured incisors and mean overjet, ethnicity (Afro-Trinidadian and Mixed ethnicity-Trinidadian), and incompetent lips as they were shown to be predictors of fractured incisors. The odds ratio showed that as the overjet increased the chances of a fractured incisor increased. This association was statistically significant, p=0.004. In terms of ethnicity, moving from Afro-Trinidadian to Indo-Trinidadian the increase of fractured incisors was not statistically significant, p=0.59. Comparing Afro-Trinidadians to Mixed ethnicity Trinidadians the difference in fractured incisors was statistically significant, p=0.035. Moving from competent to incompetent lips the odds of a fractured incisor increased and this was statistically significant, p=0.02 (Table 5.9). Mean overjet, incompetent lips and moving from Afro-Trinidadian to Mixed ethnicity were all statistically significant, $p<0.05$. This suggests that you can make an educated guess if a subject is susceptible to incisal fracture based on these three parameters.

The 95% confidence interval showed that mean overjet and incompetent lips are more significant as predictors (Table 5.10)

Table 5.9: Binary Logistic Regression model containing the variables, mean overjet, ethnicity, lip competence

Explanatory Variable	B	Relative odds	Significance
Mean overjet	0.137	1.147	0.004
Afro-Trinidadian to Indo-Trinidadian	-0.124	0.883	0.587
Afro-Trinidadian to Mixed ethnicity-Trinidadian	-0.640	0.527	0.035
Lips	0.704	2.022	0.02

5.3.4 Confidence intervals

Table 5.10: 95% Confidence Interval for Odds Ratio

	95% Confidence Intervals for Relative Odds Ratio	
	Lower	Upper
Mean Overjet	1.044	1.260
Afro-Trinidadian to Indo-Trinidadian	0.565	1.381
Afro-Trinidadian to Mixed Ethnicity	0.291	0.955
Lips competent to Incompetent	1.286	3.180

5.4 Discussion

For the purpose of determining the adequacy of the sample size the Chi-Square analysis with fractured incisors and lip competence was treated as the main analysis. Using the G* Power (Fau et al 2007) it was calculated that a 2x2 Chi-Square with 1 degree of freedom and our sample size of 672 achieved a power (to 7 decimal places) of 100% to detect medium effect sizes (w=0.3) and 73.4% power to detect small effects(w=0.1). Accordingly, this study was more than adequately powered to detect all but the smallest effects.

The prevalence of fractured incisors in 11-12-year old school children in Trinidad and Tobago was 4.72%. This is not comparable to another study in the Caribbean on Dominican school children which found a prevalence of 18.1% (Garcia-Godoy et al., 1981) and a study in the United States which found a prevalence of 18% (Kaste et al., 1996). In other studies the reported prevalence rates varied from 4.1% in Malaysian children (Nik-Hussein, 2001) to 19.8% in Finish children (Jarvinen, 1979). Differences in sampling techniques and application of diagnostic criteria could be responsible for the

varying prevalence rates among studies (Alonge et al., 2001). This study confirms findings in other studies that the maxillary incisors were more often affected with traumatic injuries than mandibular incisors and maxillary central incisors were affected more than lateral incisors (Kaste et al., 1996, Petti and Tarsitani, 1996, Kania et al., 1996, Bauss et al., 2008). This is possibly due to the maxillary central incisors having a prominent position in the arch, which is in agreement with several studies (Nik-Hussein, 2001, Garcia-Godoy et al., 1981, Jarvinen, 1979, O'Mullane, 1973, Forsberg and Tedestam, 1993). Most of the children in this study did not seek treatment, 86.3% of the fractures were unrepaired. This confirms findings by other studies (Garcia-Godoy et al., 1981, Haavikko and Rantanen, 1976). The possible reasons for the delay in seeking treatment could be lack of pain or any symptoms, patients giving a low priority to their dental injuries, unavailability of dentist due to travel, sickness, or other commitments, long wait periods at the dental hospital and patients being unaware of dentist after hours service (Lam et al., 2008).

In this study boys were affected by fractured incisors more than girls and this confirms the findings of numerous studies (Nik-Hussein, 2001, Marcenes et al., 1999, Jamani and Fayyad, 1991, Marcenes and Murray, 2002, Kaste et al., 1996, Jarvinen, 1979) but the difference was not statistically significant. Noteworthy is the Dominican study which reported higher levels in girls but this difference was not statistically significant (Garcia-Godoy et al., 1981). One explanation for both results is the increasing participation of girls in risk activities and sports (Burden, 1995).

In this study there was a higher prevalence of subjects of African descent with fractured incisors as in other studies (Kaste et al., 1996, Alonge et al., 2001, Kania et al., 1996). But there was no statistically significant association between ethnicity and fractured incisors.

The reported predisposing factors for dental trauma include an increased overjet, protrusion of upper incisors, lip incompetence, inadequate lip coverage and accident proneness (Juneja et al., 2018, Marcenes et al., 1999, Burden, 1995). This study found 37.5% of patients with fractured incisors had incompetent lips which was more than reported by other authors (Pizzoni et al., 1998, Ravn, 1974) and confirms the opinion that persons with incompetent lips are more likely to injure their incisors (O'Mullane, 1973).

Class 2 division 1 incisors where the upper incisors are protrusive were found to be more likely to have a fractured incisor compared to other malocclusions, as well as children with a mean overjet of 4 mm and above were found to have a higher prevalence of fractured incisors. This study confirms the findings in other studies that children with protrusive incisors and an increase in overjet have a higher incidence of trauma (Burden, 1995, O'Mullane, 1973, Forsberg and Tedestam, 1993).

Binary Logistic regression model showed that mean overjet and incompetent lips had a clear association with fractured incisors but the predictive value was low.

Dearing (1984) stated that children with an overjet greater than 6mm should receive prophylactic orthodontic treatment. Two methods of prevention are available, wearing of mouth guards and orthodontic treatment. Early orthodontic treatment before age 11 has been recommended to prevent dental trauma (Bauss et al., 2008, Burden, 1995, Baldava and Anup, 2007, Tulloch et al., 1998). The benefits of early class 2 division 1 treatment have been documented in randomised clinical trials (Tulloch et al., 1998). Noteworthy is that growth modification was the objective of this early treatment and with the modification there was a decrease in overjet. This early reduction in overjet greatly reduces the cost to public health care costs for trauma. Koroluk et al. (2003) reported 29.1% of patients at the start of his randomised clinical trial (before age 9) had already had incisor trauma. He asserted shortly after incisor eruption overjet reduction should begin. Other prevention techniques which can be undertaken by patients include wearing of mouth guards, seatbelts, protective gear and participation in oral health promotion (Lam et al., 2008).

Understanding the epidemiology of dental trauma in Trinidad and Tobago requires more local studies. Oral health programmes should include education on the need to seek immediate treatment.

5.5 Association with Bimaxillary Proclination

Two common features of bimaxillary proclination are an increase in increase in overjet and incompetent lips (Carter and Slattery, 1988). In most societies these two anatomic features have been identified as risk factors for trauma (Burden, 1995, Dearing, 1984). 75% of subjects in this sample had bimaxillary proclination. This however was not statistically significant, p=0.248, (Table 5.11). Bimaxillary proclination where upper and lower incisors are proclined was not a risk factor for fractured incisors. Farahani (Borzabadi-Farahani and Eslamipour, 2010) suggested that dental trauma is a surrogate for more than one unmeasured variables that may be causally linked to facial form or increased overjet.

Table 5.11: Bimaxillary Proclination and association with fractured incisors

	Bimaxillary Proclination		
	Present n (%)	Absent n (%)	Total
Fractured Incisor	54 (75)	18 (25)	72
Sound	410	190	600
Total	464	208	672
Chi-squared, P=0.248			

5.6 Conclusions

- The overall prevalence of fractured incisors is 4.72%.
- The most common injured tooth was the maxillary central incisor.
- Increased overjet and incompetent lips were clearly associated with incisor trauma but their predictive value was low.
- Males presented with more dental injuries than females but this was not statistically significant.
- Many patients delayed seeking treatment for their injuries.
- Afro-Trinidadian had the highest prevalence of fractures, but the difference was not statistically significant.
- Increased overjet, incompetent lips, class11 division 1 incisors increase the risk of incisor trauma.

CHAPTER 6 - PREVALENCE OF ORAL HABITS AND ASSOCIATION WITH BIMAXILLARY PROCLINATION IN TRINIDAD AND TOBAGO

6.1 Introduction

A habit is a practice acquired by the frequent repetition of the same act, this occurs consciously at first, then unconsciously (Moimaz et al., 2014). Oral habits can be defined as learned patterns of muscle contraction and they have a very complex nature (Sharma et al., 2015). Oral habits can also be defined as any repetitive behaviour pattern which utilises the oral cavity. An oral habit in infancy and early childhood is normal, and is associated with the need to satisfy the urge for contact and security but should disappear between the age of 1 to 3 ½ years (Dhull K et al., 2018, Majorana et al., 2015). Noteworthy, is that some situations may stimulate sucking habits, these include hunger, fear, physical and emotional stress (Moimaz et al., 2014). Oral habits can be classified as pressure habits, non-pressure habits, and biting habits. Pressure habits include lip sucking, digit sucking, tongue thrusting; non-pressure habits include mouth breathing; and biting habits include nail biting, lip biting, and pencil biting. Pressure habits are mainly responsible for the deleterious effects on the occlusion. The persistence of deleterious oral habits plays a significant role in altering the position of teeth, interarch relationships, and hinder the normal growth of the jaws. The persistence of these habits have little effect on a child's overall health. Function of the oral musculature in addition, has an indirect effect on the swallowing pattern (Khan I, 2015, Melsen et al., 1979)

There is a recognised association between oral habits and malocclusion (Larsson, 1975) and children with sucking habits are more likely to develop a malocclusion (dos Santos et al., 2012, Moimaz et al., 2014, Bowden, 1966, Farsi and Salama, 1997, Mistry et al., 2010). The trident factors affecting digit sucking are frequency, duration and intensity and these correlate with the severity of the resulting malocclusion (Majorana et al., 2015, Proffit et al., 2013). The duration of the force is more important than intensity; the resting pressure from the tongue, cheeks and lips are maintained most of the time and therefore has the greatest impact on tooth position (Majorana et al., 2015).

Prevalence of oral habits in the literature shows differences based on population, ethnicity and location or geography (Sharma et al., 2015, Khan I, 2015, Farsi and Salama, 1997, Al-Hussyeen and Baidas, June 2009). It is reported to be influenced by a lot of factors

including, education, gender, feeding methods, maternal occupation, rank of the child in the family, maternal age and socioeconomic status (Al-Hussyeen and Baidas, June 2009). Al-Hussyeen and Baidas (June 2009) also reported a trend towards an increase in prevalence due to a change in family and social environment.

Epidemiological data regarding the prevalence of oral habits in Trinidad and Tobago is needed. Trinidad and Tobago is a developing nation where there are restraints due to the high cost of orthodontic treatment; it is important to recognise the need for orthodontic treatment not only according to severity but also to identify modifiable factors that can be managed through preventative orthodontics (Moimaz et al., 2014). Prolonged oral habits have been shown to require significant health system resources for correction (Borrie et al., 2013).

The hypotheses for this cross-sectional study are

1. There is a high prevalence of habits in the Trinidad and Tobago society
2. Oral habits prevalence is not equal in all ethnic groups in Trinidad and Tobago
3. The is no gender predilection with oral habits in Trinidad and Tobago

This epidemiological survey was undertaken to determine the prevalence of oral habits among 11 and 12-year old children in Trinidad and Tobago and to determine if there is any association with ethnicity and gender. This study is reported in accordance with STROBE guidelines.

6.2 Materials and Methods

6.2.1 Sample

This survey comprised 1004 high school children. Prior to this study a pilot study was conducted. The prevalence of oral habits from this study was calculated to be 40%. The sample size was determined from this prevalence estimate of 40% and a population of 20,000 to give a confidence level of 0.95 and precision of 2.5 to be 1006 (Epitools epidemiological calculators. Ausvet Pty Ltd. Available at http:// epitools.ausvet.com.au). Of all the participants 29 examined children were removed from the final sample. 28 were

ineligible because of age they were either 13 years and over or younger than 11 years. There was 1 Chinese participant. This ethnic group was too small to be included in the analysis. The final sample consisted of 975 children aged 11-12 years from 41of 141 high schools across the twin island republic of Trinidad and Tobago representing rural and urban populations, during the period June 2013 to April 2016.

6.2.2 Ethics

The ethics committee of The University of the West Indies gave permission to conduct the research. The Trinidad and Tobago Ministry of Education gave permission to conduct the cross- sectional survey in public high schools. A letter was sent to principals of high schools across the twin island republic requesting permission to conduct the research. Another letter was sent to parents asking for consent for their child to participate in the survey.

Included in the study were males and females of all ethnicities including mixed race. Children who were attending school and had attained their 11^{th} or 12^{th} birthday by the day of examination were considered eligible for inclusion in the study. Children with a history of orthodontic treatment or undergoing orthodontic treatment at the time were excluded.

6.2.3 Method

A single examiner (T.H.) carried out all the interviewing and examinations. First, data regarding demographic profile, age, ethnicity, gender and history of orthodontic treatment was obtained through an interview with participating children. Presence or absence of habits like nail biting, digit sucking, tongue sucking and thrusting, lip sucking, licking and biting were recorded via self-report. The children were then examined extra and intraorally in a well-lit room seated upright in a chair. Clinical examination was also done for the presence or absence of tongue thrust while swallowing and the digits and oral cavity were examined for signs of digit sucking. The collection of data by a single examiner aimed to reduce bias or inconsistency that could have occurred between different examiners.

6.2.4 Statistical analysis

Prevalence of different oral habits was calculated using a statistical package (IBM SPSS Statistics for windows version 22 (IBM Corp., Armonk N.Y., USA)). Chi-square was used to test differences in gender and ethnicity for statistical significance, a value of $p<0.05$ was regarded as significant. Forward entry binary logistic regression was used with the oral habit as the dependent variable and ethnicity and gender as explanatory variables. The model was checked for overall statistical significance and Exp(B) (odds ratio) and 95% confidence intervals calculated.

6.3 Results

The sample consisted of 566 (58.1%) female and 409 (41.9%) male. Eleven year olds comprised 15.6% and twelve year olds 84.4% with a mean age of 11.84 years. The sample included 451 Afro-Trinidadians, (46.3%), 343 Indo-Trinidadians (35.2%) and 181 of mixed ethnicity (18.6%).

Tongue thrusting was present in 81.3% of children, nail biting in 46.3%, digit sucking in 34.9%, lip licking in 33.7%, tongue sucking in 16%, and lip sucking in 1.4% (Table 6.1).

Table 6.1: Total number of oral habits by gender

Type of Oral Habit	Boys (n=409)	Girls (n=566)	Total (n=975)	Chi-Square	p-value
Digit Sucking	126	214	340 (34.9%)	5.126	0.024
Tongue sucking	41	115	156 (16%)	18.718	0.000
Tongue thrusting	320	473	793 (81.3%)	4.442	0.035
Nail Biting	179	272	451 (46.3%)	1.759	0.185
Lip biting/licking	105	224	329 (33.7%)	20.529	0.000
Lip Sucking	8	6	14 (1.4%)	1.347	0.246

Sex wise prevalence showed girls were more likely to have these habits compared with boys (p-value <0.05). Nail biting and lip sucking showed no statistically significant difference between the genders.

Table 6.2 shows the relationship between ethnicity and oral habits. Afro –Trinidadians were more likely to have habits and Chi-Square showed that this association was significant (p-value <0.05).

The overall prevalence of habits was 93%. However, 68.6% presented with more than one habit and 36.4% presented with more than two habits.

Table 6.2: Association between Ethnicity and Oral Habits

Ethnicity	Digit sucking	Nail biting	Tongue sucking	Tongue thrusting	Lip sucking	Lip licking/biting
Afro-Trinidadian	165 (48.5%)	246 (54.5%)	104 (66.7%)	413 (52.1%)	3 (21.4%)	203 (61.7%)
Indo-Trinidadian	126 (37.1%)	118 (26.2%)	29 (18.6%)	230 (29%)	7 (50%)	68 (20.7%)
Mixed	49 (14.4%)	87 (19.3%)	23 (14.7%)	150 (18.9%)	4 (28.6)	58 (17.6%)
Total per habit	340	451	156	793	14	329
p-value	0.051	0.000	0.000	0.000	0.170	0.000

All regression models with the exception of lip sucking (p=0.12) were statistically significant (p<0.05). The results of the regression models are shown in Table 6.3 for all significant models. For nail biting the odds ratio (Exp(B)) was statistically significant for ethnicity (0.775 95% CI 0.656,0.917) but not for gender. This means that in stepping from Afro-Trinidadian to Indo-Trinidadian to Mixed ethnicity the odds of nail biting were 0.7, that is reduced likelihood of the habit being present. For tongue thrusting the odds ratio for both gender (0.678 (5% CI 0.488, 0.941) and ethnicity (0.598 (95% CI 0.485, 0.736) were significant, indicating in that moving from female to male gender the odds of having a tongue thrusting habit reduced by 0.7. The smallest odds ratio was for the effect of gender for a tongue sucking habit where moving from female to male gender reduced the

odds of the habit being present by 0.42. These results were consistent with the findings of the chi-squared analysis.

Table 6.3: Binary Logistic Regression for Oral habits with gender and ethnicity

Habit	Regression variable		B	S.E.	Wald	df	Sig	Exp(B)	95% C.I.	
									Lower	Upper
Nailbiting	Gender	Girls ref								
		Boys	-.146	.133	1.201	1	.273	.864	.666	1.122
		Afro-Trinidadian			31.052	2	.000			
		Indo-Trinidadian	-.823	.148	30.905	1	.000	.439	.329	.587
		Mixed Ethnicity	-.271	.177	2.355	1	.125	.762	.539	1.078
	Constant		.244	.110	4.902	1	.027	1.276		
Tongue thrusting	Gender	Girls ref								
		Boys	-.312	.173	3.259	1	.071	.732	.522	1.027
	Ethnicity	Afro-Trinidadian			68.082	2	.000			
		Indo-Trinidadian	-1.668	.205	66.152	1	.000	.189	.126	.282
		Mixed Ethnicity	-.836	.261	10.255	1	.001	.434	.260	.723
	Constant		2.526	.189	178.607	1	.000	12.507		
Finger sucking	Gender	Girls ref								
		Boys	-.341	.139	6.037	1	.014	.711	.542	.933
	Ethnicity	Afro-Trinidadian			6.780	2	.034			
		Indo-Trinidadian	.021	.149	.019	1	.890	1.021	.762	1.368
		Mixed Ethnicity	-.469	.195	5.810	1	.016	.625	.427	.916
	Constant		-.411	.112	13.370	1	.000	.663		
Tongue Sucking	Gender	Girls ref								
		Boys	-.839	.198	17.892	1	.000	.432	.293	.637
	Ethnicity	Afro-Trinidadian			30.856	2	.000			
		Indo-Trinidadian	-1.166	.226	26.699	1	.000	.311	.200	.485
		Mixed Ethnicity	-.796	.252	9.953	1	.002	.451	.275	.740
	Constant		-.900	.129	48.789	1	.000	.407		
Lip licking	Gender	Girls ref								
		Boys	-.647	.147	19.445	1	.000	.524	.393	.698
	Ethnicity	Afro-Trinidadian			52.767	2	.000			
		Indo-Trinidadian	-1.195	.167	51.334	1	.000	.303	.218	.420
		Mixed Ethnicity	-.613	.188	10.640	1	.001	.542	.375	.783
	Constant		.065	.112	.335	1	.563	1.067		

6.4 Discussion

Tongue thrusting habits are attributed to the changeover of teeth in the mixed dentition often leading to open spaces anteriorly in the dental arch, thereby prompting a habit of tongue thrusting (Sharma et al., 2015). Another author reported that tongue thrusting takes place because of delayed transition between the infantile and adult swallowing pattern (Kamdar and Al-Shahrani, 2015). Tongue thrusting was the most prevalent habit (81.3%) in this study. These findings agree with previous studies (Sharma et al., 2015, Guaba et

al., 1998) but the prevalence was much higher in our sample than that reported in these studies. This can be explained due to the high prevalence of bimaxillary protrusion in Trinidad and Tobago, which is 68.8% of the population (Hoyte et al., 2018). Several authors have noted the high prevalence of tongue habits in bimaxillary protrusion malocclusion (Bills et al., 2005, Lamberton et al., 1980).

Lip biting and sucking happens in almost all cases with the lower lip (Vogel, 1998). Lip sucking and biting places a lingually directed force on mandibular teeth and labial force on maxillary teeth resulting in upper incisor protrusion (Khan I, 2015). Lip biting can produce dryness and inflammation of the lip and in severe cases will cause vermillion hypertrophy and in some people chronic cold sore or lip crack (Massler and Chopra, 1950, Shahraki et al., 2012). Thirty- five percent of children in this study had lip related habits (33.7% lip licking and 1.4% lip sucking). The prevalence of lip habits was considerably higher when compared to prevalence in other studies (Quashie-Williams et al., 2010). Again, this may be accounted for as a higher prevalence of lip habits have been reported in bimaxillary protrusion (Bills et al., 2005, Lamberton et al., 1980). Logistic regression revealed an odds ratio of 0.51 for gender for lip licking / biting with males being half as likely to report this habit. This gender difference has not been previously reported specifically for this habit, but is consistent with the predilection of females to show oral habits.

Nail biting does not result in development of a malocclusion since the forces involved are similar to those with chewing, it is more likely to cause inflammation of nail beds (Khan I, 2015). Nail biting was the second most prevalent habit (46.3%) in our sample and again this was similar to some previous reported studies (Shetty and Munshi, 1998) but again was higher than reported in other studies (Sharma et al., 2015, Garde et al., 2014). Nail biting or onychophagia is thought to be a response to psychological disorders and some children will change their habits from digit sucking to nail biting (Shahraki et al., 2012). Nail biting is however often associated with anxiety, stress, and can cause self-inflicted gingival injuries, alveolar destruction, tooth wear and apical root resorption, but this data did not find an association with gender. One-quarter of patients with temporomandibular joint pain and dysfunction have a nail biting habit (Odenrick and Brattstrom, 1985). More

than half of children with nail biting habit have a psychological disorder such as depression (Leung and Robson, 1990). Boys with nail biting are more likely than girls to have Attention Deficit Hyperactivity Disorder (ADHD) (Shahraki et al., 2012). Further research into possible causes for this common practice in this population is required.

Digit sucking can lead to an imbalance between external and internal muscle forces (Garde et al., 2014). The effects of digit sucking include, lingual inclination of lower and labial inclination of upper incisor, increased overjet, anterior open bite, increased overjet, compensatory tongue thrust, deep palate, narrowing of the maxillary arch with posterior cross bite, speech defects, and finger defects such as eczema and angulations of the finger (Shahraki et al., 2012). The prevalence of Escherichia coli and Enterobacteria among children with nail biting and digit sucking habits is much higher compared to children without these habits (Shetty and Munshi, 1998, Baydas et al., 2007). Digit sucking was seen in 34.9% of cases this was again higher than that reported by other studies (Quashie-Williams et al., 2010, Garde et al., 2014). There has not been a direct cause and effect between non-nutritive sucking habits and malocclusion and the effects of habits seem to be superimposed on a genetic predisposition to malocclusion (Borrie et al., 2015). The high prevalence seems to be a reflection of cultural and social differences between Trinidad and Tobago children and developed western countries, with increasing development this pattern is likely to decrease, however this was not affected by ethnicity.

The habit of mouth breathing was not assessed in this survey. It is however important to note contributing factors to a child's ability to breathe through the nose include allergic rhinitis and hypertrophied adenoids. The facial morphology type associated with mouth breathing is called Adenoid facies (Schneider and Peterson, 1982). This comprises a long face, transverse contraction of the upper jaw, dark circles, high arched palate and a gummy smile associated with class 2 or 3 malocclusion, narrow nostrils with a high prevalence of anterior open bite and posterior crossbite. Postural changes such as increased vertical face height for clockwise rotation of the jaw, lip incompetence, low position of the tongue in the floor of the mouth are a result of mouth breathing due to airway obstruction(Grippaudo et al., 2016). Mouth breathing has been shown to be closely related to anterior or posterior crossbite, displacement, open bite, increased and reduced overjet

(Grippaudo et al., 2016). Therefore, early intervention is recommended to prevent worsening of this malocclusion.

Looking at ethnicity, in this study Afro-Trinidadians were more likely to have an oral habit, although this was not found for the lip or digit sucking habits. In Indo-Trinidadians the likelihood of oral habits was reduced with odds ratios varying from 0.559 (CI 0.433,0.721) (nearly half as likely) for tongue sucking to an odds ratio for nail biting of 0.775 (CI 0.656,0.917) when compared to Afro-Trinidadians. Further research into the possible causes for this association with ethnicity is required.

This study like other studies showed females were more likely to have habits (Garde et al., 2014, Lagana et al., 2013a, Lagana et al., 2013b, Kharbanda et al., 2003) with possible explanations being educational structures, hormonal changes and diet (Garde et al., 2014). In Trinidad and Tobago at this age the children would have just completed The Secondary School Entrance Exam (SEA) and girls tend to perform highly at this exam and this high level of performance could lead to high levels of stress thus possibly causing the high level of habits in girls.

Most of the children examined had at least one oral habit with 36.4% having more than two habits. This suggests that factors such as cultural or environmental beyond gender and ethnicity are influencing the development of habits, and this is supported by the low overall predictive power of the regression models.

Limitations to this study include the use of self-reported data collected during face to face interviews, where it is possible that the child may not have reported accurately but given what they felt was the expected response. This could explain in part the high reporting of habits in the study. Parents of children did not provide or confirm the information on oral habits provided by them. A letter to the parent or guardian to provide or confirm information would have made the process more robust. This study was designed to investigate the prevalence and association with gender and ethnicity of oral habits and was not designed to identify risk factors. Therefore, the results of the regression analysis need to be interpreted with care.

6.5 Association of prevalence of oral habits and bimaxillary proclination

Aetiology of all malocclusions has been attributed to a combination of genetics and environment. Both act synergistically to create malocclusion but genetics tend to influence skeletal pattern and environment influences tooth position (Lundstrom, 1984; Dibbets, 1996). With bimaxillary proclination the dentition adapts to the skeletal and soft tissue pattern.

Some authors have implicated environmental factors such as soft tissue function and volume in the aetiology of bimaxillary protrusion. The habits mentioned were mouth breathing, tongue and lip habits and augmentation in tongue volume (Bills et al., 2005; Lamberton et al., 1980).

Adesina et al. (2013) found the mean measurements of the tongue to be higher in bimaxillary proclination patients. Adesina also stated that aetiology of bimaxillary proclination could be related to tongue dimensions.

Forward resting posture of the tongue with light force and long duration based on the equilibrium theory has both a horizontal and vertical effect on the teeth (Adesina et al. 2013). In this study decreased bite made up 30.3% and open bite 4.8%, (Figure 6.1).

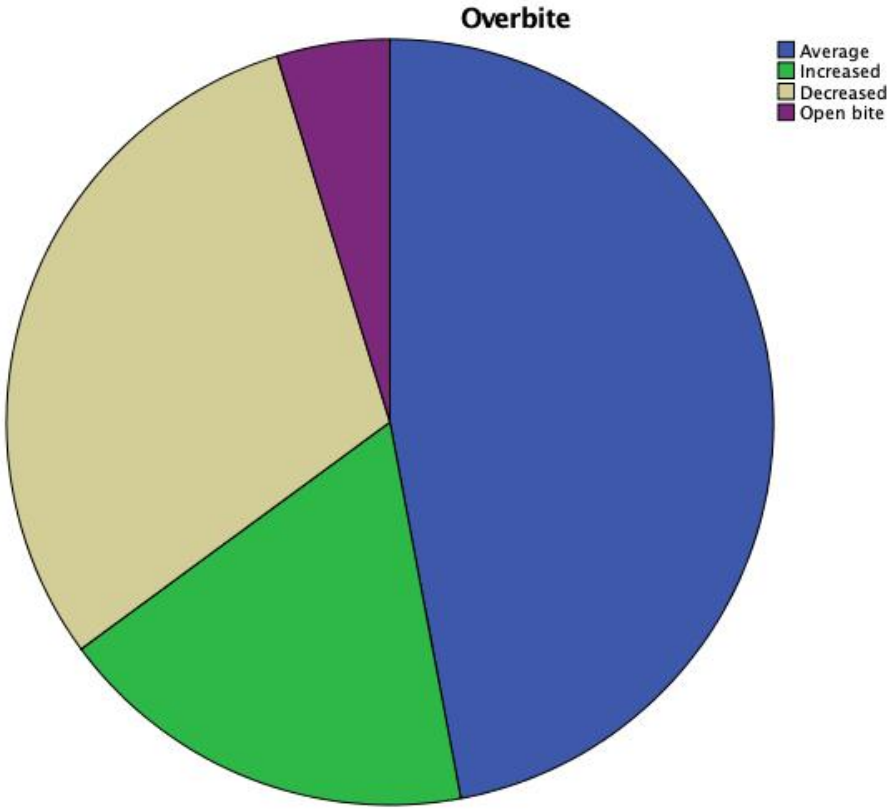


Figure 6.1: Pie chart showing overbite in sample

Studies have reported that oral habits are associated with more severe malocclusions (Grippaudo et al. 2016). Tongue thrust habit has been shown to be associated with long facial pattern and proclination of maxillary teeth (Cayley et al. 2000). Other authors found mouth breathing subjects exhibited significant increase in lower incisor proclination (Basheer, et al. 2014).

70.7% of Afro-Trinidadians had bimaxillary proclination. Afro-Trinidadians were more likely to have a habit. 93% of the subjects had a habit. 82% of subjects in this study had a tongue thrusting habit. This strengthens the theory by Sassouni, 1969 who stated that the presence of a tongue thrust habit would lead to bimaxillary protrusion. The high prevalence of this habit in the population could be a reason for the high prevalence of bimaxillary proclination.

6.6 Conclusions

- There is a high prevalence of deleterious oral habits in 11 and12 year old children in Trinidad and Tobago.
- The overall prevalence of habits was 93%. 68.6% of children presented with more than one habit.
- Tongue thrusting, nail biting and digit sucking were the most prevalent oral habits.
- Oral habits were more prevalent in girls and Afro-Trinidadians.
- There is an association between tongue thrusting and bimaxillary proclination

This highlights the need for community based educational preventative and interceptive strategies to prevent the deleterious effects of oral habits.

CHAPTER 7 - TREATMENT OF BIMAXILLARY PROCLINATION SYSTEMATIC REVIEW AND META-ANALYSIS

7.1 Introduction

Orthodontic treatment of bimaxillary protrusion is usually by a combination of extractions and fixed appliances, with maximum anchorage (Wahl, 2008). Methods to support anchorage include the use of headgear, transpalatal arches and orthodontic mini-screws and mini-plates (temporary anchorage devices). Orthognathic surgery is also proposed as it is indicated in some cases where bimaxillary prognathism is present. Other treatment modalities that have been reported include glossectomy when the tongue is identified as the major aetiological factor.

To date there is no consensus in the literature as to the most effective way to manage bimaxillary protrusion. Therefore, there is a need to systematically review the relevant literature to identify the best treatment for this common problem.

7.2 Objective

This study aims to identify the most effective orthodontic intervention to manage bimaxillary protrusion through undertaking a systematic review and meta-analysis of effectiveness of treatments.

7.3 Materials and Methods

7.3.1 Protocol and registration

The protocol for this systematic review on treatment of bimaxillary protrusion was registered on the National Institute of Health Research Database (www.crd.york.ac.uk/prospero,registration protocol: CRD42019136179).

This study was performed according to PRISMA guidelines and the main research question was defined in PICO format (Table 7.1).

7.3.2 Eligibility criteria

The following selection criteria were applied for articles to be included in the review:

1. Participants: Subjects with bimaxillary protrusion undergoing orthodontic treatment.
2. Intervention: Orthodontic treatment with or without extractions,
3. Comparison: Orthodontic or other non-surgical treatment with or without extractions.
4. Outcomes: Skeletal and dental changes (from cephalometric measurements), aesthetic assessments, patient experience, stability.
5. Study Design: Prospective controlled / comparative clinical trials.
6. Exclusion criteria: Treatment with Orthognathic surgery.

Table 7.1: PICO format and associated search terms

Population	Intervention	Comparison	Outcome
Bimaxillary Proclination	Orthodontic Treatment	No treatment	Aesthetics/esthetics
Bimaxillary Protrusion			Patient Experience
Bimaxillary dentoalveolar Protrusion			Stability
Bidental			Relapse
Bimaxillary Prognathism			SNA
Biprotrusion			SNB
			Overjet
			Anterior Posterior
			Vertical
			Interincisal
Bimax*	Ortho*		Lower Facial Height
Bimaxillary*			Maxillo-Mandibular Planes Angles
			Frankfort-Mandibular Planes angle

7.3.3 Information sources, search strategy, and study selection

The following electronic databases were searched up to 25th February 2019 and updated on 21st October 2019- PubMed, Medline, Scopus, and the Cochrane Library. Language restrictions were not applied. Table 7.1 shows search terms used to search electronic databases. Unpublished and incomplete studies were searched for electronically using Clinical Trials website (www.clinicaltrials.gov) and with the broad search terms treatment and bimaxillary. Reference lists of included studies were screened for relevant research.

Two investigators (T.H and D.B) who were not blinded to the authors or the results of the research, assessed articles for inclusion in the review, undertook assessment of risk of bias, and extraction of data independently. Disagreements were resolved by discussion between both authors.

7.3.4 Data items and collection

The Cochrane data extraction form (Higgins JPT, 2011) was used to record type of orthodontic treatment, methods (allocation, blinding, duration, treatment type), participants (sample size, age of participants at the beginning of treatment, sex) interventions, and outcome data of interest.

7.3.5 Risk of bias/ quality assessment in individual studies

Using the Cochrane Collaboration Risk of Bias assessment tool (Higgins JPT, 2011) six criteria were analysed to assess the risk of bias in each study. Two review authors assessed the risk of bias in included studies, independently and then in duplicate. The criteria were:

- Adequate sequence generation: was the allocation sequence adequately generated?
- Allocation concealment: was allocation adequately concealed?
- Blinding of outcome operators, assessors, participants: was knowledge of the allocated intervention adequately prevented during the study?

- Incomplete outcome data: were incomplete outcome data adequately addressed?
- Selective outcome reporting: were reports of the study free of suggestion of selective outcome reporting?
- Other sources of bias: was the study apparently free of other problems that could put it at a high risk of bias?

An overall assessment of risk of bias (high, low, unclear) was then made. A judgement of unclear indicated either lack of sufficient information to make a judgement or uncertainty over the risk of bias.

7.3.6 Summary measures and approach to synthesis

Clinical heterogeneity of the included studies was assessed by looking at the treatment protocol- treatment mechanics and materials used, measurement techniques and data collection.

Methodological heterogeneity was assessed by looking at differences in study design and methodological quality (risk of bias).

Statistical heterogeneity was assessed by I^2 statistics and inspecting a graphic display of estimated treatment effects in conjunction with emphasis on the overlap of 95% confidence intervals. I^2 test for homogeneity were undertaken to quantify the extent of heterogeneity before each meta-analysis. I^2 values above 50% would mean moderate to high heterogeneity. The Chi-Square test was also used to test for heterogeneity, a p-value below 0.1 also means significant heterogeneity.

Mean difference was calculated and 95% confidence intervals (CI) were calculated for each outcome and combined by using a random-effects model which was considered most appropriate in view of variations in studies. For continuous outcomes, mean difference was entered for outcomes.

7.3.7 GRADE

The quality of evidence was assessed by using the GRADE system with a GRADE evidence profile table (Guyatt et al., 2008). The GRADE system was used to assess the overall body of evidence. The quality of evidence can be classified as:

- High quality: Further research is very unlikely to change our confidence in the estimate of effect.
- Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
- Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
- Very low quality: We are very uncertain about the estimate.

7.4 Results

7.4.1 Study selection and characteristics of included studies

Six hundred and eighty-five studies were identified as being relevant to the review from the electronic database searches which reduced to one hundred and ninety-eight after duplicates were excluded. After initial screening of titles sixty-eight were screened by abstract. After reading abstracts thirty- six records were assessed as potentially satisfying the inclusion criteria and full texts of the articles were obtained and reviewed. Thirty–two of these were excluded, leaving four studies that were finally included (Chopra et al., 2017, Chen et al., 2015, Mitra et al., 2011, Upadhyay et al., 2008). The process is summarised in the PRISMA flow chart (Figure 7.1). Three of the included articles included in the qualitative analysis were prospective clinical trials and one was a randomised clinical trial. The details of these studies are shown in the characteristics of included studies in Table 7.2. Three studies were included in the quantitative synthesis (meta- analysis).

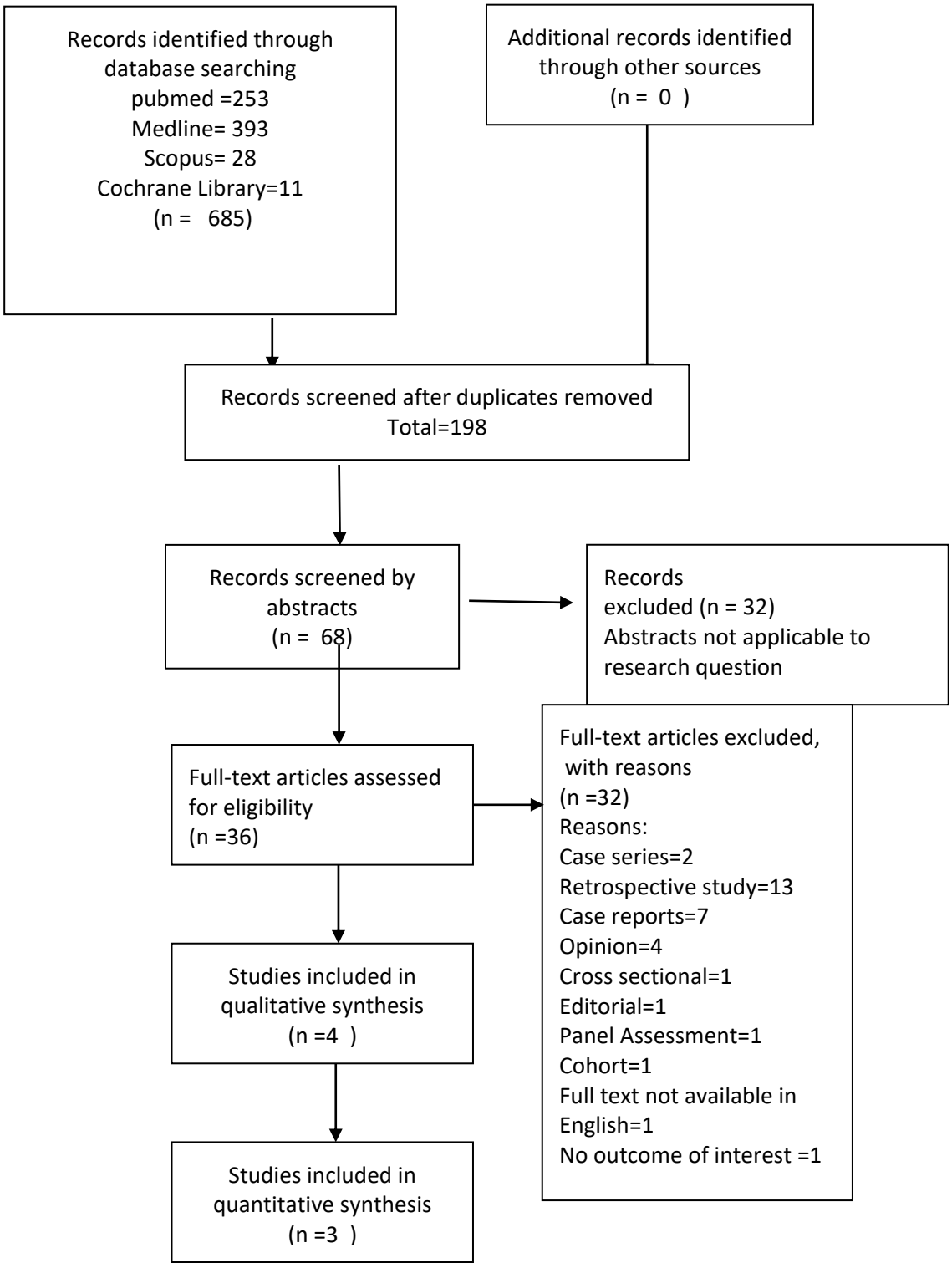


Figure 7.1: Prisma flow diagram of article retrieval

Table 7.2: Data on Studies included in the Review

Author(s) Year	Design	Participants	Interventions	Outcomes
Chopra et al (2017)	Prospective Clinical trial	50 participants 13 to 17 years. 24 males and 26 females	Group 1 received conventional anchorage with nance button or lingual arch. Group 2 received orthodontic implants	1. Anchorage loss 2. Treatment time 3. Incisor retraction
Chen et al., (2015)	Clinical trial (Non-randomised)	31 participants 13 men 18 women 25.87±3.37 years Group 1=15 Group 2=16	Group 1 micro implant Group 2 headgear anchorage	1. Anchorage loss 2. Treatment time 3. Incisor retraction.
Mitra et al., (2011)	Prospective clinical trial (split mouth design)	30 participants 13-17 years	Right side of the mouth elastic chain was used for space closure, on the left side of the mouth E-chain was used	1.Rate of space closure
Upadhyay et al (2008)	Randomised clinical trial	36 participants (Group 1-18 Group 2-18) Minimum age 14 years. Group 1mean age 17.6years. Group 2 mean age 17.3years	Group 1 mini-implants used Group 2 conventional methods used (transpalatal arch, banding second molars, and headgear)	1. Anchorage loss 2. Treatment time 3. Incisor retraction

7.4.2 Risk of bias within studies

Similar answers were given for all six criteria used to assess risk of bias in all the studies (Table 7.3, Figure 7.2). Only Upadhyay et al, (2008) was a randomised clinical trial. No study had blinding of participants and operators because the researchers were the ones placing the appliances. Only Upadyay et al (2008) had blinding of assessors and had a low risk of bias for allocation concealment, incomplete outcome data, free from other bias and adequate sequence generation. The other studies had high risk of bias with allocation concealment.

In (Chen et al., 2015) patients chose their anchorage device, so there was no randomisation or allocation concealment, sequence generation or blinding. Mitra et al (2011) was a split mouth design where participants may have been blinded but the operator was not blinded and this negates the importance of the randomisation procedure (Mitra et al., 2011).

In Chopra et al (2017) there was no sequence generation or allocation concealment reported. It was also unclear how the incomplete data was addressed.

One of the primary outcomes, skeletal and dental changes is not easily manipulated, limiting the potential problems of lack of blinding.

Therefore, three studies were considered appropriate for quantitative synthesis. Mitra et al. (2011) was the only study that assessed rate of space closure and was therefore omitted from the quantitative synthesis.

Table 7.3: Risk of bias of studies included in quantitative synthesis

Study	Adequate sequence generation	Allocation concealment	Blinding of Participants and operators	Incomplete outcome data addressed	Free of selective reporting	Free of other bias
Chopra et al (2017)	High	High	High	Unclear	Low	Low
Chen et al (2015)	High	High	High	Unclear	Low	Low
Mitra et al (2011)	Low	Low	Unclear	Low	Low	Low
Upadhyay et al (2008)	Low	Low	High	Low	Low	Low

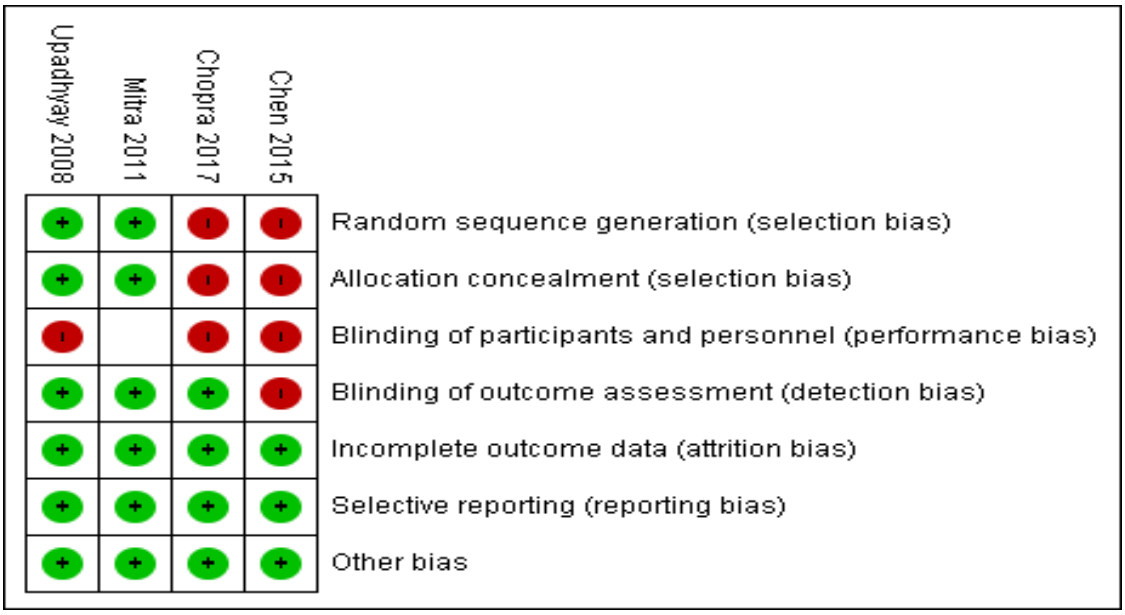


Figure 7.2: Risk of bias summary outlining judgement of risk of bias items for studies included in the quantitative synthesis

7.4.3 Meta-analysis

Three studies were included in the meta-analysis (Chopra et al., 2017, Chen et al., 2015, Upadhyay et al., 2008). Three random-effects models were generated, anchorage loss, incisor retraction and treatment time (Figure7.3, 7.4, 7.5). In total 58 patients were included in the TADs group and 59 in the other anchorage techniques group. The random-effects model assumes that there is different anchorage loss, incisor retraction and treatment time between TADs and other anchorage techniques.

The first model (Figure 7.3) shows less anchorage loss with TADs and the difference was statistically significant (p=0.002, 95%CI -3.89 to -0.88). The mean difference for anchorage loss was 2.38mm favouring TADs. Based on the heterogeneity of the included studies the test of the overall effect z=3.12. The confidence interval did not include the value 0, indicating that there is a significant difference between anchorage loss with TADs versus other anchorage techniques. The test for homogeneity confirmed that for this outcome heterogeneity among the three studies was I^2 93%; p<0.00001 chi-squared =27.71. The statistical heterogeneity was at an unacceptable high level. The high value of I^2 indicates that although difference in anchorage loss is statistically significant, differences lie in a narrow range.

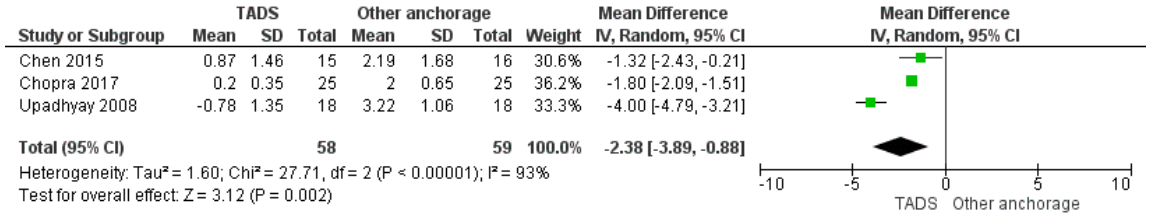


Figure 7.3: Random-Effects meta-analysis of anchorage loss

The second model (Figure 7.4) shows that the incisor retraction was greater with TADs compared with other anchorage techniques, but the difference was not statistically significant (p=0.10, 95% CI -2.95 to 0.26). The mean difference for incisor retraction was 1.35mm. The confidence interval does include the value 0, so this indicates there is a no significant difference between TADs and other anchorage devices for incisor retraction. The test for homogeneity confirmed that meta- analysis of this outcome was reasonable I^2 =64%; p=0.06 Chi-Square=5.52.

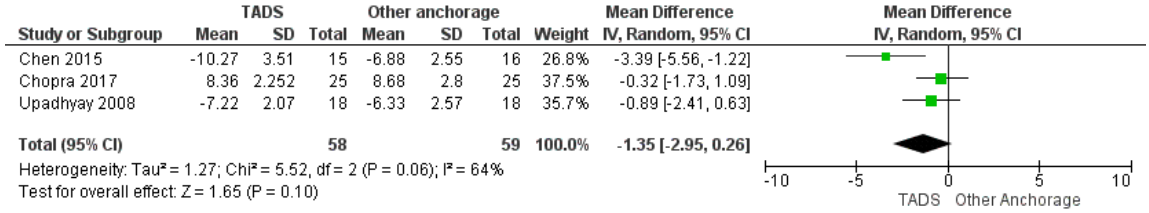


Figure 7.4: Random -Effects meta-analysis for incisor retraction

The third model (Figure 7.5) shows that treatment time was less with TADs and the difference was statistically significance (p=0.01, 95% CI -1.64 to -0.21. The mean difference was 0.92 months. Statistical heterogeneity was at an acceptable level (1^2 = 0%; Chi-Square=1.77, p=0.41). The test of overall effect was wider than the confidence interval and the confidence interval did not include 0, indicating that in certain cases a difference is expected in treatment time between TADs and other anchorage techniques.

Statistical analysis of publication bias was not indicated because there were less than ten studies in the meta-analysis.

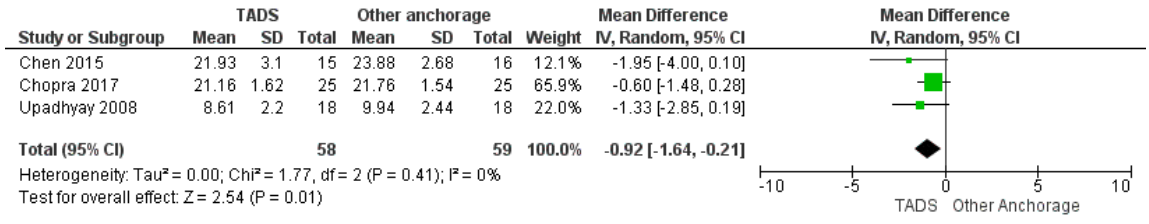


Figure 7.5: Random-effects meta-analysis for treatment time

7.4.4 GRADE analysis

The assessment of the quality of the collected evidence, according to GRADE, regarding, anchorage loss, incisor retraction and treatment time of TADs versus other anchorage techniques indicated that the level of evidence contributing to the conclusions was low (Table 7.6). This suggest that further research is likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Table 7.4: Summary of Findings (SOF) table according to GRADE

Quality assessment							Summary of Findings				
Participants (studies) Follow up	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall quality of evidence	Study event rates (%)		Relative effect (95% CI)	Anticipated absolute effects	
							With Anchorageloss, Incisor Retraction and Treatment Time	With TADS versus other anchorage techniques		Risk with Anchorageloss, Incisor Retraction and Treatment Time	Risk difference with TADS versus other anchorage techniques (95% CI)
Anchorage loss (CRITICAL OUTCOME; Better indicated by lower values)											
117 (3 studies)	very serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	undetected	⊕⊕⊖⊖ LOW[1] due to risk of bias	59	58	-		The mean anchorage loss in the intervention groups was **2.38 lower** (3.89 to 0.88 lower)
Incisor Retraction (CRITICAL OUTCOME; Better indicated by lower values)											
117 (3 studies)	very serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	undetected	⊕⊕⊖⊖ LOW[1] due to risk of bias	59	58	-		The mean incisor retraction in the intervention groups was **1.35 lower** (2.95 lower to 0.26 higher)
Treatment Time (CRITICAL OUTCOME; Better indicated by lower values)											
117 (3 studies)	very serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	undetected	⊕⊕⊖⊖ LOW[1] due to risk of bias	59	58	-		The mean treatment time in the intervention groups was **0.92 lower** (1.64 to 0.21 lower)

[1] Sequence generation, allocation concealment, blinding of assessors

7.5 Discussion

7.5.1 Summary of evidence

Despite an extensive search of the literature only four studies were identified that approximated to the inclusion criteria. They looked at different treatment mechanics for bimaxillary protrusion. Only one was a randomised clinical trial. Three studies looked at anchorage reinforcement, treatment time and incisor retraction and one looked at rate of space closure only and therefore only three studies were eligible for quantitative synthesis with meta-analysis.

Risk of bias was high in all the articles identified except the randomised clinical trial and this high risk of bias would affect the confidence in the findings of the systematic review (Fleming and DiBiase, 2008). Therefore, more randomised clinical trial studies would be desirable for more robust conclusions in the future.

Inherent bias formed part of some studies especially the study where patients could select the device. The effect that bias has on systematic reviews has been well documented (Millett, 2011).

The Cochrane assessment tool was used to assess risk of bias. For reliable quality evaluation it had six main aspects. The randomisation method of Upadhay et al (2008) was the only trial with a robust randomisation. Mitra et al (2011) was a split mouth design which offers concurrent experimental and control assignment but was not included in the meta-analysis because it only looked at rate of space closure. Chopra et al (2017) alternately assigned patients to groups which resulted in a high risk of bias. Blinding of operators and participants was assigned a high risk of bias in all studies because it was impossible to blind operators and participants except in Upadhay et al (2008) who made up for this by blinding assessors, which can compensate for non-blinding of patients. Noteworthy, was that other studies did not mention blinding of assessors.

More adherence to RCT guidelines is needed in future studies.

The GRADE analysis on the quality of evidence was evaluated to be low due to all the shortcomings of the research included in the meta-analysis and qualitative synthesis. All studies introduced a lot of clinical heterogeneity due to the different types of anchorage reinforcement techniques that were used. All three studies involved extraction of all four first premolars so these studies were comparable in this aspect.

Anchorage loss

Bimaxillary protrusion cases are very anchorage demanding. Therefore, elimination of undesired mesial molar movement is key in these cases. The conventional anchorage techniques include transpalatal arches, Nance holding arch, and headgear. The results of the systematic review and meta-analysis provide evidence that anchorage loss is less with TADs in bimaxillary protrusion cases and in all three studies it was statistically significant. Upadhyay et al (2008) also demonstrated anchorage gain may also be achieved with temporary anchorage devices in bimaxillary protrusion cases. The other techniques such as the transpalatal arch have biomechanical deficiencies and full time use of headgear is not tolerated by patients. It must be noted that the make and model of the TADs were not disclosed and this can be a source of variation if the same make and model was not used. All in all the TADs allowed for better anchorage preservation than other techniques.

Incisor Retraction

Meta-analysis showed more retraction of incisors may be achieved with TADs in all three studies but this was not statistically significant. The dimensions of working arch wires used ranged from 0.017x0.025 (Upadhyay et al., 2008) to 0.019x0.025 (Chopra et al., 2017). Also, both MBT (Chopra et al., 2017, Chen et al., 2015, Yao et al., 2008) and Roth prescriptions (Upadhyay et al., 2008) were used. This alteration in incisor torque prescription could have had an effect on the amount of retraction achieved. Also, the

studies showed methodological heterogeneity because all studies used different reference planes to assess retraction.

Treatment time

In all studies the treatment time was minimally shorter with TADs. The shorter treatment time observed may be due to use of a one-step retraction technique with TADs versus two step with conventional techniques. Heterogenity between studies was also seen as Upadyay et al (2008) reported treatment time at the end of space closure as opposed to Chen et al and Chopra et al who reported total treatment time. Noteworthy, is that more anchorage loss is seen in conventional techniques and this is possibly responsible for some of the space closure thereby providing a deceptive shorter treatment time (Chen et al., 2015). Other factors that may affect treatment time include patient compliance, skill of the operators and the closing mechanics deployed.

7.6 Conclusion

On the basis of this systematic review, we conclude:

- The use of TADs in bimaxillary protrusion cases showed statistically significant less anchorage loss than traditional anchorage reinforcement techniques.
- The use of TADs showed shorter treatment time in bimaxillary protrusion cases.
- More incisor retraction was achieved with TADs in bimaxillary protrusion cases but this was not statistically significant.
- There is some low quality evidence that micro-implants could be the preferred method for anchorage for bimaxillary protrusion cases.
- There is a lack of high quality evidence regarding orthodontic treatment for managing this condition.

- Due to the lack of high quality evidence for treating bimaxillary protrusion, the evidence quality was assessed as low therefore the results have to be interpreted with caution.
- Therefore, high quality randomised clinical trials with robust methodologies are needed in this area of orthodontics.

CHAPTER 8 - PROTOCOL OF A RANDOMIZED CLINICAL TRIAL TO COMPARE SELF LIGATING AND CONVENTIONAL LIGATING BRACKETS IN THE TREATMENT OF BIMAXILLARY PROTRUSION

8.1 Introduction

Self-ligating bracket systems have been making a huge impact in orthodontics over the last three decades. The first system the Russell Lock Edgewise was described as long as 1935(Stolzenberg, 1935). These systems are ligatureless orthodontic brackets with an inbuilt metal labial face which can be opened or closed.

Compared to conventional ligation systems self- ligation helps reduce treatment time (Harradine, 2003) because of advantages in the design which are

1. Low friction between archwire and bracket
2. Less chair side assistance
3. More certain full archwire engagement
4. Better oral hygiene
5. More biologic movement

A review of the literature showed no studies in populations where bimaxillary protrusion is prevalent. Therefore, in the Trinidad and Tobago population it is unknown if these advantages can be reported.

This protocol is for a randomised clinical trial (RCT) designed to compare the effectiveness of self-ligating brackets versus conventional-ligating brackets for orthodontic treatment of bimaxillary protrusion. Both systems are widely used by clinicians worldwide but the self -ligating bracket systems are the fastest growing in the field of orthodontics.

8.2 Protocol

8.2.1 Purpose of randomized clinical trial

To investigate differences in outcome from orthodontic treatment undertaken using self-ligating brackets and conventional brackets in the treatment of bimaxillary protrusion

8.2.1.1 Problem to addressed

The proposed study outlines a prospective randomized clinical trial to evaluate the effectiveness and outcome of two different ligation systems in treating bimaxillary protrusion

8.2.1.2 Principle research question

In the treatment of bimaxillary protrusion is there a difference between a self- ligating system and a conventionally ligated system with respect to:

- Patient's experience of treatment in terms of
    - Duration of treatment
    - Number of appointments
    - Pain/discomfort during treatment
- Smile Aesthetics
- Occlusal outcome
- Facial Attractiveness
- Cephalometric outcomes

8.2.1.3 Null hypotheses to be tested

- There is no difference in treatment experience when comparing self-ligating systems and conventionally ligated in orthodontic treatment of bimaxillary protrusion

- There is no difference in smile aesthetics or facial attractiveness when comparing self- ligating systems and conventionally ligated in orthodontic treatment of bimaxillary protrusion
- There is no difference in occlusal outcome when comparing self-ligating systems and conventionally ligated in orthodontic treatment of bimaxillary protrusion
- There is no difference in cephalometric outcomes when comparing self-ligating systems and conventionally ligated in orthodontic treatment of bimaxillary protrusion

8.2.1.4 Why is the trial needed now?

From the systematic review on treatment (see Chapter 7) there is no high quality evidence for the most effective treatment of bimaxillary protrusion. There is no evidence on which bracket system is better for treating bimaxillary protrusion.

8.2.1.5 How will the result of the trial be used?

The results of this study will inform orthodontic clinicians and dentists on the relevant effectiveness of the two treatment methods.

8.2.2 Plan of investigation

8.2.2.1 Proposed study design

The study design type is a prospective randomised clinical trial. It will take place at the orthodontic clinic at The University of the West Indies (UWI) dental school.

8.2.2.2 Interventions

Patients receiving orthodontic treatment in UWI orthodontic clinic will be enrolled into the study. The patients will be treated by one operator who will be registered to practice in Trinidad and Tobago.

8.2.2.3 Operator

The operator has at least thirteen years' experience using both orthodontic bracket systems. There will be only one clinician to treatment plan all cases. Treatment will be done according to normal treatment protocols with the relevant appliance system. This includes extraction decision and mechanotherapy. Once treatment commences there will be no additional appointments required for the study. The date of placement of the full orthodontic appliance will mark the start of treatment.

8.2.2.4 Consent

Consent will be sought at least one week prior to commencement of treatment.

After obtaining consent, the patient would be randomly allocated to receive treatment with a self-ligation system or a conventional ligation technique

1. Self- ligation system – SmartClip™ (3M Unitek)
2. Conventional ligation technique- Victory Series™ (3M Unitek).

8.2.2.5 Fixed appliance therapy protocol

Self -ligation technique:

- Brackets
    - 3M Unitek SmartClip™
    - 022" slot
- Bracket prescription
    - MBT
- Archwires and archwire sequence
    - Archform - Orthoform II 3M Unitek
    - Usual operator choice of archwire dimensions and material
- Archwire engagement

  Treatment visit interval as per operator practice

Conventional ligation Technique:

- Brackets
    - 3M Unitek Victory Series™
    - 022"slot
- Bracket prescription
    - MBT
- Archwires and archwire sequence
    - Archform -Orthoform II 3MUnitek
    - Usual operator choice of archwire dimensions and material
- Archwire engagement
    - Elastomeric modules or steel ties
- Archwire engagement

Treatment visit interval as per operator practice

8.2.2.6 Inclusion criteria

- Bimaxillary Protrusion
- Class 1 or class 2 division 1 incisor relationship with an overjet less than or equal to 6mm
- Class 3 incisor overjet not less than 0
- No previous orthodontic treatment
- No systemic illness
- No use of anti-inflammatory drugs prior to placement of the fixed appliance
- Good oral hygiene and periodontal health with periodontal pockets of less than or equal to 4mm, full mouth plaque score less than or equal to 20 percent
- Cooperative and motivated patient
- In the permanent dentition with all teeth present at least to the first molars
- No radiographic bone loss observed on the dental panoramic image

8.2.2.7 Exclusion criteria

- Patients who required surgery to correct skeletal discrepancies
- Patients with hyperdontia, hypodontia, or syndromic diseases (e.g. cleft lip and palate)
- Uncooperative patients
- Patients where the operator is not in equipoise

8.2.2.8 Obtaining consent

When a patient attends for a consultation appointment and satisfies the above criteria he/she would be considered for inclusion in the study. The patient and parent would then be told the basic outline of the study and will be given the information sheets.

Patients who are willingly to take part in the study would then be given consent forms for both the patient and parent to sign and will be randomised.

8.2.2.9 Registering for the study

The research assistant will then record the following details

- Name of subject
- Gender
- Date of birth
- Full postal address
- Phone contact

8.2.2.10 Randomization process

8.2.2.10.1Sequence generation

A random number table will be used by the research assistant and one of the supervisors not involved in identifying or treating the patients to allocate patients into the self-ligating group or the conventional ligation group and placed in a sealed envelope. Patients requiring tongue guards prior to fixed appliance treatment will be stratified to ensure equal allocation of subgroups of participants to both groups. All documents used for randomisation will be kept in a locked cabinet in an office (T.H) away from the clinical environment in The University of the West Indies Child Dental Health Unit in the Dental School.

8.2.2.10.1 Allocation concealment mechanism

An opaque sealed envelope will be prepared by the research assistant. This envelope will contain the treatment allocation into self- ligating group or conventional ligation group.

Once informed consent is obtained, the case will be allocated a research number, the case will be treatment planned using the normal process for the particular

problem this would include extraction decision and mechanotherapy. The patient will then be made dentally fit and baseline data will be collected. The allocation will only be revealed at the time of placement of fixed appliances. The research assistant would reveal the group to the clinician and the participant at the same time.

The number in the sequenced sealed envelope will then be used as the study ID number.

8.2.2.10.3 Steps following allocation

Once treatment commences it would continue routinely without requiring extra appointments for the study. The start of treatment will be determined when the full appliance is placed.

8.2.2.10.4 Protecting against bias

This clinical trial will be a single blinded study. It will not be possible to be double blinded since neither operator nor patient can be blinded to the treatment type. Once the research assistant reveals from the sealed envelope the appliance type to be used, the study ID number will be attached to the patient file and all data including models of the participant. It will not show which group the participant will be allocated to. Therefore, the data collection and analysis will be blinded.

8.2.2.10.5 Duration of treatment

Treatment is expected to take approximately 18-24 months depending upon the malocclusion. Treatment end will depend on clinical need and not trial need.

8.2.2.10.6 Data collection

The information below will be collected during the study

- Number of attendances
- Duration of each visit and overall treatment duration
- Number of failed or cancelled appointments
- Frequency and reason for additional attendance for appliance breakage or debonds
- Pre and post- treatment PAR (Peer Assessment Rating) scores derived from study models
- Cephalometric (radiograph) analysis including soft tissue analysis. A lateral cephalometric radiograph was taken prior to treatment and at debonding
- "Smiles better" questionnaire at 6months and patient perception questionnaire at the start of treatment and at debond.

8.2.2.10.7 Protocol deviations:

All patients who failing to attend an appointment will be offered a new appointment. Patients wishing to withdraw from the trial will be able to do so at any point with no detriment to their treatment and records would be taken at that stage and where appropriate included in an intention to treat analysis.

Appliance breakage – patients attending because of breakages will be seen at this appointment.

8.2.3 Data collection

T_1- Registration into trial

- Date
- Patient Gender
- Patient's date of birth
- Photographs
- Digital photographs stored as unaltered (no cropping etc) jpeg files
    - Extra-oral
        - Full face
        - Full face smiling
        - Right profile
        - Right ¾
        - Right ¾ smiling
    - Intraoral
        - Anterior in occlusion in ICP
        - Right buccal in occlusion in ICP
        - Left buccal in occlusion in ICP
        - Upper occlusal
        - Lower occlusal

Study Models

- Duplicated orthodontically trimmed study models in white plaster
- An original wax bite recording occlusion in ICP

Radiographs

- Lateral cephalogram

Questionnaires

- Treatment questionnaire (before)
- Patient's own rating of their teeth was recorded using the IOTN aesthetic component

8.2.4 Treatment visits (every planned appliance placement/adjustment)

Date

Operator

Breakages (including any loss or failure of ligation with either bracket)

- Record any bracket loss
- Record any failure of ligation (loss of module or open gate)

Treatment performed

T 6/12 (Six months into active treatment)

- 'Smiles Better' questionnaire (Yassir et al., 2017)

T_{END} – End of Active Treatment (Debond)

Date

Photographs

- Digital photographs stored as unaltered (no cropping etc) jpg files
    - Extra-oral
        - Full face

    - Full face smiling
    - Right profile
    - Right ¾
    - Right ¾ smiling
- Intraoral
    - Anterior in occlusion in ICP
    - Right buccal in occlusion in ICP
    - Left buccal in occlusion in ICP
    - Upper occlusal
    - Lower occlusal

Radiographs

- Lateral cephalogram

Study Models

- Duplicated orthodontically trimmed study models in white plaster
- An original wax bite recording occlusion in ICP

Questionnaires

- Treatment questionnaire (after)
- 'Smiles Better' questionnaire (Yassir et al., 2017)
- Record patient's own rating of their teeth using the IOTN aesthetic component

8.3 Sample Size Calculation

- There have been few published studies reporting data on overall orthodontic treatment duration, the primary outcome for this study, on which to base the sample size calculation. Most recent reports have focused on only one aspect of treatment rather than overall treatment duration.
- Eberting et al. (2001) compared treatment effectiveness and efficiency of Damon self-ligating (SL) brackets to those brackets ligated with either steel ligatures or elastomeric 'O' rings. The results of this study are summarised below in Table 8.1

Table 8.1: Eberting et al study shows time taken in months for completion of treatment

	Sample mean	Sample s.d.	n
Conventional ligation	30.87 months	7.85	107
Self-ligation (Damon)	24.54 months	6.45	108
Difference	6.33 months		

Harradine's study (Harradine, 2001) was designed to compare treatment efficiency with conventional fully programmed brackets and Damon SL self-ligating brackets. The results of this study are summarised below.

Table 8.2: Harradine study shows time taken in months for completion of treatment.

	Sample mean	Sample s.d.	n
Conventional ligation	23.5 months	5.16	30
Self-ligation (Damon)	19.4 months	5.9	30
Difference	4.1 months		

Additional data is available from a previous RCT undertaken in the development of this programme of research, and is shown below:

Table 8.3: Smith and Bearn study shows time taken in months for completion of treatment (unpublished data).

	Sample mean	Sample s.d.	n
Conventional ligation	21.99 months	4.75	27
Self-ligation (Damon)	25.87 months	6.0	27
Difference	3.88 months		

Therefore, taking the common standard deviation to be 6 (the mean of the s.d. for these studies) a prior power calculation for this study requires a sample size of 39 patients in each group to have an 80% power to detect a difference in mean duration of 4 months (clinically significant to both operator and patient), assuming that the common standard deviation is 6.0 using a two-group t-test with a 0.05 two sided significance level. Allowing 25% for dropouts / non-completion we therefore aim to recruit 100 patients in total, 50 patients per treatment group.

8.4 Ethical Approval

Ethical approval was sought through The University of The West Indies ethics committee Ref: CE001/12/12 (Appendix 2)

8.5 Primary Outcome Measures

Facial aesthetics

- Panel assessment of pre and post facial photographs
- Photogrammetric assessment of pre and post profile photographs

Occlusion

- ABO score
- Archform dimensions
    - ICW
    - IPW
    - IMW
    - Arch length

Treatment progress

- Duration in months
- Number of scheduled appointments
- Number of casual appointments

Cephalometric (radiographic) analysis

- SNA
- SNB
- ANB

- Saddle/SellaAngle(SN-Ar)
- Convexity (NA-Apo)
- SN-PP
- PP-MP
- UI – Palatal Plane
- LI – MP
- Lower Lip to E- Plane
- Interincisal angle (U1-L1)
- Upper Face Height (N-ANS)
- Lower anterior face height (LAFH)
- LAFH/TAFH
- PFH/AFH
- Mx Unit Length
- Md Unit Length
- Lower Incisor Protrusion LI – APo
- Nasolabial Angle (Col-Sn-UL)
- Mentolabial Angle
- Upper Lip to E – Plane
- Lower Lip to E- Plane

8.6 Secondary Outcome Measures

Smile aesthetics

- Panel assessment of smile aesthetics
  - Lay
  - Dental
  - Orthodontics
- Patient's IOTN aesthetic score rating before and after treatment (Appendix 3)

Patient experience

- 'Smiles better' questionnaire and patient perception questionnaire (Appendix 3)
- Breakage experience

8.7 Data Analysis

Grouping Variables

- Primary grouping variable: appliance system
- Secondary grouping variable: extractions

Pre-treatment equivalence

- Equivalence of the two primary groups will be assessed using
  - Pre-treatment cephalometric data
  - Occlusal features (determined from study models)
  - Start PAR

Group comparison

Data will be checked for normality and any necessary transformations carried out. An intention to treat analysis will be carried out including all patients enrolled into the study.

Comparison between the two groups in the primary and secondary outcomes using parametric (t-tests) and non-parametric tests (Mann Witney) as appropriate.

Regression analysis

Factors influencing the primary outcomes will be identified using linear regression analysis. Factors entered into the regression will include

- Appliance system
- Extraction/non-extraction
- Operator
- Treatment duration
- Co-operation
    - Breakages
    - Casual visits
- key skeletal cephalometric data
    - ANB
    - MMPA
- key features of presenting malocclusion
    - OJ
    - OB
    - Crowding
    - Incisor relationship

Proposed frequency of data analysis

Data analysis will be carried out at the end of the study. We will not carry out any interim analysis of the data

8.8 Conclusion

The randomised clinical trial at The University of the West Indies dental school is progressing According to protocol and findings disseminated when completed.

CHAPTER 9 - CEPHALOMETRIC NORMS FOR BIMAXILLARY PROTRUSION

9.1 Introduction

Based on cranial differences the human race can be placed into three major groups the Caucasian, Negroid and Asian (Hewes, 1962). Trinidad and Tobago is a cosmopolitan country. The three major ethnicities in Trinidad and Tobago are people of East Indian descent (35.43%of population), African descent (34.22% of population) and the mixed population (22.82% of population). Bimaxillary protrusion has been shown to be the major malocclusion in Trinidad and Tobago (Hoyte et al., 2018). Several racial cephalometric standards have been established for relatively homogenous groups (Alexander and Hitchcock, 1978, Alcalde et al., 1998, Bacon et al., 1983, Carter and Slattery, 1988, Behbehani et al., 2006, Cerci et al., 1993). However, many populations are cosmopolitan like Trinidad and Tobago and have produced mixed facial characteristics that have not yet been studied. Cephalometric differences have been shown between racial groups and morphological subgroups within these groups can be seen (Angel, 1950). Racial characteristics have been noted to lead to cephalometric variations. Therefore, in terms of ethnicity, it is important to recognise the difference of a homogenous group and a blended group to ensure treatment planning is tailored to appropriate outcomes, and improve patient's expectations (Alcalde et al., 1998).

Orthodontic diagnosis and treatment planning require careful evaluation of the patient's cephalometric values and comparison to known population norms. Radiographic cephalometry has also been used to assess treatment progress, craniofacial growth, tasks in research and individual patient growth (Ajayi, 2005).

No data exists on cephalometric standards for Trinidad and Tobago population. These specific analyses would enable clinicians to improve diagnosis and treatment planning.

The purpose of this study was to establish cephalometric standards for the Trinidad and Tobago population.

9.2 Materials and Methods

The study was conducted after receiving approval from The University of the West Indies ethics committee (Appendix 4). The study was conducted following the guidelines of the Declaration of Helsinki (Helsinki, 2004)

The sample size consisted of 109 standardised lateral cephalometric radiographs. These radiographs were obtained from patients receiving orthodontic treatment at the dental hospital who had given consent for their records to be used. These bimaxillary protrusion patients were part of a fixed appliance study (see Chapter X). Their incisor relationships class1, class 2 division 1 and class3. The subjects all had overjet <7mm and aged 10-17 years mean age.

9.2.1 Obtaining consent

Patients consent was sought prior to the commencement of orthodontic treatment. The procedure as well as the risks and benefits were explained to the patient.

9.2.2 Cephalometric measurements

One operator (T.H.) took all lateral cephalograms with a single cephalostat (Gendex) at 70 kv, 9MA. The distance from the X-ray focus to the mid-saggital plane was 150cm and between the film and the mid-saggital plane was 15cm. All subjects were positioned with their Frankfort plane parallel to the floor. Participant's lips were in a relaxed position and teeth in maximum intercuspation. The cephalograms were digitised using Dolphin™ Digital Imaging System version 10.5, Chatsworth, CA. The cephalograms were then digitally traced using 48 hard and soft tissue landmarks and 25 linear and angular cephalometric measurements were recorded (Table 9.1) The tracings were done twice for each radiograph at least three months apart.

All tracing and analyses were conducted and 39 were reassessed by D.B a supervisor.

Any disagreement was resolved by dialogue and if necessary, by reanalysis and retracing.

The means and standard deviation for different genders and the whole sample were obtained. The mean was then compared to Caucasoid, African-American and Chinese norms.

There were 52 boys and 57 girls (Figure 9.1) aged 10-17 years (Figure 9.2), mean age 13.42 years...

The following landmarks were identified on each cephalogram (figure) Sella (S), Nasion (N), Oribitale (O), Porion (P), Gnathion (GN), Pogonion (Pog), Gonion (Go), Menton (M), Anterior Nasal Spine (ANS), Posterior Nasal Spine (PNS), A-point, B-point, Maxillary Incisor Apex (MxIA), Mandibular Incisor Apex (MIA), Upper Incisor Tip (UIT), Lower Incisor Tip (LIT).

The definitions of the various landmarks have been previously reported. From the landmarks the following skeletal and dental lengths and angles were measured: Sella-Nasion-A-point angle (SNA), Sella-Nasion-B-point angle (SNB), A point-Nasion-B point angle (ANB), Saddle/Sella angle (SN-Ar), Convexity angle (NA-Apo), Sella –Nasion-Palatal plane angle (SN-PP), Palatal plane-Maxillary plane (PP-MP), Maxillary plane-Sella-Nasion angle (MP-SN), Upper incisor axis to Palatal plane angle (U1-PP), Lower incisor axis to Mandibular plane angle (L1-MP), Interincisal angle (U1-L1), upper face height (N-ANS), lower anterior face height (LAFH), lower face height ratio (LAFH/TAFH), posterior face height to anterior face height ratio (PFH/AFH), Maxillary unit length (Co-ANS), Mandible unit length (Co- Pog), Lower incisor protrusion (L1-Apo), Overbite, Overjet, Upper lip to E-Plane, Lower lip to E-Plane, Nasolabial angle (Col-Sn-UL), Mentolabial Angle.

9.2.3 Statistical analysis

Intra-examiner reliability was calculated using a statistical package (IBM SPSS Statistics for Windows, version 22, IBM Corp., Armok, N.Y., USA). The methodology was checked for quality by looking at bar charts and normality curves (Appendix 5 and 6). Box plots were produced to aid in checking for outliers. Outliers were then assessed to ascertain their cause. Possible causes of outliers include incorrect landmark identification, a technical error or a correct value appearing as it was an abnormal measure. Basic descriptive statistics included means, standard deviations, maximum and minimum were computed for each cephalometric variable. Differences with gender were also computed. An independent t-test was conducted to ascertain any sexual dimorphism.

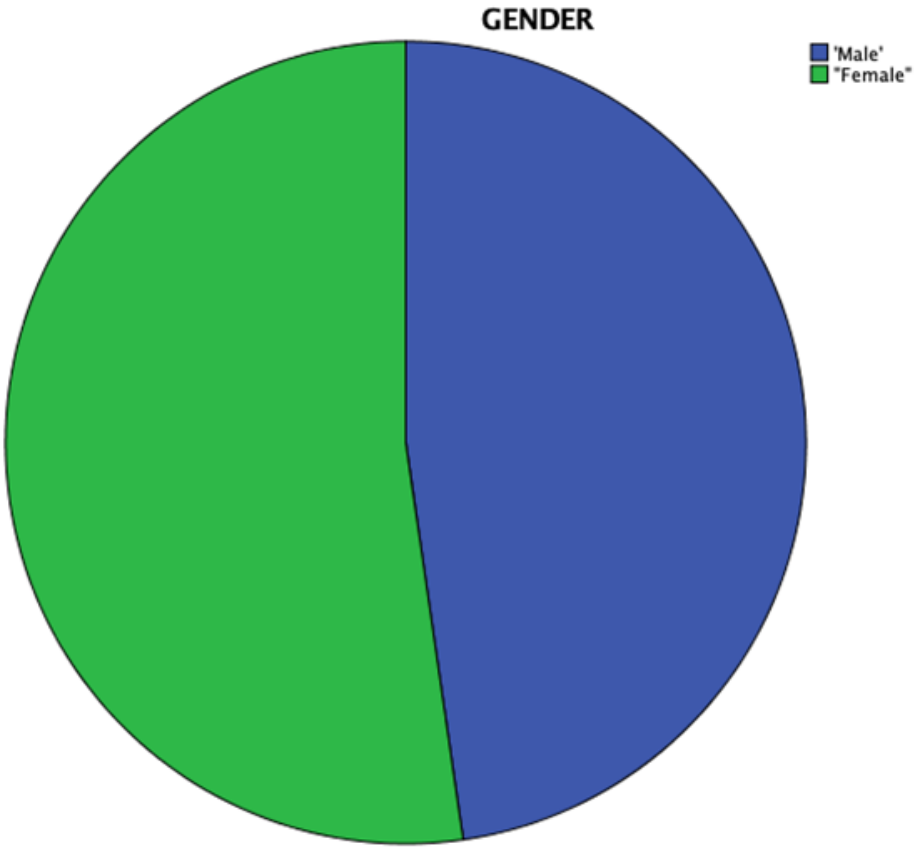


Figure 9.1: Pie chart showing number of boys (52) and girls (57) in the sample

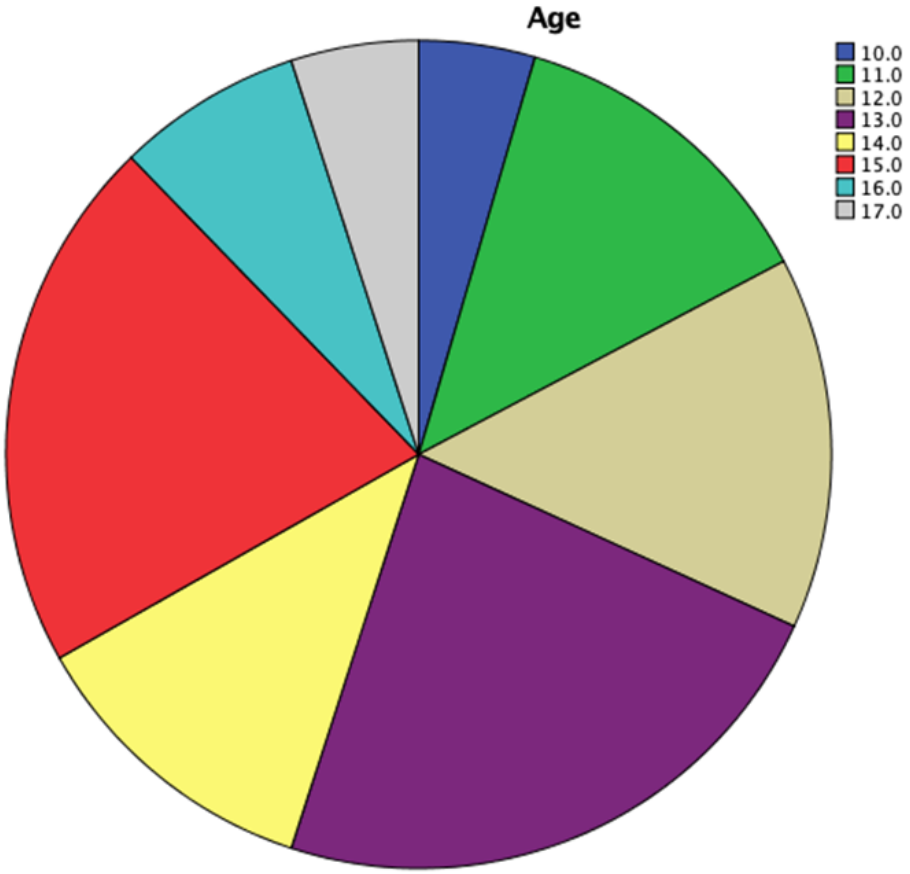


Figure 9.2: Pie chart showing different ages of subjects in the sample

9.3 Results

The cephalometric findings by gender is presented in Table 9.1. Male and female data were compared with an independent t-test. Twenty-five analyses were compared; therefore the criterion p-value was adjusted so that statistical significance was any value <0.002 (0.05/ 25=0.002) are listed in Table 9.1. The combined data was analysed and the mean, minimum, maximum and standard deviation, Table 9.2. Intra-examiner reliability was also calculated Table 9.3. The norms were compared to the Caucasian, African - American and Chinese bimaxillary protrusion norms Table 9.4.

Table 9.1: Comparison of minimum, maximum, mean standard deviation and independent t-test for boys and girls

Linear (mm) and angular (º) measurements	Boys n=52				Girls n=57				Independent sample t-test P-value*
	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	
SNA	69.9	98.9	86.7	4.6	73.5	105.9	85.2	5.1	0.018
SNB	69.8	92.0	79.7	4.2	68.2	92.3	77.8	4.6	0.001
ANB	-1.8	14.1	7.1	2.4	2.4	15.1	7.3	2.5	0.395
SN-AR	110.0	149.9	124.9	6.7	103.4	148.6	128.4	7.6	0.004
NA-Apo	-3.4	32.4	17.0	6.0	1.3	34.9	17.4	7.0	0.645
SN-PP	-12.9	9.4	-1.0	4.2	-8.5	11.1	0.8	4.2	0.002
PP-MP	20.9	42.2	32.1	4.8	21.0	45.0	32.5	5.3	0.587
MP-SN	22.2	50.4	36.1	5.6	23.7	57.6	38.2	7.0	0.10
U1-Palatal Plane	108.7	138.9	118.4	6.3	105.5	133.2	119.0	6.0	0.450
L1-MP	85.6	115.8	100.9	5.7	87.0	117.9	101.8	6.0	0.246
U1-L1	82.2	129.9	110.7	8.5	91.6	130.6	108.8	7.8	0.77
N-ANS	36.3	64.6	49.7	4.8	36.3	60.2	49.7	4.7	0.983
ANS-Me	53.0	90.3	67.7	7.1	54.8	83.0	66.7	6.3	0.247
LAFH/TAFH	51.7	61.4	56.8	2.2	51.1	62.7	56.4	2.3	0.209
PFH/AFH	57.2	73.4	65	4.1	51.3	74	63.4	5.1	0.100
Co-ANS	72.9	106.8	88.5	7.0	72.6	102.9	87.4	6.1	0.185
Co-PoG	93.5	140.7	112.3	8.9	94.6	136.9	110.8	8.1	0.191
Lower Lip to E-Plane	-1.6	14.1	6.4	2.8	-3.3	12.2	4.9	3.6	0.02
L1-Apo	-3.9	10.5	3.7	2.8	-1.4	9.6	3.9	2.4	0.720
Overbite	-5.9	5.4	1.7	2.4	-4.1	4.9	1.4	1.8	0.260
Overjet	-0.4	10.3	4.2	1.9	-0.2	8.5	4.6	1.7	0.176
Upper Lip to E-Plane	-2.1	8.6	2.9	2.3	-4.6	8.6	1.3	3.3	0.001
Lower Lip to E-Plane	-1.6	14.1	6.4	2.8	-3.3	12.2	4.9	3.6	0.002
Col-Sn-UL	48.7	112.2	84.7	12.1	56.5	116.4	84.6	11.1	0.957
Mentolabial Angle	98.7	164.8	130.6	15.3	96.9	169.5	131.2	15.3	0.782

*Significant difference at P<0.002

Table 9.2: Norms for the Trinidad and Tobago population

Measurement (º)	Minimum	Maximum	Mean	Standard Deviation
SNA	69.9	105.9	85.9	4.9
SNB	68.2	92.3	78.7	4.5
ANB	-1.8	15.1	7.2	2.5
SN-AR	103.4	149.9	126.7	7.4
NA-Apo	-3.4	34.9	17.2	6.5
SN-PP	-12.9	11.1	-0.03	4.3
PP-MP	20.9	45.0	32.3	5.1
MP-SN	22.2	57.6	37.2	6.4
U1-Palatal Plane	105.5	138.9	118.7	6.1
L1-MP	85.6	117.9	101.4	5.9
U1-L1	82.2	130.6	109.7	8.2
N-ANS	36.3	64.6	49.7	4.7
ANS-Me	53.0	90.3	67.2	6.7
LAFH/TAFH	51.1	62.7	56.6	2.3
PFH/AFH	51.3	74.0	64.2	4.8
Co-ANS	72.6	106.8	88.0	6.6
Co-PoG	93.5	140.7	111.5	8.5
L1-Apo	-3.9	10.5	3.8	2.6
Overbite	-5.9	5.4	1.5	2.1
Overjet	-0.4	10.3	4.4	1.8
Upper Lip to E-Plane	-4.6	8.6	2.0	3.0
Lower Lip to E-Plane	-3.3	14.1	5.6	3.2
Col-Sn-UL	48.7	116.4	84.7	11.6
Mentolabial Angle	96.9	169.5	130.9	15.3

Table 9.3: Intra-examiner reliability

Measurements	Intraclass Correlation Coefficient	
	Single Measures	Average Measures
SNA	0.825	0.904
SNB	0.874	0.933
ANB	0.761	0.864
SN-AR	0.655	0.792
NA-Apo	0.789	0.882
SN-PP	0.749	0.857
PP-MP	0.872	0.931
MP-SN	0.917	0.957
U1-Palatal Plane	0.803	0.891
L1-MP	0.863	0.926
U1-L1	0.821	0.902
N-ANS	0.616	0.762
ANS-Me	0.760	0.863
LAFH/TAFH	0.738	0.849
PFH/AFH	0.843	0.915
Co-ANS	0.524	0.688
Co-PoG	0.904	0.949
Lower Lip to E-Plane	0.904	0.949
L1-Apo	0.792	0.884
Overbite	0.744	0.853
Overjet	0.855	0.922
Upper Lip to E-Plane	0.877	0.935
Lower Lip to E-Plane	0.904	0.95
Col-Sn-UL	0.739	0.85
Mentolabial Angle	0.796	0.887

Table 9.4: Cephalometric norms for other ethnicities

Angle	Caucasian Standards		African-American		Chinese Standards		Trinidad and Tobago	
	Mean	SD	Mean	Standard Error	Mean	SD	Mean	SD
SNA	82.0	3.5	88.2	0.7	83.78	3.49	85.9	4.9
SNB	78.0	3.0	83.9	0.7	79.88	3.84	78.7	4.5
ANB	2.3	2.8	4.3	0.4	3.90	1.96	7.2	2.5
MPA	27		27.7	Not reported	28		32.3	5.1
Interincisal angle	135	6.0	112.8	1.5	121.68	7.78	109.7	8.2
UI- Max	109	5.0	118	Not reported	113		118.7	6.1
LI-Man	93		101	Not reported	98.38	7.58	101.4	5.9
LI- Apo	2.7	1.7	Not reported	Not reported	3.1	1.8	3.8	2.6
Upper Lip to E- Plane(mm)	-0.6	2.0	Not reported	Not reported	0.8	1.9	2.0	3.0
Lower Lip to E-Plane(mm)	-2.0	2.0	Not reported	Not reported	2.8	2.2	5.6	3.2

(Fonseca and Klein, 1978)
(Chan, 1972)

9.4 Discussion

The results of this study showed some unique characteristics of bimaxillary protrusion in Trinidad and Tobago population. Trinidad and Tobago is a cosmopolitan country the cephalometric norms from this study can only use in this and any other similar cosmopolitan society.

All measurements displayed normality as seen by the normality curves (Appendix 1 and 2).

The intra-examiner reliability in all measurements except Co-ANS was very close to 1. This shows a high degree of reliability and agreement between the repeated tracings. The discrepancy with Co-ANS could be explained with the difficulty in locating ANS. Landmark identification is considered to be the major source of errors with cephalometric tracing(Baumrind and Frantz, 1971, Houston et al., 1986). In this study however landmark identification, tracing and measurements were carried out by one examiner to minimise error.

The independent t-test showed sexual dimorphism with the measurements of SNB, upper and lower lip to E-Plane, $p<0.002$, Table 9.1. These values were higher in males compared to females. This demonstrates that males in the society had a more prognathic mandible and protrusive profile than females.

The skeletal, dental and soft tissue characteristics of an individual are affected by variables like race and gender. Proper diagnosis and treatment planning would therefore entail identifying the normal features of a specific race or ethnic group. This study used lateral cephalograms from the bimaxillary protrusion population in Trinidad and Tobago and showed that there are differences in the skeletal, dental and soft tissue profiles not just when compared to Caucasians but also to other bimaxillary protrusive populations.

The mean SNA and SNB values show that Trinidad and Tobago children have a prognathic maxilla and mandible relative to anterior cranial base and their values were close to the Chinese standards for prognathism (Chan, 1972) (Table 9.4). In both this study and two African -American studies (Fonseca and Klein, 1978, Alexander and Hitchcock, 1978) the maxilla was significantly anterior to the cranial base. The maxilla and mandible in relation to the cranial base were more anteriorly placed in this sample as compared to Caucasian sample.

The SNB angle was however not large enough to offset the larger SNA angle resulting in a large ANB difference (7.2°± 2.5°). The ANB was significantly higher in this study than African-American (Fonseca and Klein, 1978) and Chinese (Chan, 1972) bimaxillary protrusion studies.

The MMPA of Trinidadian children was significantly steeper than Caucasians, Chinese and African-American children. The high values for FMPA were reported by Kapila (1989) on Kenyan children and Drummond (1968) on African-American children. This implies that Trinidad and Tobago population are possibly vertical growers. Ricketts (1960) stated that subjects with a low mandibular plane angle tended to have large chins and are horizontal growers. This was confirmed by Aki et al. (1994) who showed that subjects with a thick symphysis i.e chin with large depths are horizontal growers. The subjects in this study had a receding chin. The mandible however was not retrusive because the position of B point as reflected by SNB angle was 78.7° ±4.5°.

Fonseca and Klein (1978) also found lower face height (A-Pog) to be increased in their sample as compared with Caucasians. In this sample lower face height was measured using ANS-Me and it was also found to be increased (value 67.2%) compared with Caucasian norms.

The presence of bimaxillary proclination can be assessed by using an interincisal angle of less than 120° as the definition (Keating, 1985, Lamberton et al., 1980). This study showed

protrusive dentoalveolar relationships with bimaxillary proclination being similar to that reported in African American subjects (Fonseca and Klein, 1978). The mean interincisal angle was 109.7° ± 8.2°. Bimaxillary proclination has being described as a feature of the Trinidadian profile (Hoyte et al., 2018). U1-L1 met at a more acute angle because of the increased proclination. The interincisal angle was lower than that for African American (Fonseca and Klein, 1978). Noteworthy, Alexander and Hitchcock (1978) reported similar findings of procumbent and protrusive incisors in African-Americans. Bimaxillary Protrusion was also reported as a general feature of Bantu children, (Savage, 1963). The lower incisor to APog demonstrated that the lower incisors in this study was protrusive compared to Caucasians norms but the amount of protrusion was closer to the Chinese norms.

The soft tissue profile differed mainly in the protrusion of the lips. The upper lip to E-Plane was much more protrusive in this sample compared to Chinese and Caucasian standards. The lip protrusion in this study would be unacceptable by Ricketts' standards but it reinforces the view that what is unacceptable in one population can be normal in another.

The observed differences suggest that different cephalometric norms are required to treat the bimaxillary protrusion population in Trinidad and Tobago.

9.5 Conclusion

- From the values obtained in this study, Caucasian and other bimaxillary protrusion norms cannot be applied to the Trinidad and Tobago population. Trinidad and Tobago is a cosmopolitan society so when this population is to be assessed norms for this population should be the yardstick
- The maxilla and mandible were more protrusive than Caucasian samples but similar to Chinese standards

- The upper and lower incisors were more proclined than Caucasians in this study and similar to African American standards
- The lower face height was higher in this study compared to other ethnicities
- The upper and lower lip were more protrusive in this study compared to Chinese and Caucasian norms.
- The standards provided in this study should serve as orthodontic treatment and post treatment objectives

CHAPTER 10 - SUMMARY, CONCLUSONS AND FUTURE RESEARCH

The aim of this study was to examine bimaxillary protrusion in the Trinidad and Tobago population the prevalence of this malocclusion, features and management in this population.

This study showed that the prevalence of bimaxillary protrusion varied greatly among populations, and the Trinidad and Tobago population showed the highest prevalence. Methodology, geography and ethnicity had a major impact on reported prevalence. Further studies are required to better asses impact of factors affecting reported prevalence.

Bimaxillary prognathism has a prevalence of 64.4% and bimaxillary proclination has a prevalence of 68.8% in Trinidad and Tobago. There is evidence that there is an association between bimaxillary prognathism and ethnicity and a range of oral habits. There is no evidence that there is an association between bimaxillary proclination with ethnicity. There is an association between ethnicity and digit sucking, tongue sucking and tongue thrusting. Afro-Trinidadians were more likely to have all three habits. IOTN was shown not to be a useful tool for assessing treatment need in this population.

The overall prevalence of fractured incisors was found to be 4.72% in this population. Afro-Trinidadians had the highest prevalence of fractures, but the difference was not statistically significant. Males presented with more dental injuries than females, but this was not statistically significant. The most common injured tooth was the maxillary central incisor. Increased overjet, incompetent lips and class 2 division 1 incisors increase the risk of incisor trauma. Early orthodontic treatment is recommended in these patients. It was noted that many patients delayed seeking treatment for their injuries.

In this population there was a high prevalence of deleterious oral habits in 11-12 year old children. The overall prevalence of habits was 93%. 68.6% of subjects presented with more than one habit. Tongue thrusting, nail biting and digit sucking were the most prevalent oral habits. Oral habits were more prevalent in girls and Afro-Trinidadians. Oral habits are an environmental influence on bimaxillary proclination and other malocclusions

present in Trinidad and Tobago, which can worsen the effects of this malocclusion especially the effect on proclined incisors.

The use of TADs in bimaxillary protrusion cases showed statistically significant less anchorage loss than traditional anchorage reinforcement techniques. The use of TADs showed shorter treatment time in bimaxillary protrusion cases but this was not statistically significant. More incisor retraction was achieved with TADs in bimaxillary protrusion cases but this was not statistically significant. There is a lack of high quality evidence for managing this condition. Also, due to the lack of high quality evidence for treating bimaxillary protrusion, the evidence quality was assessed as low therefore the results have to be interpreted with caution. Therefore, high quality randomized clinical trials with robust methodologies are needed in this area of orthodontics. A protocol for a high quality randomised clinical trial has been presented here with reflections on delivering this trial in Trinidad and Tobago. There is some low quality evidence that micro-implants could be the preferred method of anchorage for bimaxillary protrusion cases. A systematic review was necessary since it highlighted only three high quality studies in this area and more high quality studies in this area are needed.

From the cephalometric values obtained in this study, Caucasian and other bimaxillary protrusion norms cannot be applied to the Trinidad and Tobago population. Trinidad and Tobago is a cosmopolitan society so when this population is to be assessed norms for this population should be the yardstick. The standards provided in this study should serve as orthodontic treatment and post treatment objectives for bimaxillary protrusion patients in this population. The maxilla and mandible were more protrusive than Caucasian samples but similar to Chinese standards. The upper and lower incisors were more proclined than Caucasians in this study and similar to African American standards. The lower face height was higher in this study compared to other ethnicities. The upper and lower lip were more protrusive in this study compared to Chinese and Caucasian norms.

These studies highlight the need for more high quality research on bimaxillary protrusion in the Trinidad and Tobago population.

These studies highlight the need for more high quality research on bimaxillary protrusion in the Trinidad and Tobago population. Examples include

1. Cephalometric norms need to be tailor made to individual populations further investigations into Trinidad and Tobago's entire population are needed to differentiate the set of parameters.
2. IOTN was shown not to be a useful tool in this population. It was tailor made to Caucasian populations since it was invented in the U.K. A new treatment need index tailored to a bimaxillary protrusion population should be devised.
3. It is not known if there are deleterious effects of proclined incisors. For example, does a patient with an oral habit and a proclined incisor have more periodontal breakdown. More studies are required in this area.
4. The aesthetic and psychosocial effects of proclined incisors should also be studied.
5. Does bimaxillary proclination have a deleterious effect on the periodontal tissue? Is there more root resorption in these cases? Is there earlier tooth loss because of proclination? What are the periodontal long term effects of bimaxillary proclination?
6. Are patients with oral habits more susceptible to incisal fracture?

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APPENDIX

Appendix 1: Ethical approval for prevalence study

THE UNIVERSITY OF THE WEST INDIES
ST AUGUSTINE, TRINIDAD AND TOBAGO, WEST INDIES
FACULTY OF MEDICAL SCIENCES
ETHICS COMMITTEE
Telephone: (868) 645-2640 Ext. 5025 Fax: (868) 663-9836 e-mail: deanfms@sta.uwi.edu

April 26, 2013

Dr. Trudee Hoyte
School of Dentistry
Faculty of Medical Sciences
The University of the West Indies
St. Augustine

Dear Dr. Hoyte

Prevalence of various malocclusions in different ethnic groups in Trinidad and Tobago

Further to our letter of March 6, 2012 and your amendments received on April 26, 2013, I am pleased to advise that your application for research on the above captioned topic has been approved on behalf of Ethics Committee.

Please note that you should use copies of the attached signed Consent Form to document your participants' consent.

Yours sincerely

Shivananda Nayak (Prof.)
Chairman, Ethics Committee
Faculty of Medical Sciences

/lb

MINISTRY OF EDUCATION
Office of the Chief Education Officer
ALEXANDRA STREET, ST. CLAIR
PORT-OF-SPAIN
TELEPHONE: 628-7350 FAX: 628 -9165

3rd May, 2013

Dr. Carlen Chandler
Research Assistant in Orthodontics
School of Dentistry
University of the West Indies
St. Augustine

Dear Dr. Chandler

Permission to Conduct Research Study

The Ministry of Education is pleased to convey approval to conduct research in Secondary schools on ***"The Prevalence of Malocclusions in Trinidad and Tobago."***

I would also like to request a copy of any intermediate reports and the final report on the conclusion of your study.

Regards.

Mr. Harrilal Seecharan
Chief Education Officer
Ministry of Education

Appendix 2: Ethical approval for randomized clinical trial 1 and 2

THE UNIVERSITY OF THE WEST INDIES
ST AUGUSTINE, TRINIDAD AND TOBAGO, WEST INDIES
FACULTY OF MEDICAL SCIENCES
ETHICS COMMITTEE
Telephone: (868) 645-2640 Ext. 5025 Fax: (868) 663-9836 e-mail: deanfms@sta.uwi.edu

March 11, 2013

Dr. Trudee Hoyte
Orthodontics Department
School of Dentistry
Faculty of Medical Sciences
St. Augustine

Dear Dr. Hoyte,

Comparison of self-ligating and conventional brackets in treatment of bimaxillary proclination – A randomized clinical trial

Further to my letter dated December 10th 2012 and upon receipt of the additional information, I write to inform you that approval has been granted for you to proceed with your research as captioned.

Approval will be granted until February 10, 2014, further extension will be given on receipt of progress report of the research along with a covering letter requesting extension.

Please note that you should use copies of the attached signed Consent Form to document your participants' consent.

Yours sincerely,

Shivananda Nayak (Prof.)
Chairman, Ethics Committee
Faculty of Medical Sciences

THE UNIVERSITY OF THE WEST INDIES
ST. AUGUSTINE, TRINIDAD AND TOBAGO, WEST INDIES
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13th February 2020

Professor Surendra Arjoon
Chairman, Ethics Committee
Faculty of Medical Sciences

Dear Prof Arjoon,

Ref: CEC007/03/13
Comparison of self- ligating and conventional brackets in treatment of bimaxillary proclination- A randomized clinical trial.

I have acquired equipment and materials as well as a cohort of patients for the research. Pre- treatment records have been taken on these patients and general dentistry carried out to ensure that the patients have good oral hygiene before orthodontic treatment begins. I have started treatment on one hundred and ten (110) patients, in which sixty-five (65) patients have already completed treatment.

I require an extension of ethics approval for the year 2020/2021 because treatment of current patients is not completed.

Thanking you in advance.

Yours sincerely,

Trudee Hoyte

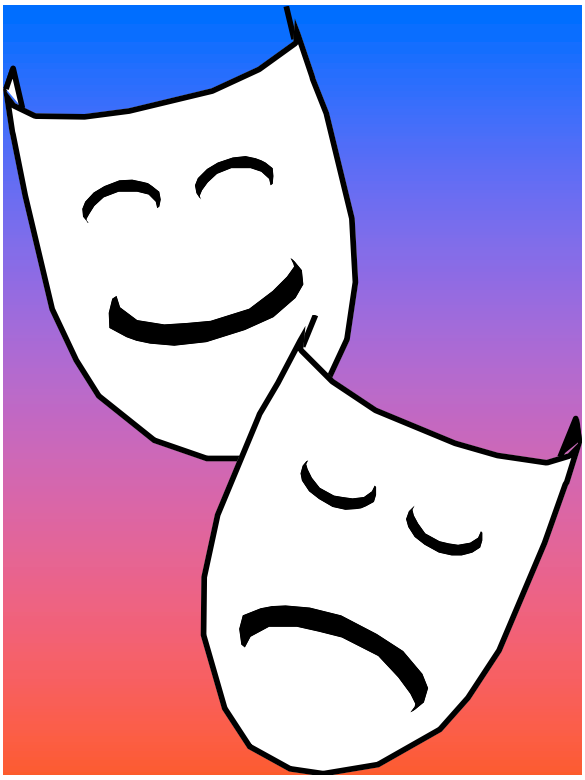
Dr. Trudee Hoyte
Orthodontics Department
School of Dentistry
Faculty of Medical Sciences
St. Augustine

Appendix 3: Smiles Better questionnaire, IOTN before and after survey

Date:	Affix Unique Study I.D. label here

Smiles Better

A few questions about you and your brace



Version 1. March 2008

A Few Questions About You And Your Brace

We would like to know how you feel about wearing your brace. By answering these questions, YOU can help to make wearing a brace better for people in the future.

Please circle the answer, which is nearest to how you feel, like this :

If you think wearing a brace has improved your smile put a ring around (improved)
or
How often do you play sport Not at all (A little) A lot

*Please tell us about how you feel **NOW**, not about when your brace was new.*

---

1. How much have the following things changed because of wearing your brace?

Speech	Improved	Same	Slightly worse	Much worse
Eating	Improved	Same	Slightly worse	Much worse
Drinking	Improved	Same	Slightly worse	Much worse
Sleeping	Improved	Same	Slightly worse	Much worse
Appearance	Improved	Same	Slightly worse	Much worse
I am teased	Less	Same	Slightly more	Much more

2. Now you are wearing a brace, how have the following affected you?

Sore teeth	Not at all	A little	A lot
Soreness in your mouth	Not at all	A little	A lot
Soreness from rubbing	Not at all	A little	A lot
Feeling embarrassed	Not at all	A little	A lot
Dribbling	Not at all	A little	A lot
Keeping the brace clean is a nuisance	Not at all	A little	A lot

We would like to know if wearing a brace can affect other things in your life.

SCHOOLWORK

3a. How have the following things associated with wearing a brace affected your schoolwork?

For example, if you think your schoolwork is better you would put a ring around improved

How have any changes in your speech affected your schoolwork ?	Improved	Same	Worse	Much Worse
How have any changes in your eating affected your schoolwork ?	Improved	Same	Worse	Much Worse
How have any changes in how you drink affected your schoolwork ?	Improved	Same	Worse	Much Worse
How have any changes in your sleep patterns affected your schoolwork ?	Improved	Same	Worse	Much Worse
How have any changes in your appearance affected your schoolwork ?	Improved	Same	Worse	Much Worse
If you have experienced teasing how has it affected your schoolwork ?	Improved	Same	Worse	Much Worse

3b. How have your experiences of the following affected your schoolwork?

Sore teeth	Not at all	A little	A lot
Soreness in your mouth	Not at all	A little	A lot
Soreness from rubbing	Not at all	A little	A lot
Feeling embarrassed	Not at all	A little	A lot
Dribbling	Not at all	A little	A lot
Keeping the brace clean	Not at all	A little	A lot

GETTING ON WITH FRIENDS

Version 1. March 2008

4a. How have the following things associated with wearing your brace affected your friendships?

For example, if you think it is easier to get on with your friends because of the way your brace has changed your smile, you would put a ring around improved

How have any changes in your speech affected your friendships ?	Improved	Same	Worse	Much Worse
How have any changes in your eating affected your friendships ?	Improved	Same	Worse	Much Worse
How have any changes in how you drink affected your friendships?	Improved	Same	Worse	Much Worse
How have any changes in your sleep patterns affected your friendships ?	Improved	Same	Worse	Much Worse
How have any changes in your appearance affected your friendships?	Improved	Same	Worse	Much Worse
If you have experienced teasing how has it affected your friendships ?	Improved	Same	Worse	Much Worse

4b. How have your experiences of the following affected the way in which you get on with your friends?

Sore teeth	Not at all	A little	A lot
Soreness in your mouth	Not at all	A little	A lot
Soreness from rubbing	Not at all	A little	A lot
Feeling embarrassed	Not at all	A little	A lot
Dribbling	Not at all	A little	A lot
Keeping the brace clean	Not at all	A little	A lot

FAMILY RELATIONSHIPS

5a. How have the following things associated with wearing a brace affected how you get on with your family?

For example, if you think you argued a lot more with your parents because of your brace, you would put a ring around much worse

How have any changes in your speech affected your relationship with your family?	Improved	Same	Worse	Much Worse
How have any changes in your eating affected your relationship with your family?	Improved	Same	Worse	Much Worse
How have any changes in how you drink affected your relationship with your family?	Improved	Same	Worse	Much Worse
How have any changes in your sleep patterns affected your relationship with your family?	Improved	Same	Worse	Much Worse
How have any changes in your appearance affected your relationship with your family?	Improved	Same	Worse	Much Worse
If you have experienced teasing how has it affected your relationship with your family?	Improved	Same	Worse	Much Worse

5b. How have your experiences of the following affected your relationship with your family?

Sore teeth	Not at all	A little	A lot
Soreness in your mouth	Not at all	A little	A lot
Soreness from rubbing	Not at all	A little	A lot
Feeling embarrassed	Not at all	A little	A lot
Dribbling	Not at all	A little	A lot
Keeping the brace clean	Not at all	A little	A lot

HOBBIES / INTERESTS

6. If you feel that wearing a brace has had any effect on your hobbies please tick the appropriate box.

For example:

If you feel that wearing a brace has meant that you get the lead roles in the school play you would tick the **I enjoy doing more** *box beside* **drama**

Activity	I enjoy doing more…….	No different	I do less…….
Music			
Sport			
Drama			
Singing			
Going to clubs eg Scouts or guides			

If you think wearing a brace has affected other hobbies or interests please write them in the activity column and say in what way by ticking the appropriate boxes.

TOOTH MOVEMENT

Now that you are wearing a brace do you feel that your teeth are moving?	Not at all	A little	A lot
Is it important to you whether or not your teeth are moving?	Not at all	A little	A lot

Version 1. March 2008

YOUR EXPERIENCE OF WEARING A BRACE

Is wearing a brace what you expected?	Yes	No	Not sure
Have you had any extra visits to the hospital because your brace has broken?	Yes	No	
If you have had to make extra visits because your brace has broken, has this bothered you?	Not at all	A little	A lot

YOUR ADVICE TO OTHER PATIENTS

Based upon **YOUR** experience of wearing a brace, what would **YOU** say to someone who was about to have a brace fitted?

Appendix 4: Ethical approval for Cephalometric study

THE UNIVERSITY OF THE WEST INDIES
ST AUGUSTINE, TRINIDAD AND TOBAGO, WEST INDIES
FACULTY OF MEDICAL SCIENCES
ETHICS COMMITTEE
Telephone: (868) 645-2640 Ext. 3025 Fax: (868) 663-9836 e-mail: deanfms@sta.uwi.edu

April 5, 2013

Dr. Trudee Hoyte
School of Dentistry
Faculty of Medical Sciences
The University of the West Indies
St. Augustine

Dear Dr. Hoyte

Development of baseline cephalometric indices for the population of Trinidad and Tobago.

Further to our letter of July 9, 2012 and your amendments received on April 5, 2013, I am pleased to advise that your application for research on the above captioned topic has been approved on behalf of Ethics Committee.

Yours sincerely

Shivananda Nayak (Prof.)
Chairman, Ethics Committee
Faculty of Medical Sciences

/lb

Appendix 5: Histogram normality curves and box plots by gender for the Trinidad & Tobago population

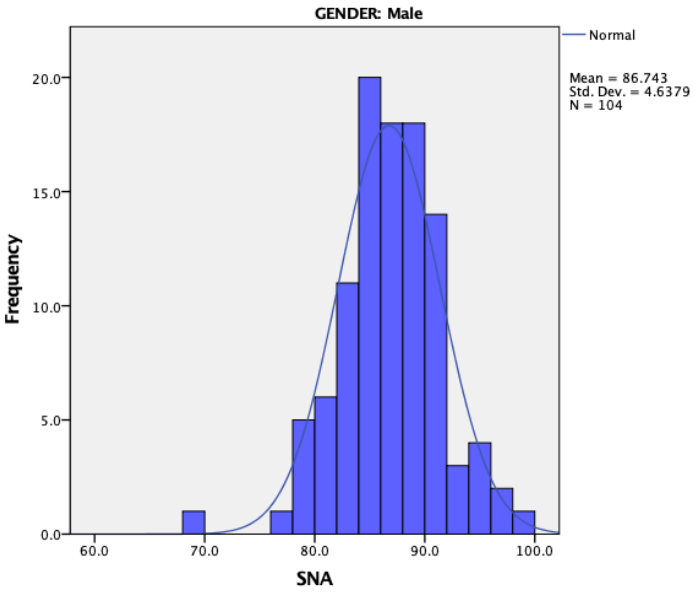


Figure 9.3 Histogram and normality curve for SNA for boys

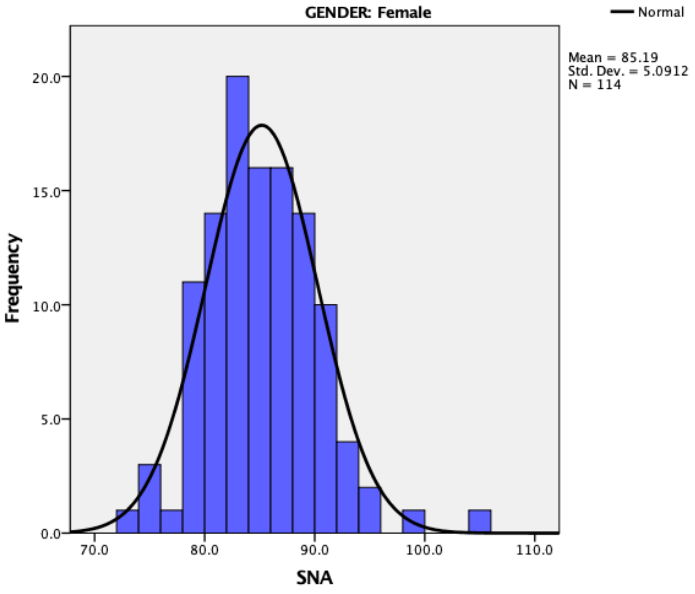


Figure 9.4 Histogram and normality curve for SNA for girls

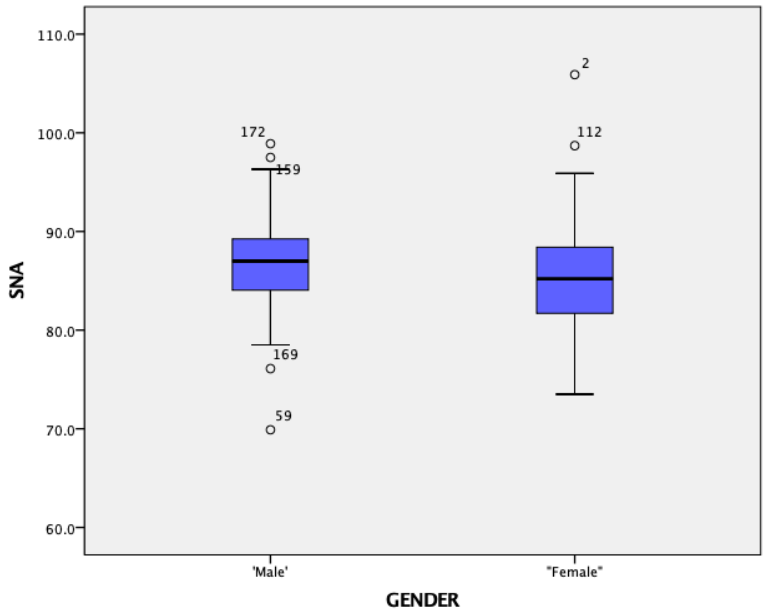


Figure 9.5 Box plots for SNA by gender

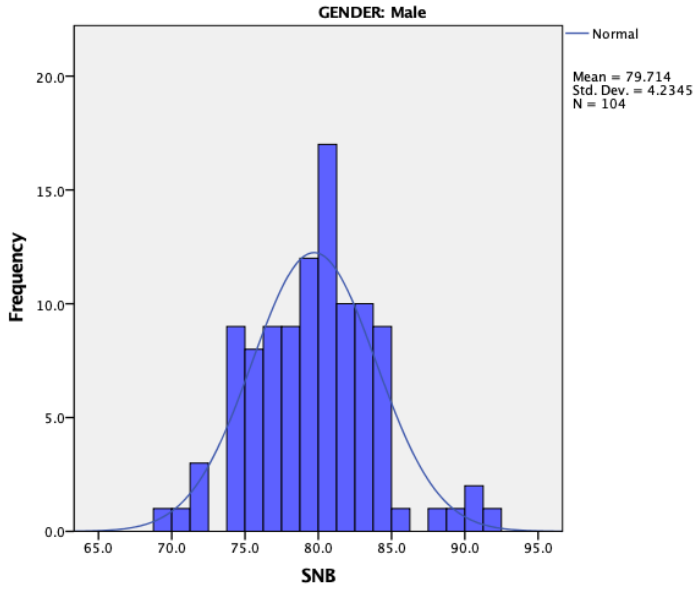


Figure 9.6 Histogram and normality curve for SNB for boys

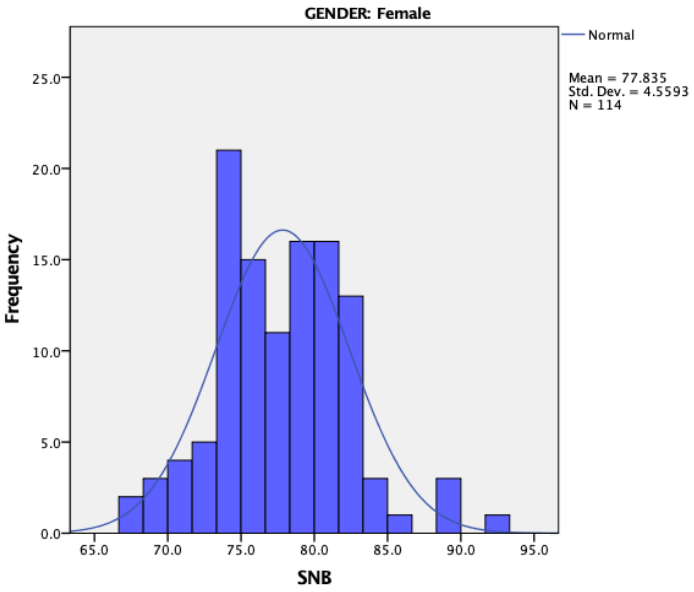


Figure 9.7 Histogram and normality curve for SNB for girls

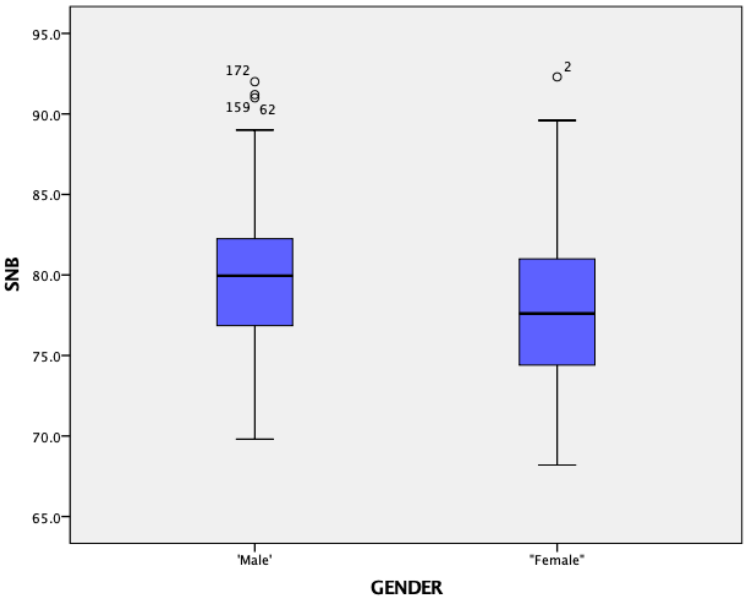


Figure 9.8 Box plots for SNB by gender

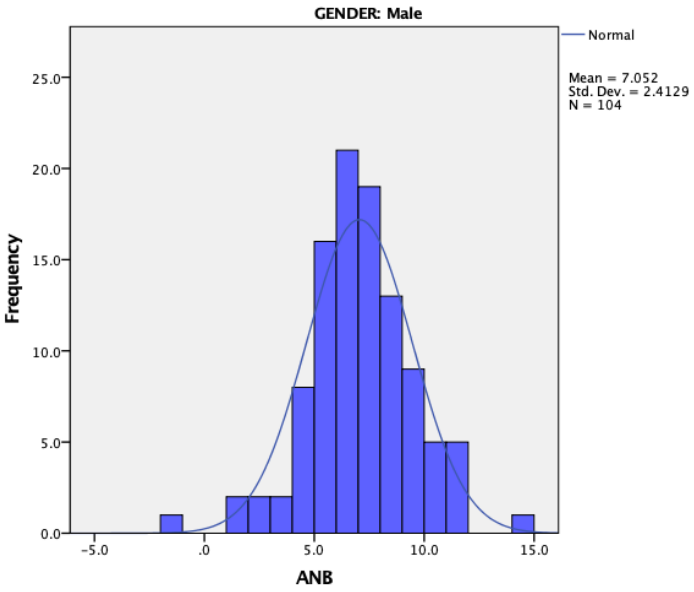


Figure 9.9 Histogram and normality curve for ANB for boys

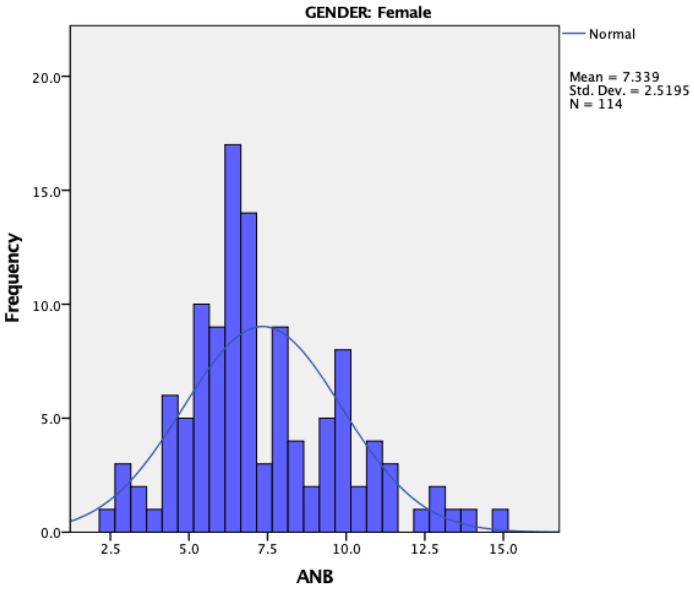


Figure 9.10 Histogram and normality curve for ANB for girls

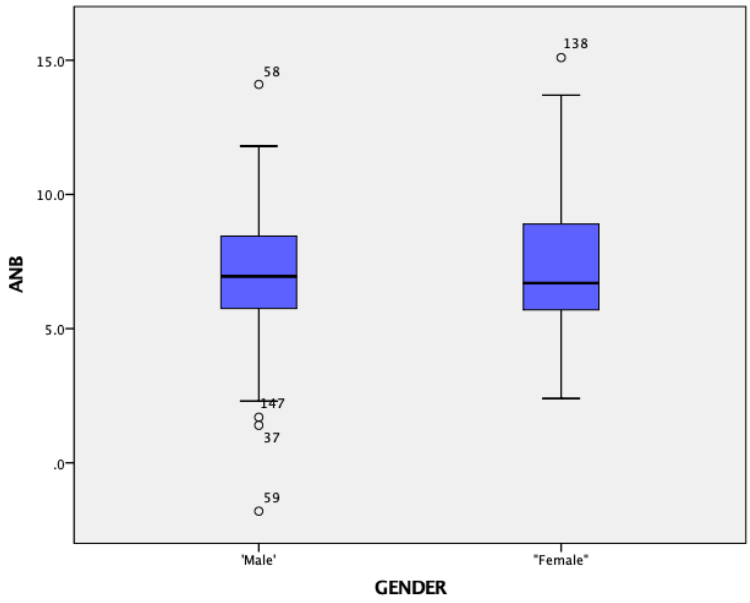


Figure 9.11 Box plots for ANB by gender

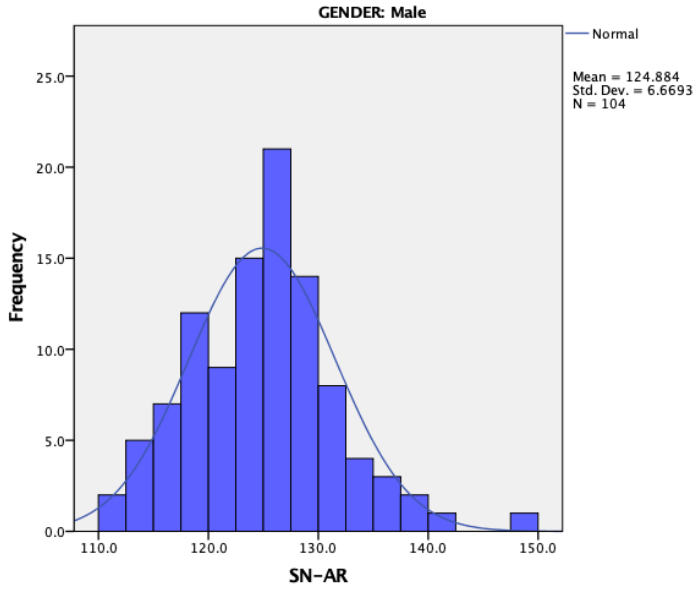


Figure 9.12 Histogram and normality curve for SN-AR for boys

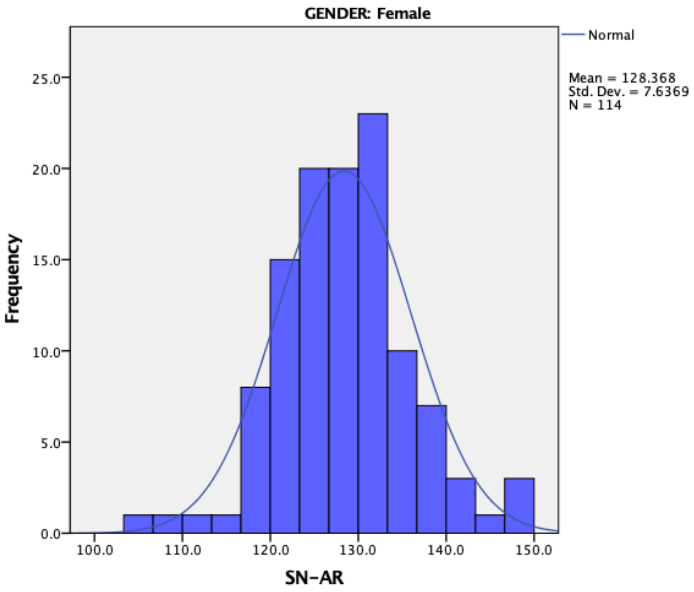


Figure 9.13 Histogram and normality curve for SN-AR for girls

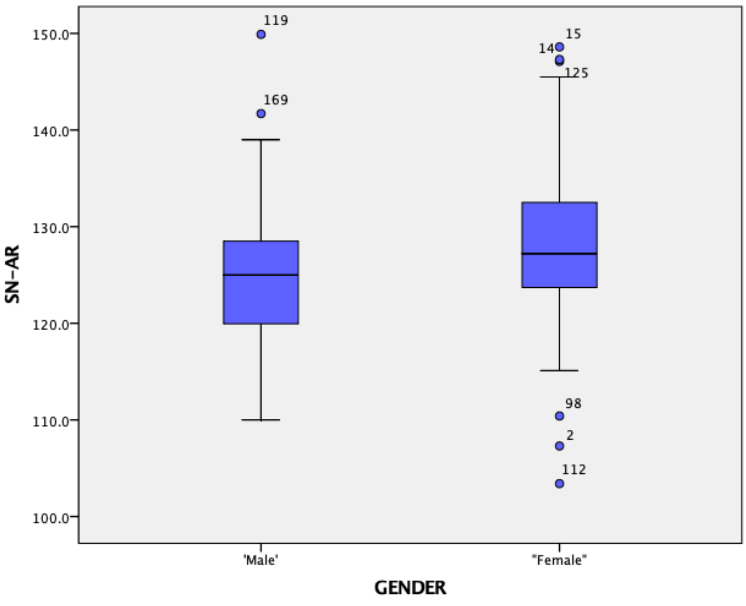


Figure 9.14 Box plots for SN-AR by gender

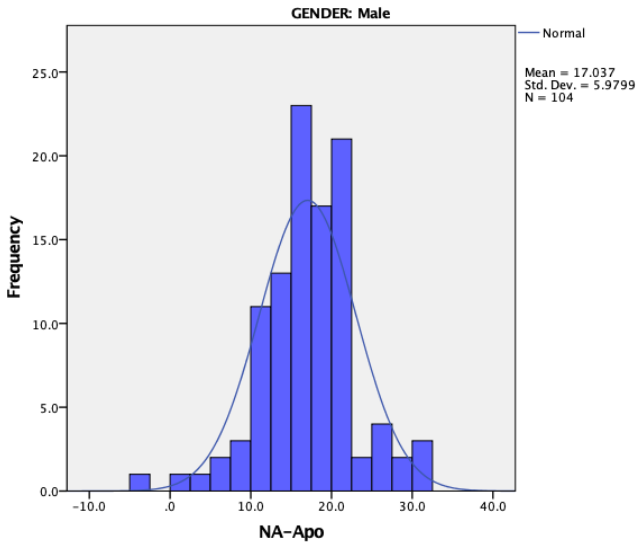


Figure 9.15 Histogram and normality curve for NA-Apo for boys

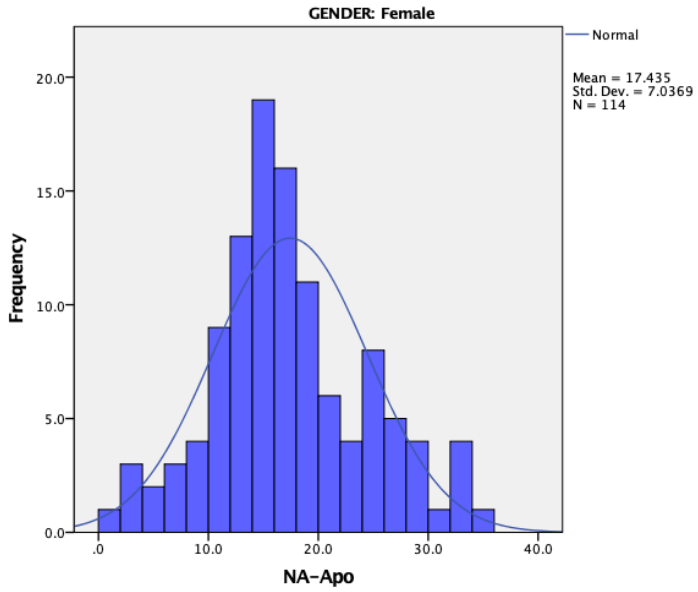


Figure 9.16 Histogram and normality curve for NA-Apo for girls

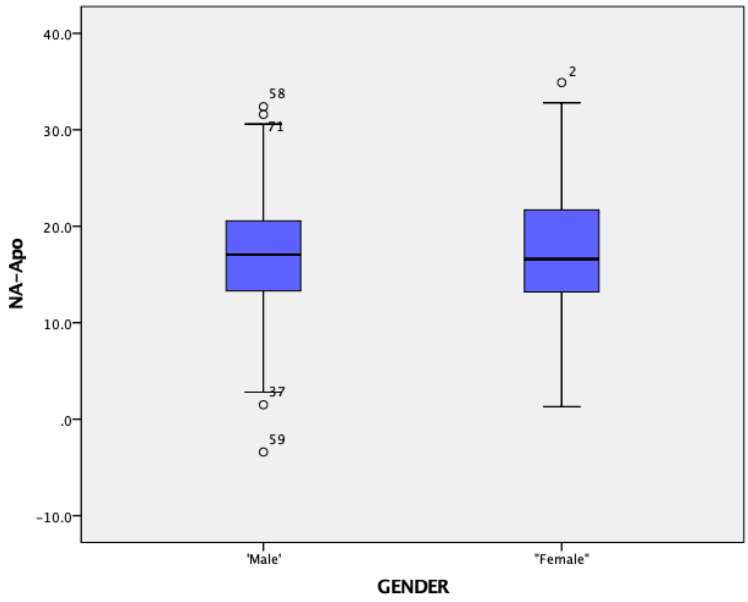


Figure 9.17 Box plots for NA-Apo by gender

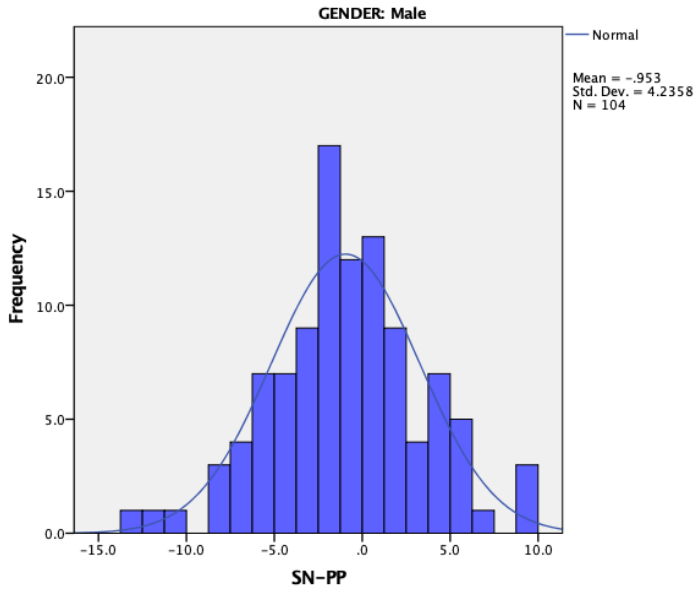


Figure 9.18 Histogram and normality curve for SN-PP for boys

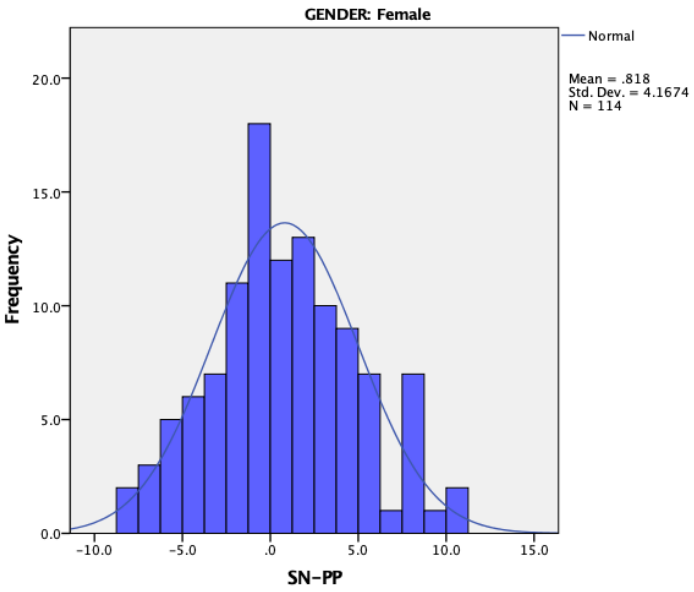


Figure 9.19 Histogram and normality curve for SN-PP for girls

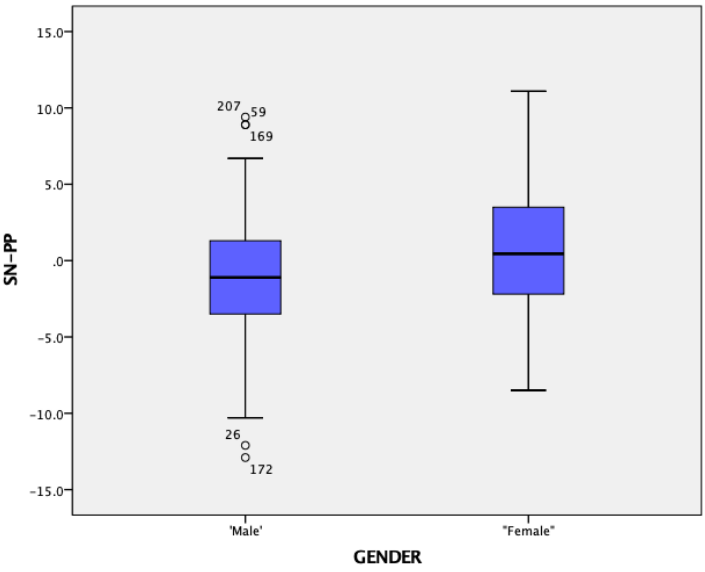


Figure 9.20 Box plots for SN-PP by gender

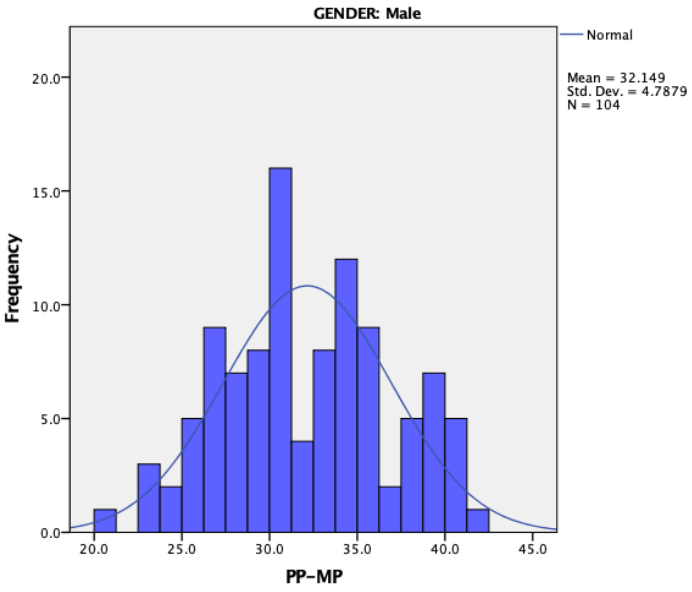


Figure 9.21 Histogram and normality curve for PP-MP for boys

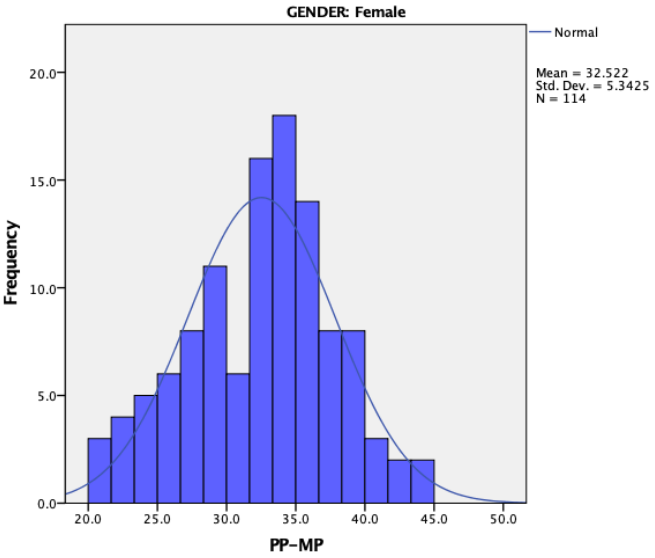


Figure 9.22 Histogram and normality curve for PP-MP for girls

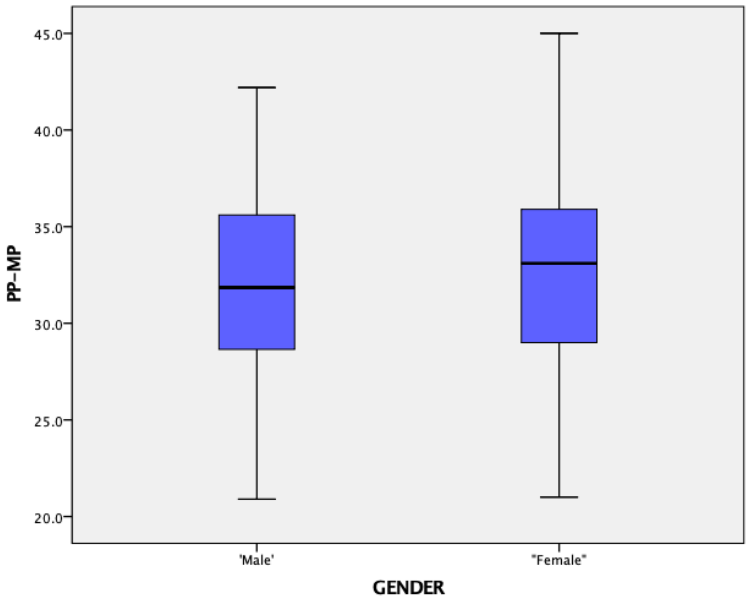


Figure 9.23 Box plots for PP-MP by gender

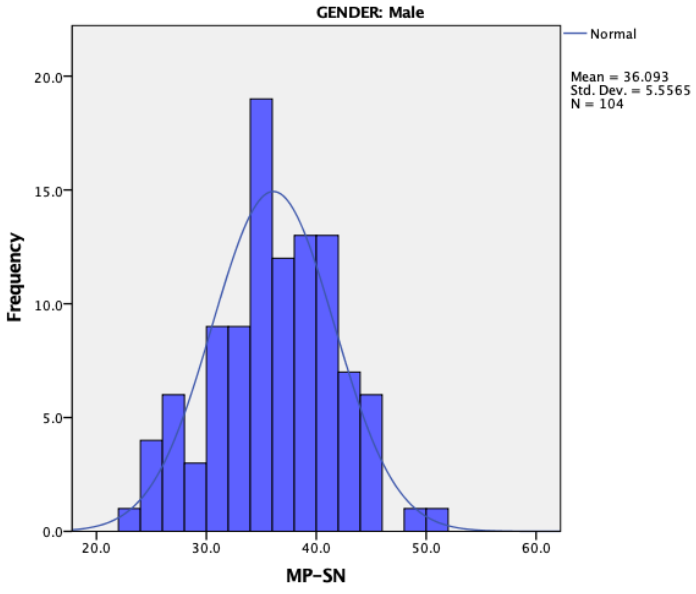


Figure 9.24 Histogram and normality curve for MP-SN for boys

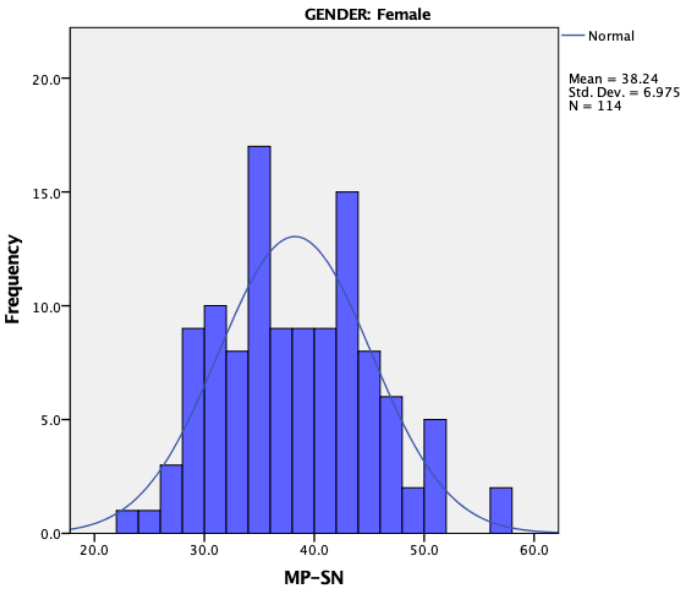


Figure 9.25 Histogram and normality curve for MP-SN for girls

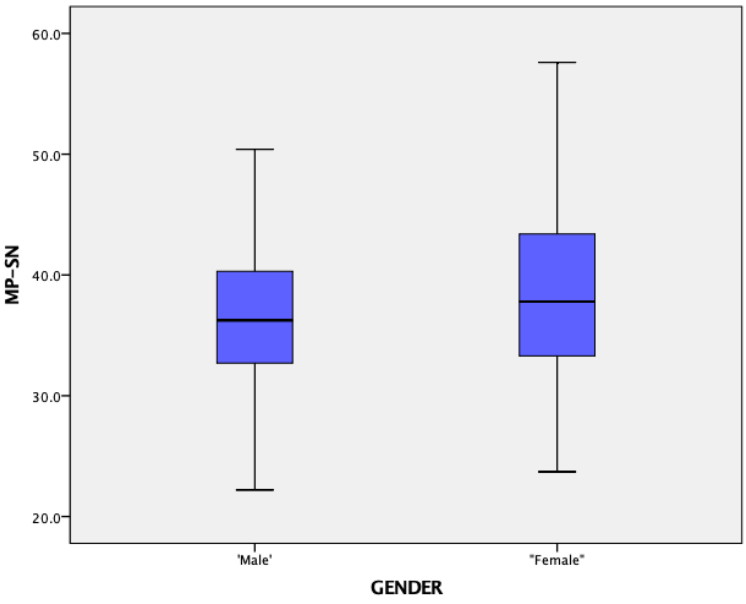


Figure 9.26 Box plots for MP-SN by gender

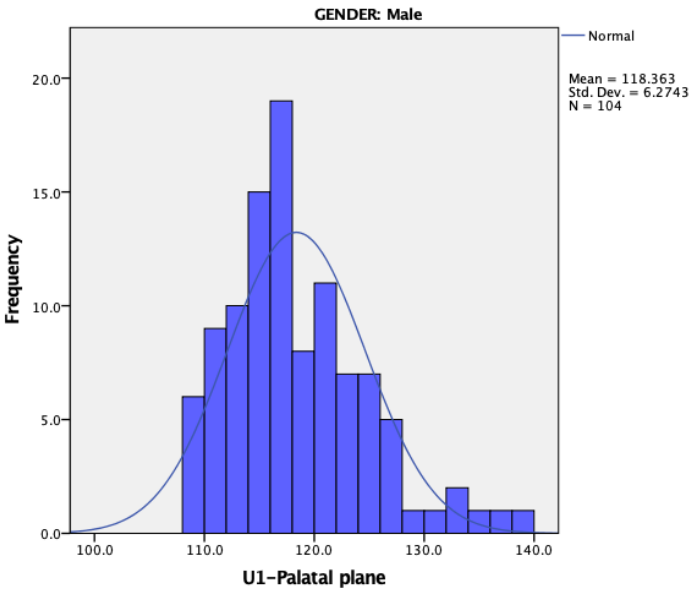


Figure 9.27 Histogram and normality curve for U1- Palatal plane for boys

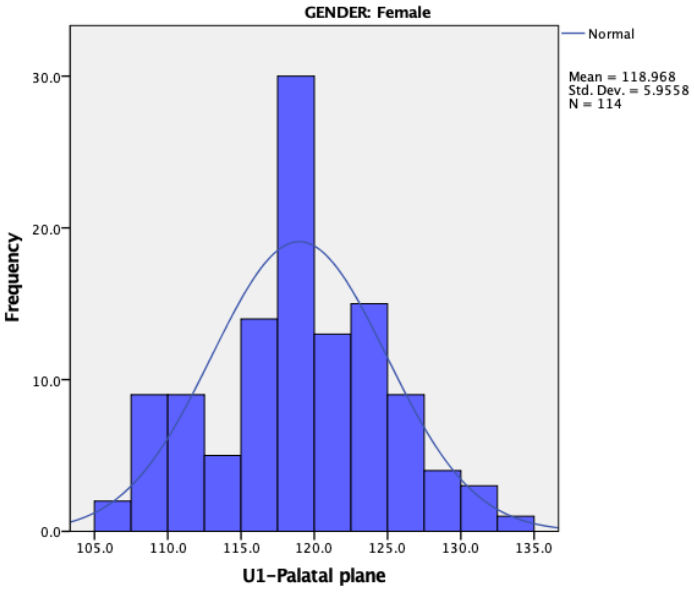


Figure 9.28 Histogram and normality curve for U1- Palatal plane for girls

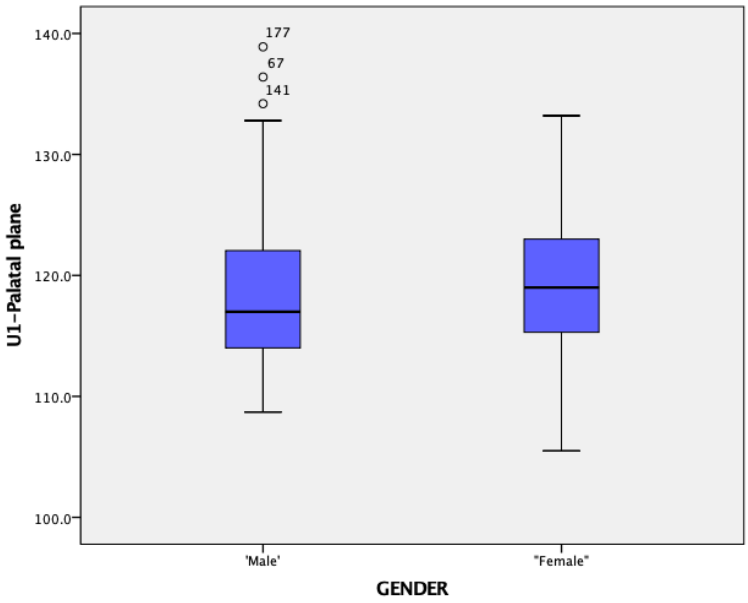


Figure 9.29 Box plots for U1- Palatal plane by gender

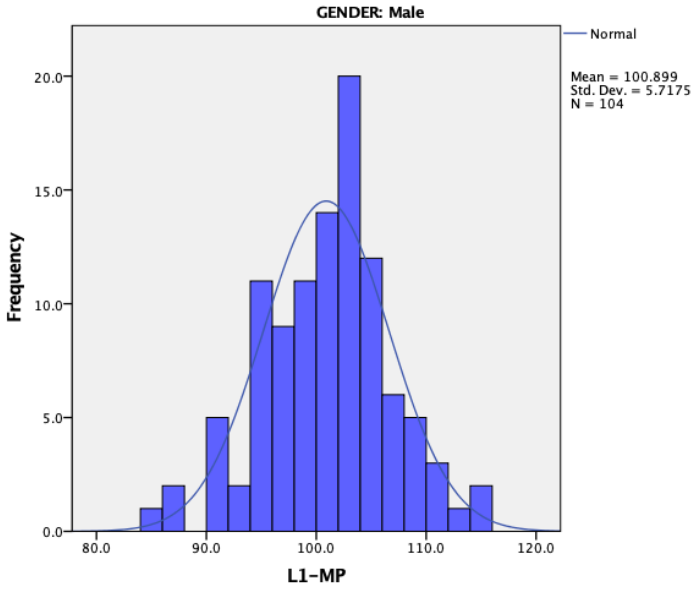


Figure 9.30 Histogram and normality curve for L1- Mandibular plane for boys

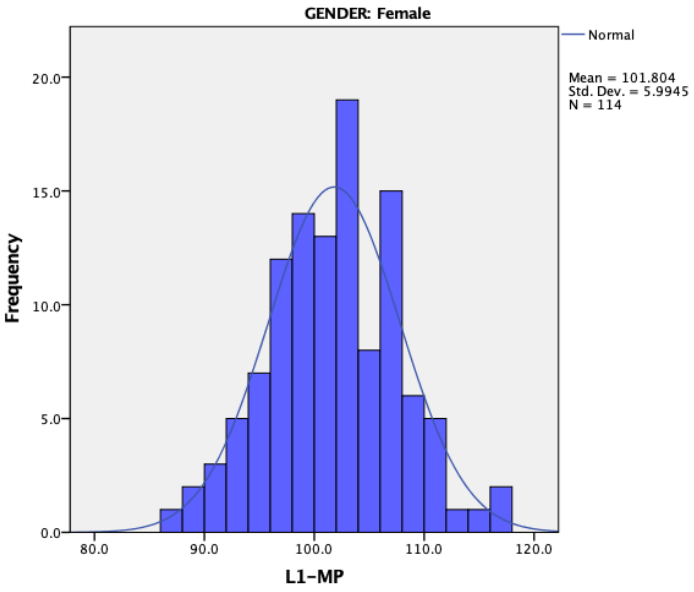


Figure 9.31 Histogram and normality curve for L1- Mandibular plane for girls

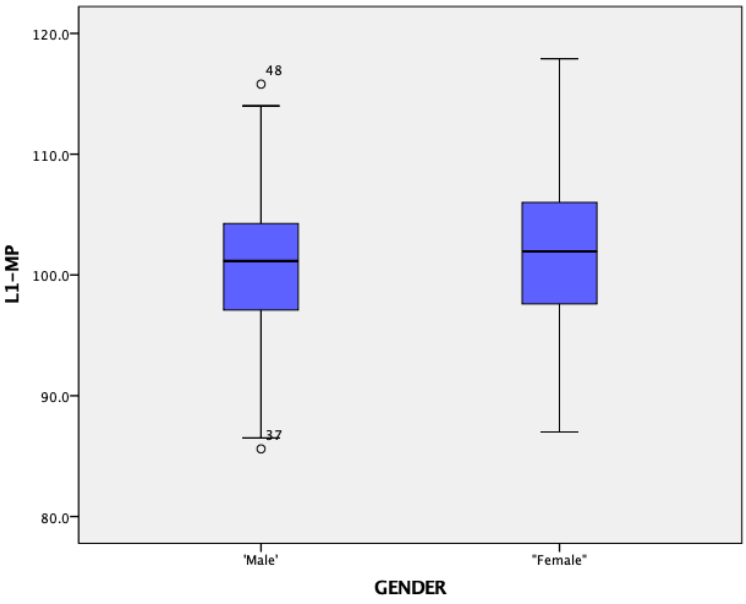


Figure 9.32 Box plots for L1- Mandibular plane by gender

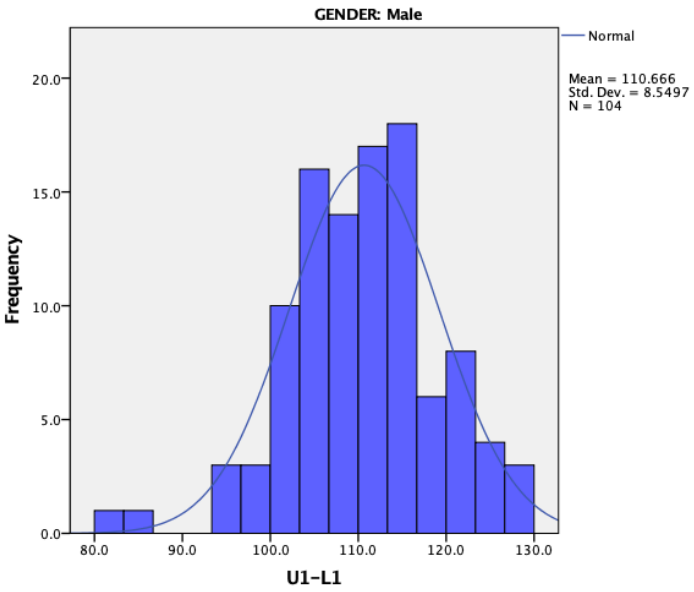


Figure 9.33 Histogram and normality curve for U1- L1 for boys

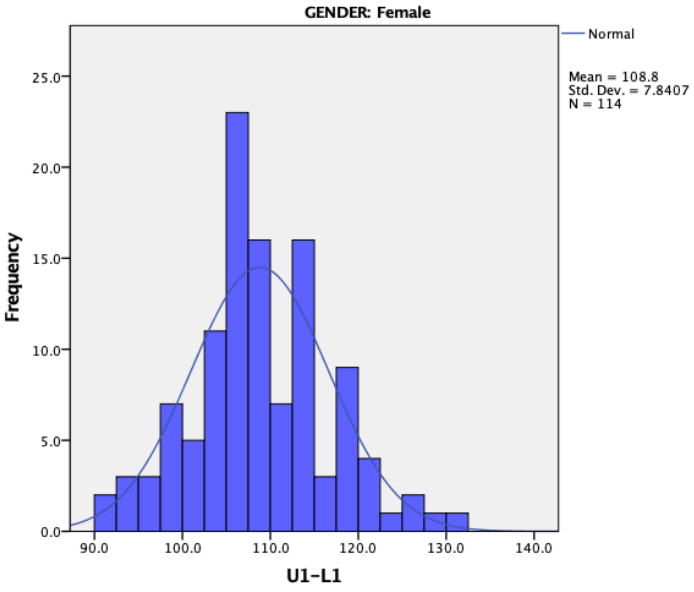


Figure 9.34 Histogram and normality curve for U1- L1for girls

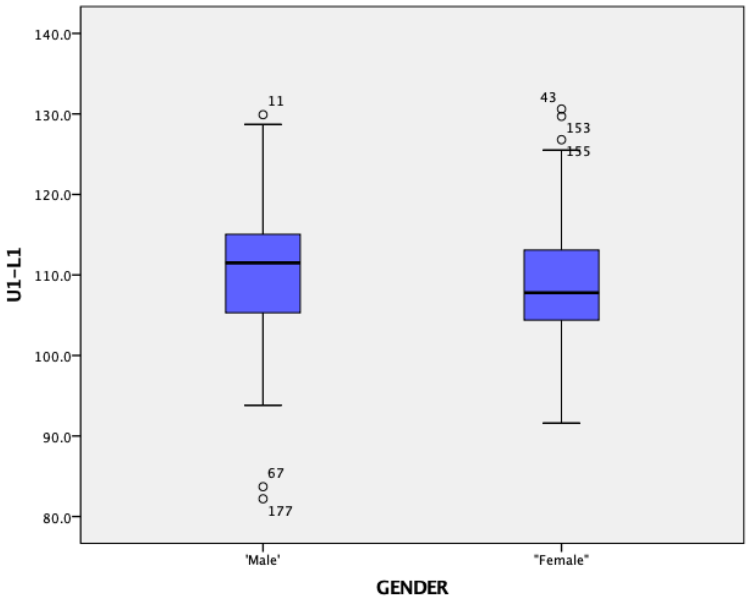


Figure 9.35 Box plots for U1- L1by gender

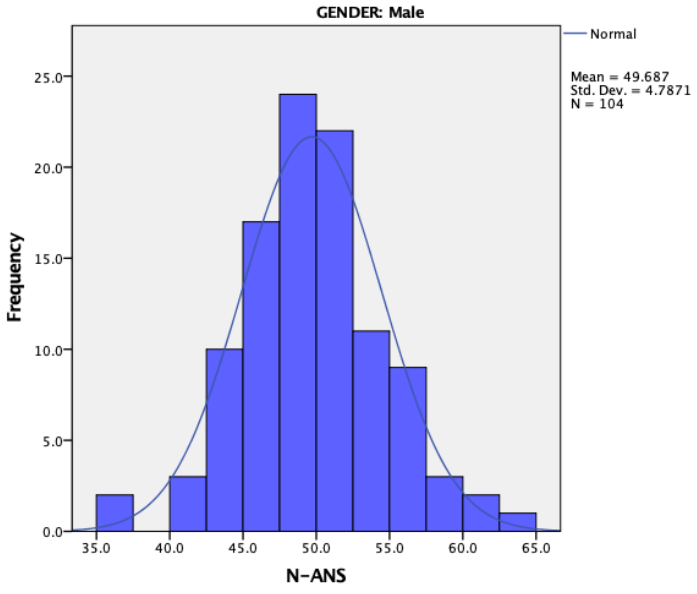


Figure 9.36 Histogram and normality curve for N-ANS for boys

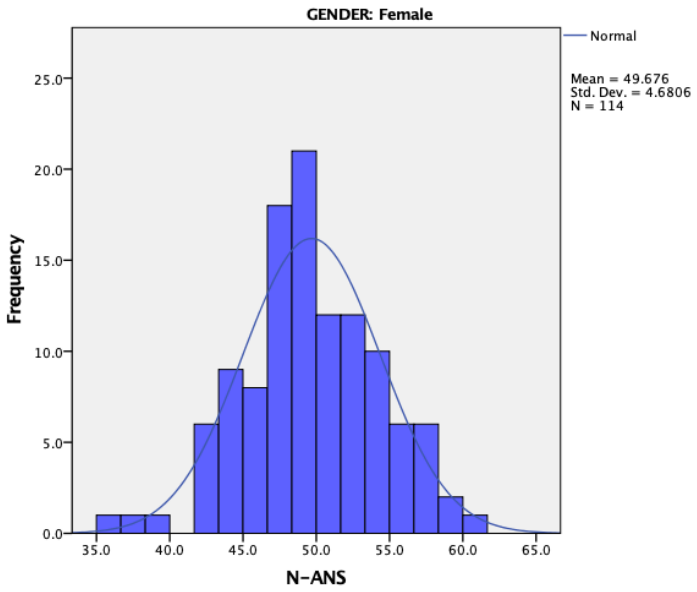


Figure 9.37 Histogram and normality curve for N-ANS for girls

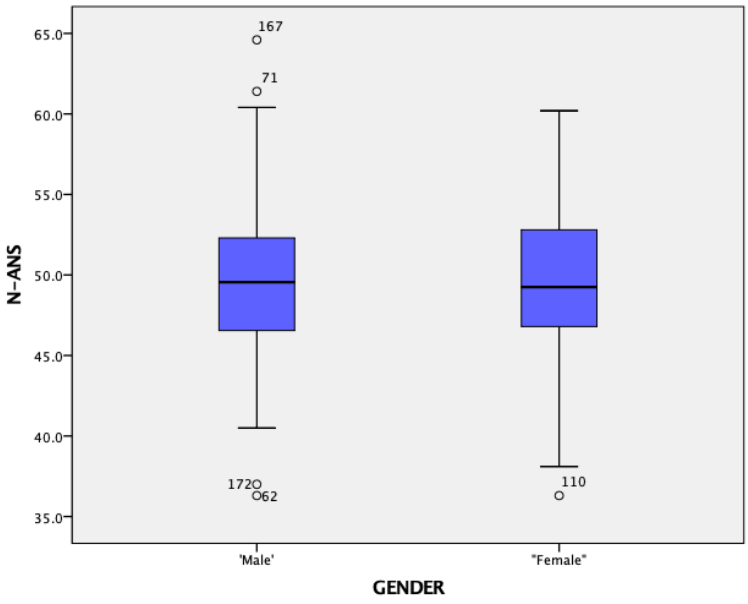


Figure 9.38 Box plots for N-ANS by gender

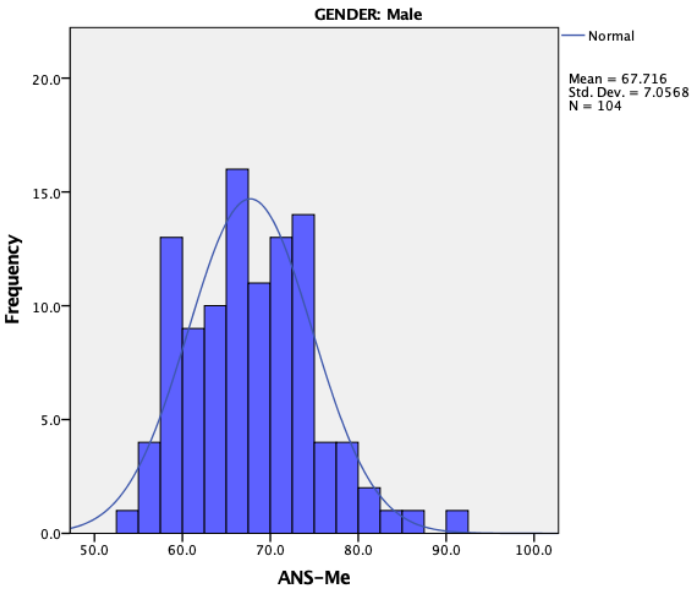


Figure 9.39 Histogram and normality curve for ANS- Me for boys

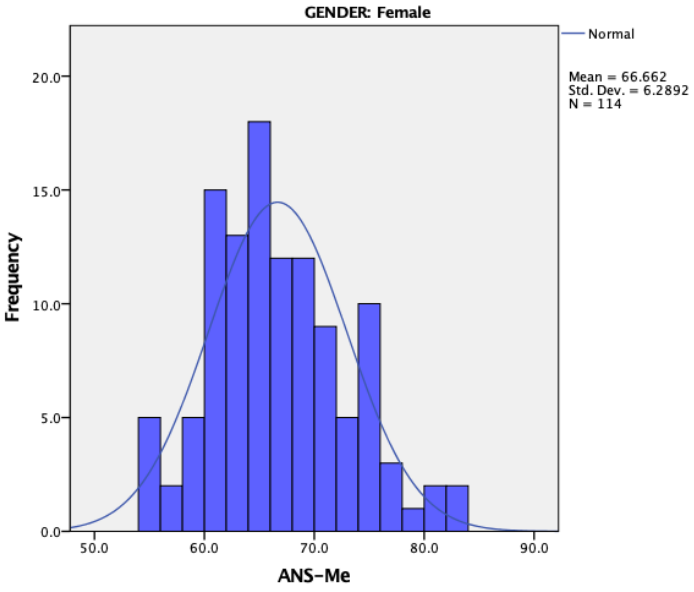


Figure 9.40 Histogram and normality curve for ANS- Me for girls

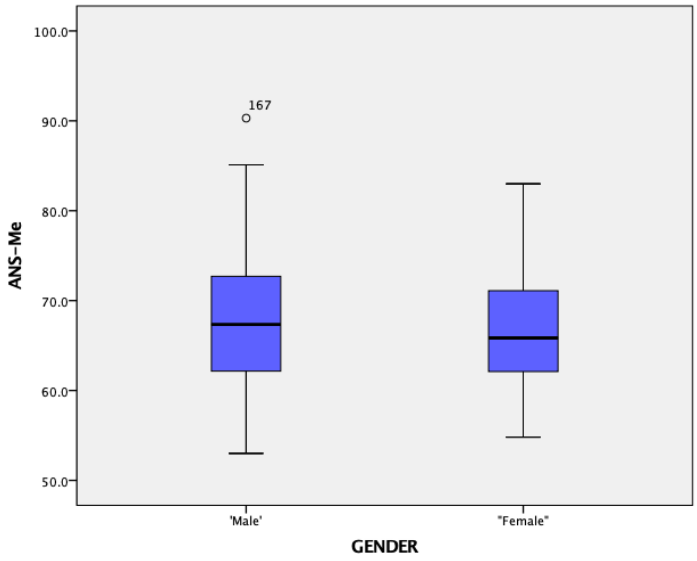


Figure 9.41 Box plots for ANS-Me by gender

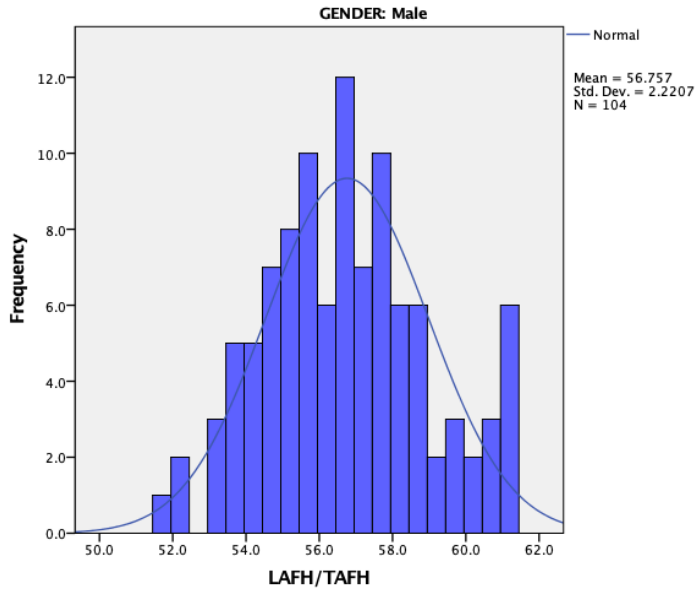


Figure 9.42 Histogram and normality curve for LAFH/TAFH for boys

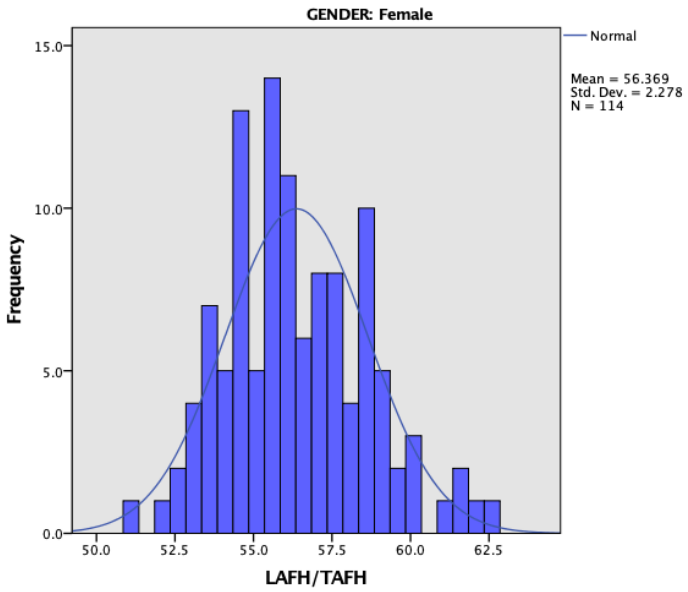


Figure 9.43 Histogram and normality curve for LAFH/TAFH for girls

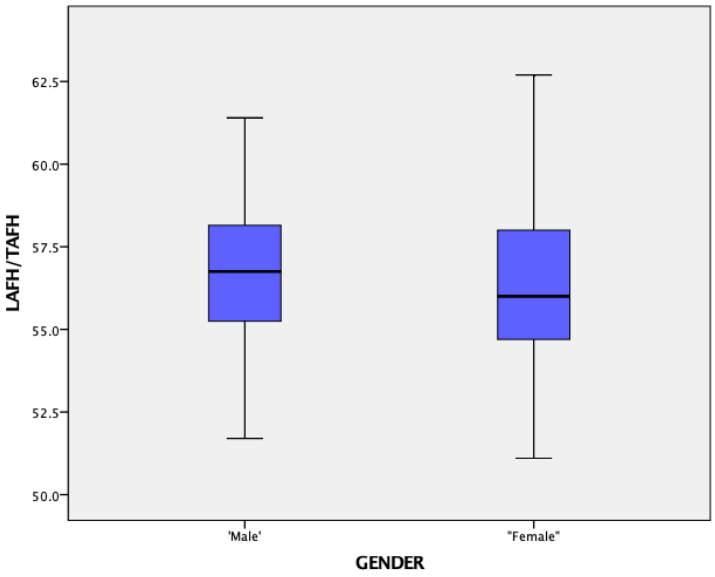


Figure 9.44 Box plots for LAFH/TAFH by gender

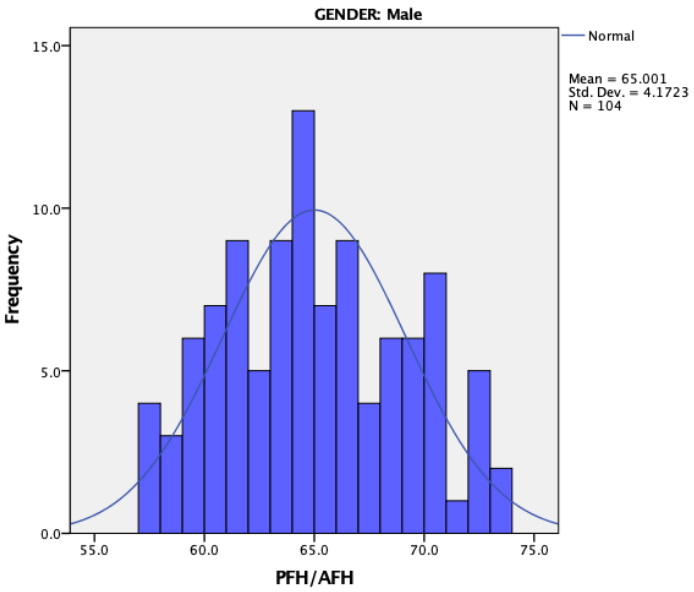


Figure 9.45 Histogram and normality curve for PFH/AFH for boys

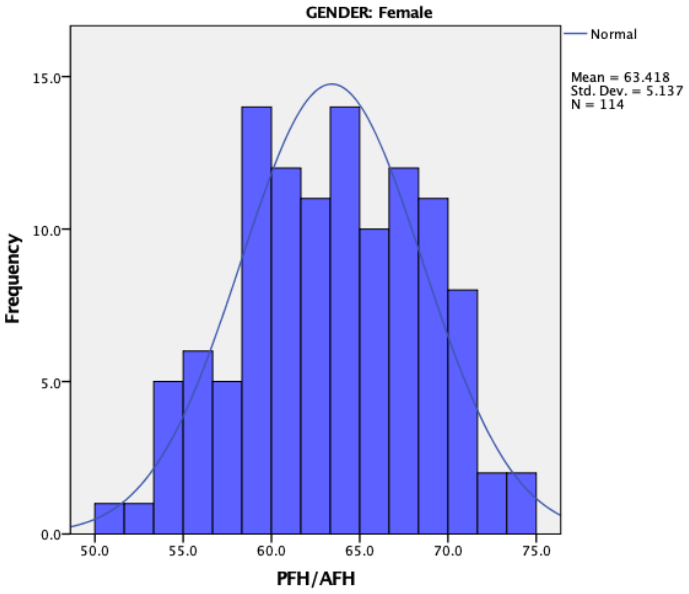


Figure 9.46 Histogram and normality curve for PFH/AFH for girls

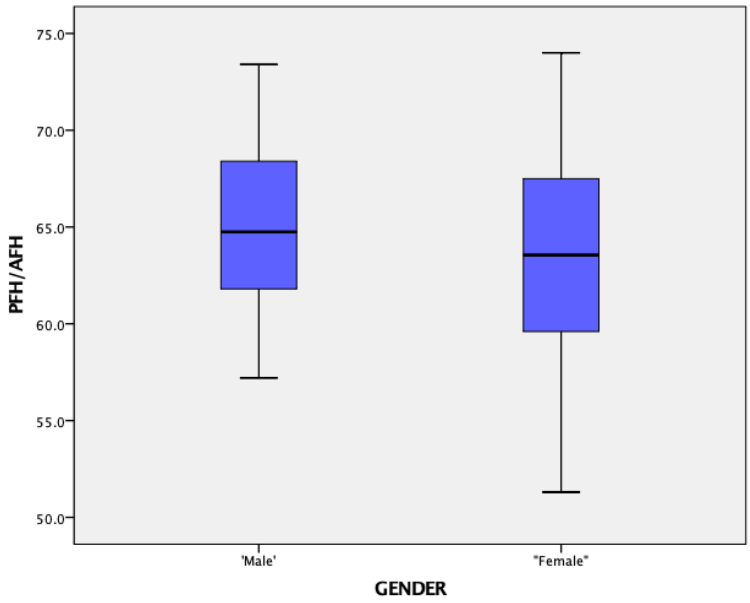


Figure 9.47 Box plots for PFH/AFH by gender

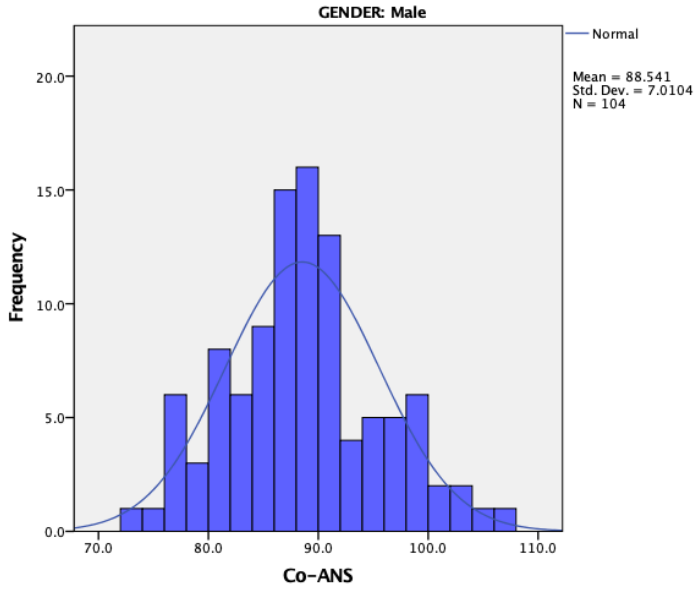


Figure 9.48 Histogram and normality curve for Co-ANS for boys

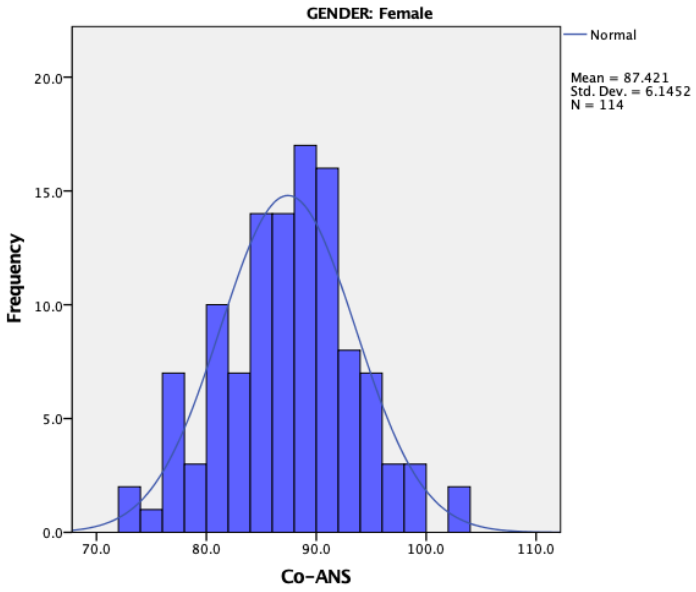


Figure 9.49 Histogram and normality curve for Co-ANS for girls

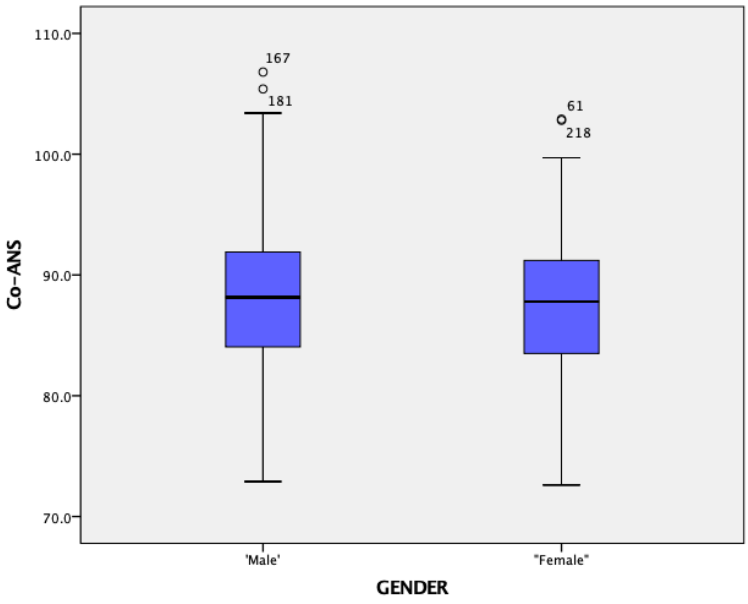


Figure 9.50 Box plots for Co-ANS by gender

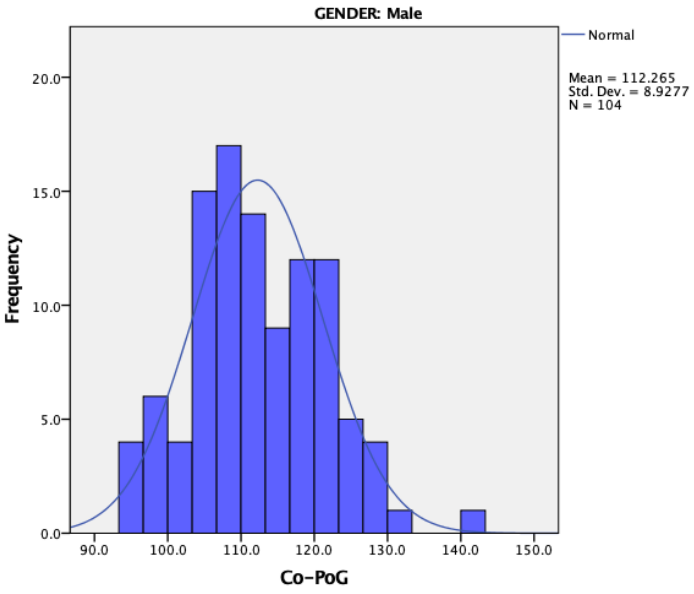


Figure 9.51 Histogram and normality curve for Co-Pog for boys

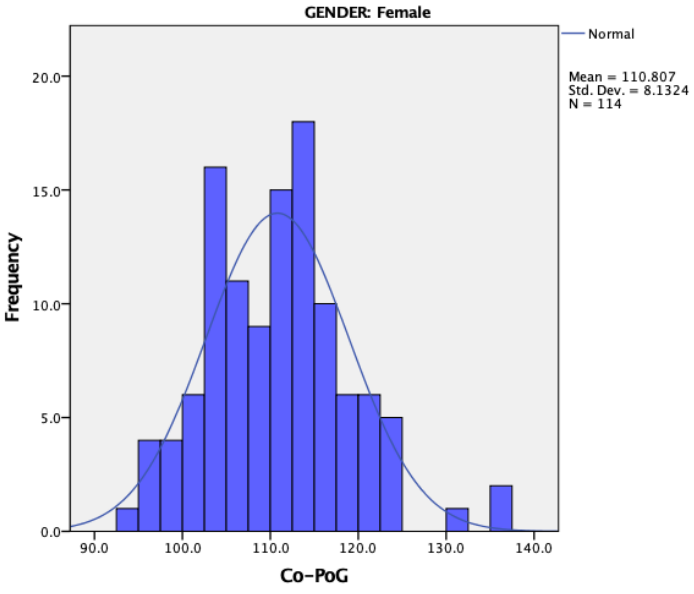


Figure 9.52 Histogram and normality curve for Co-Pog for girls

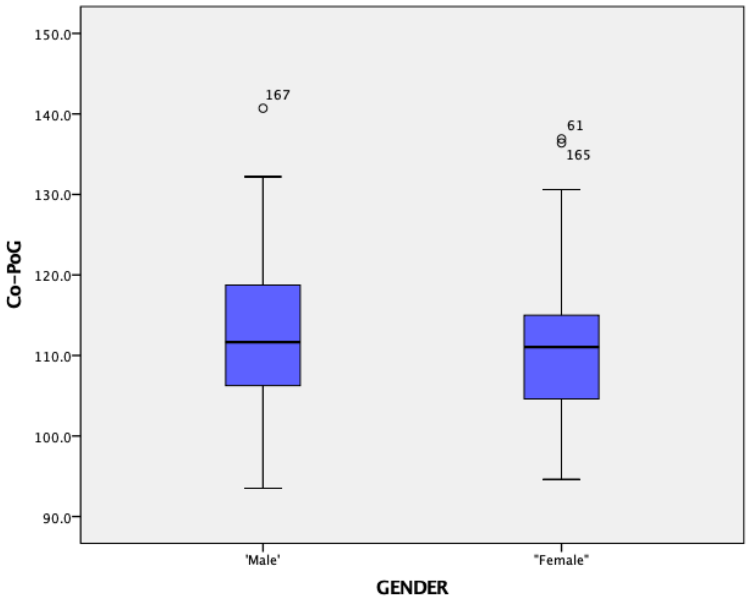


Figure 9.53 Box plots for Co-Pog by gender

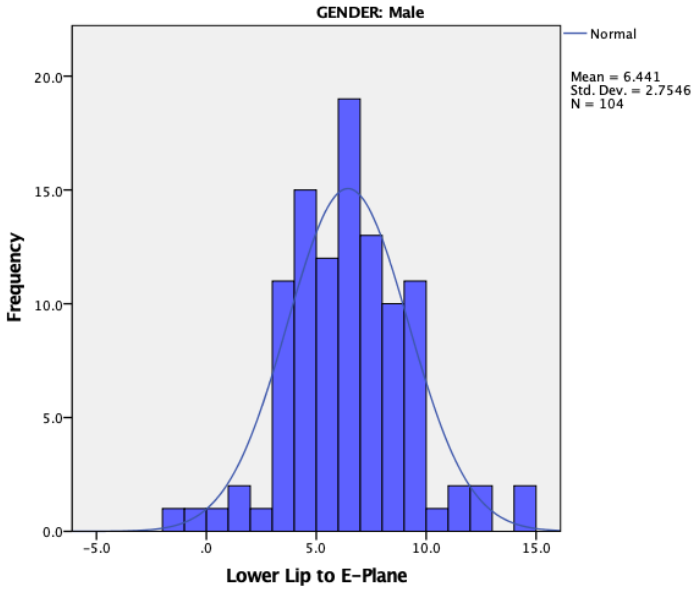


Figure 9.54 Histogram and normality curve for Lower Lip to E- Plane for boys

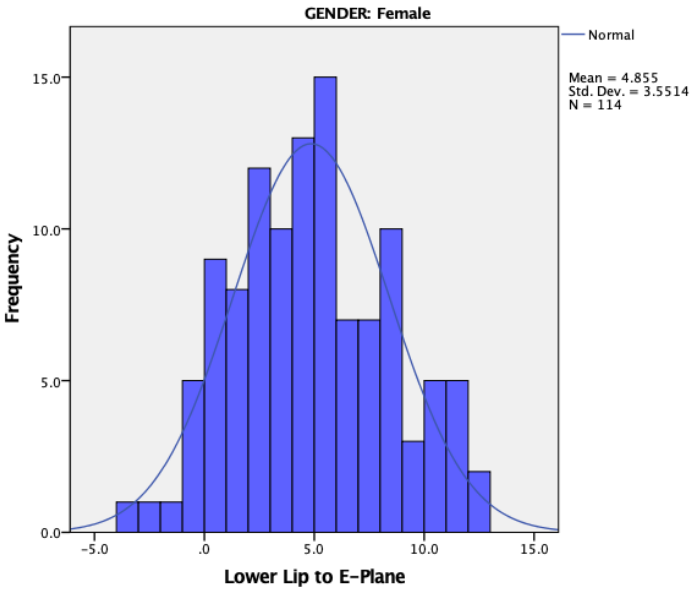


Figure 9.55 Histogram and normality curve for Lower Lip to E- Plane for girls

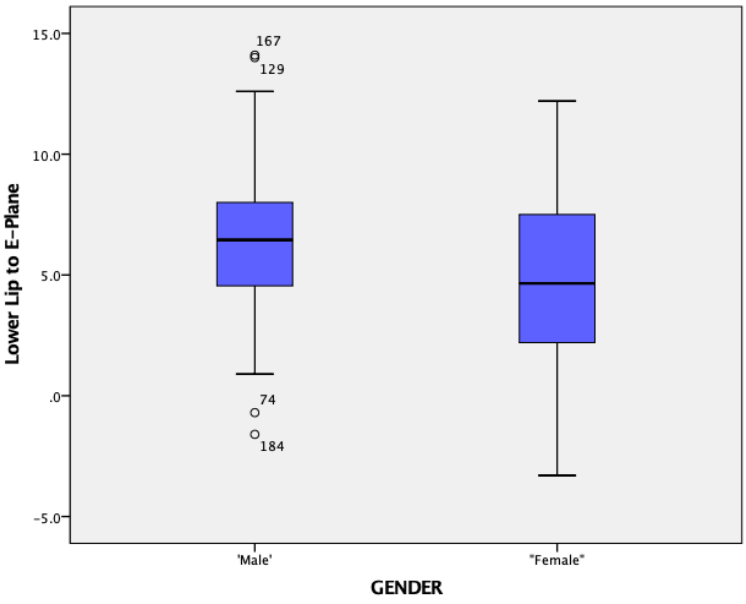


Figure 9.56 Box plots for Lower Lip to E-Plane by gender

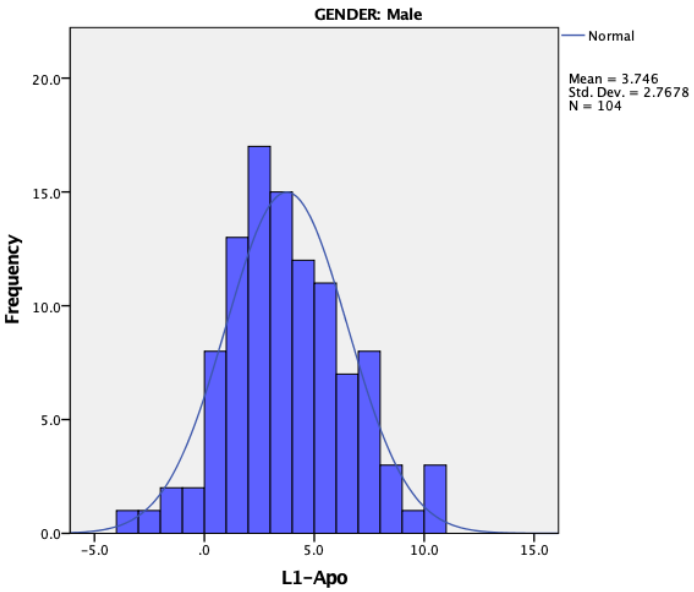


Figure 9.57 Histogram and normality curve for L1-Apo for boys

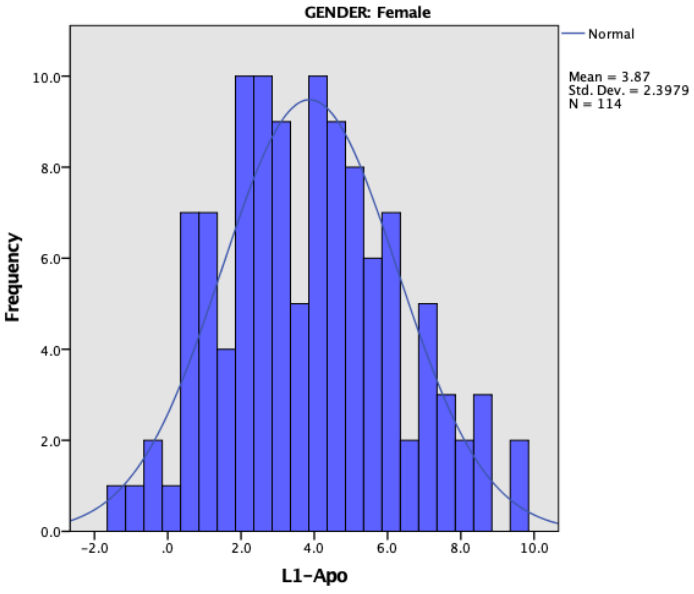


Figure 9.58 Histogram and normality curve for L1-Apo for girls

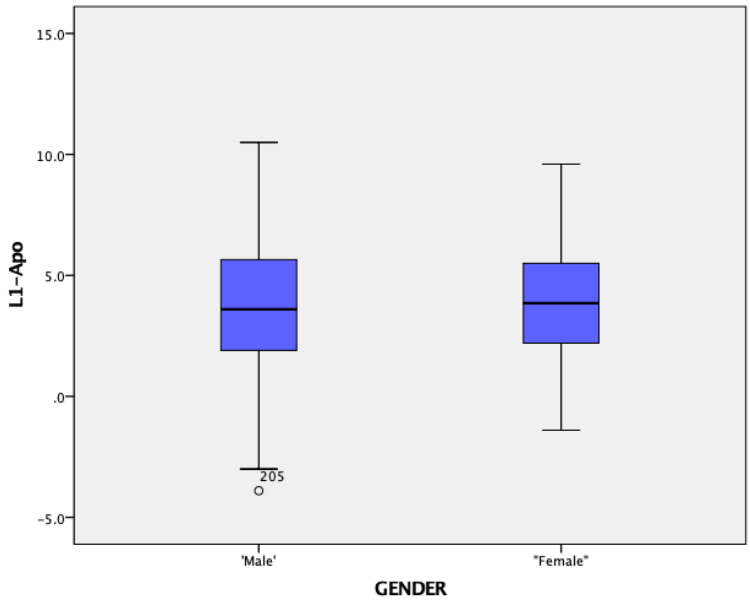


Figure 9.59 Box plots for L1-Apo by gender

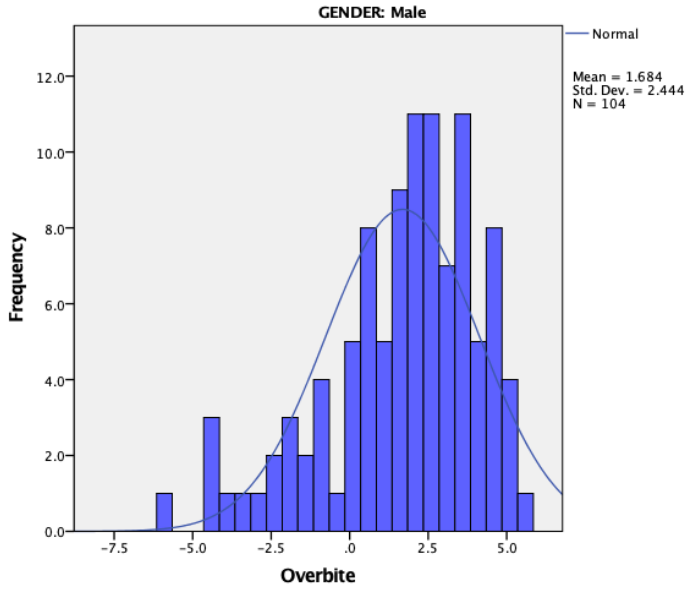


Figure 9.60 Histogram and normality curve for Overbite for boys

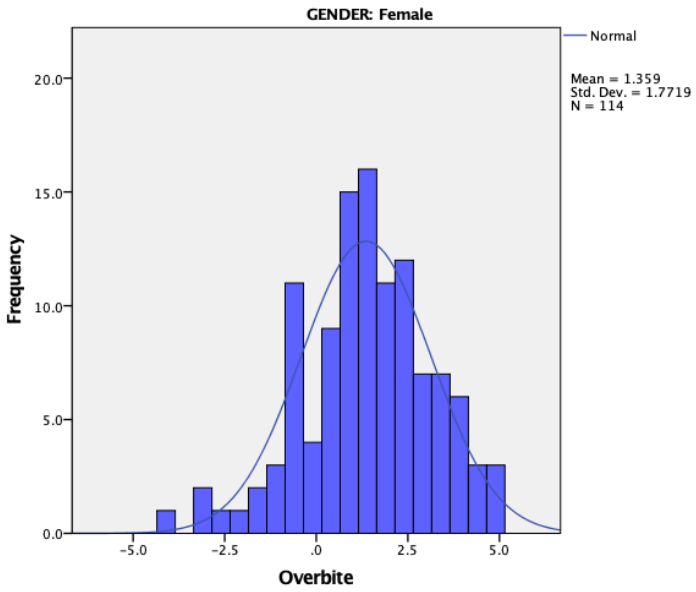


Figure 9.61Histogram and normality curve for Overbite for girls

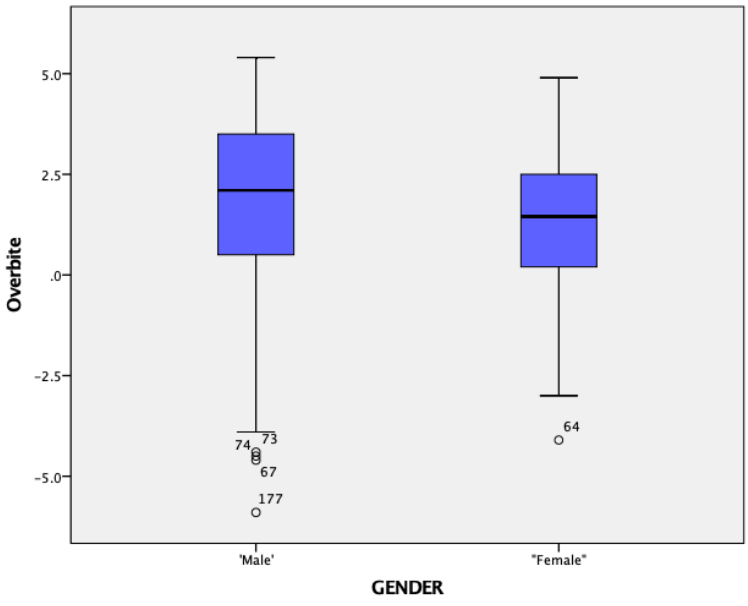


Figure 9.62 Box plots for Overbite by gender

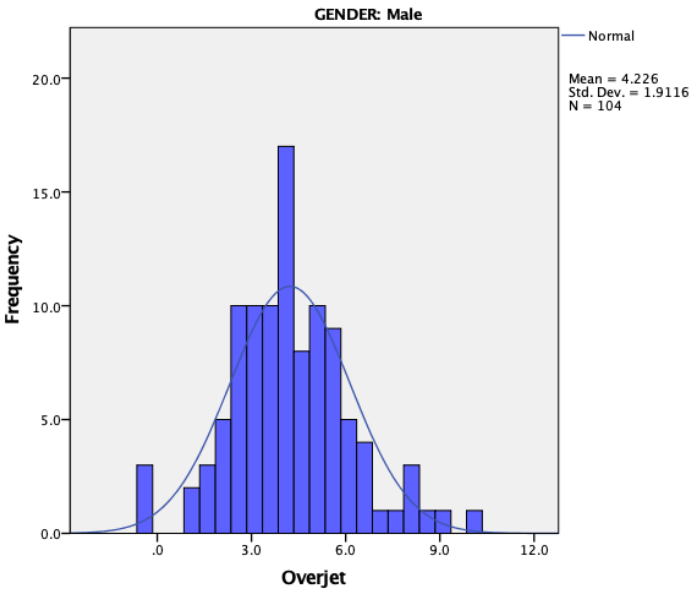


Figure 9.63 Histogram and normality curve for Overjet for boys

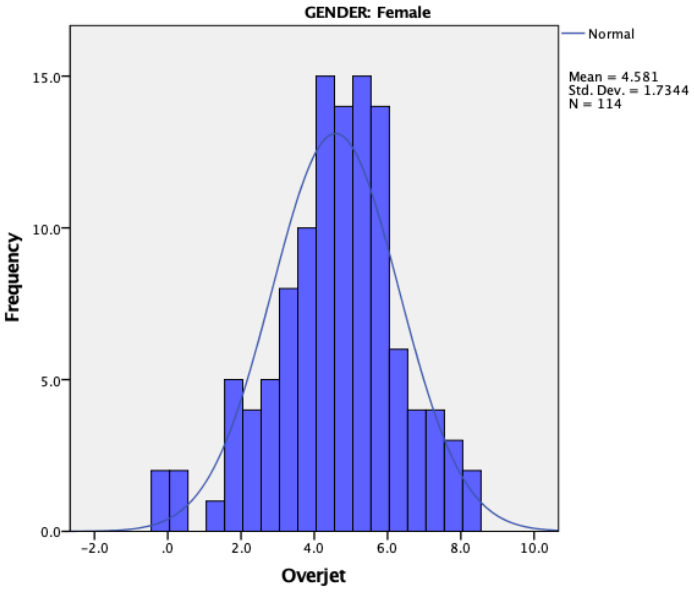


Figure 9.64 Histogram and normality curve for Overjet for girls

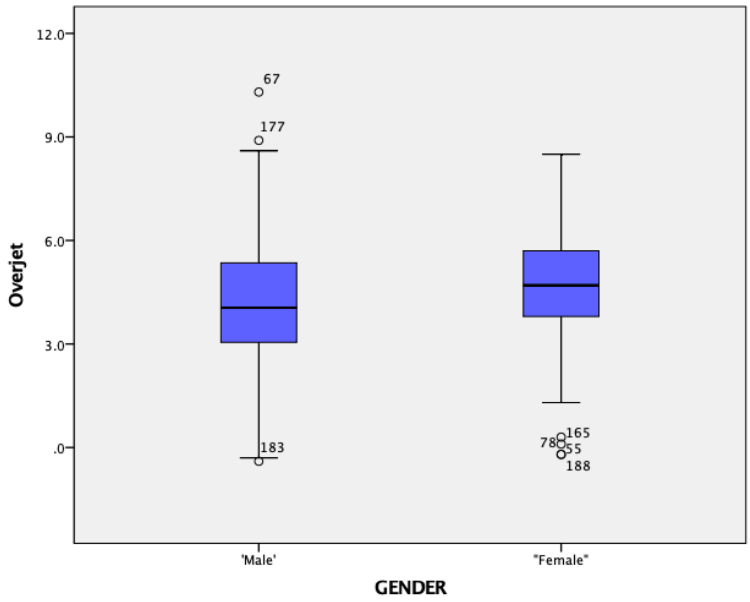


Figure 9.65 Box plots for Overjet by gender

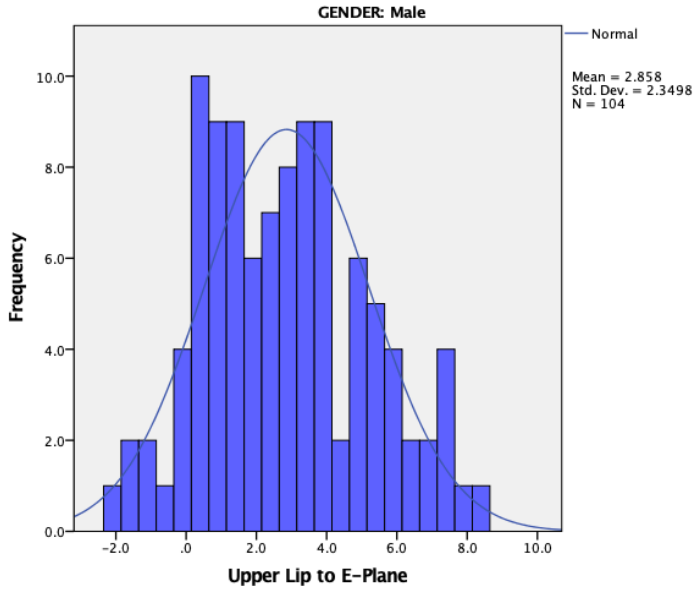


Figure 9.66 Histogram and normality curve for Upper Lip to E-Plane for boys

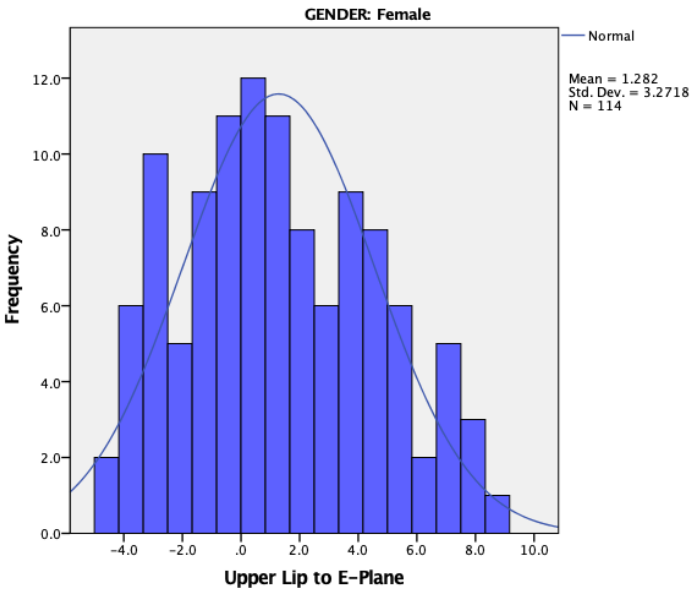


Figure 9.67 Histogram and normality curve for Upper Lip to E-Plane for girls

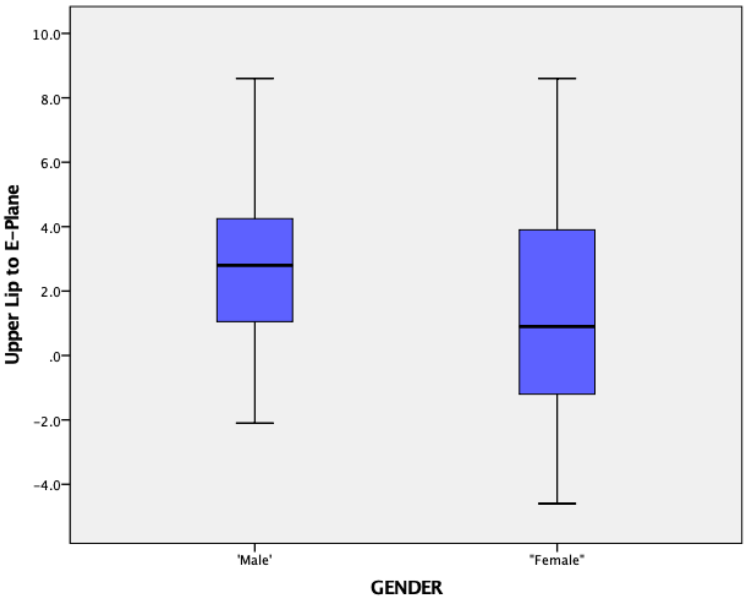


Figure 9.68 Box plots for Upper Lip to E-Plane by gender

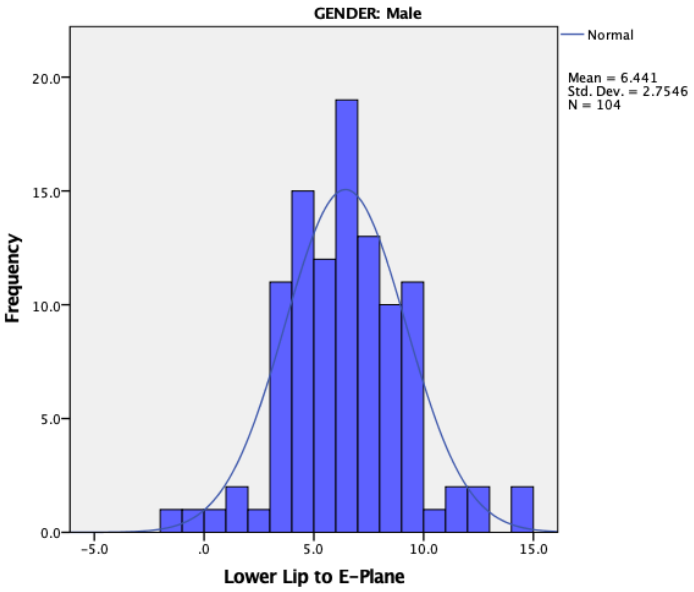


Figure 9.69 Histogram and normality curve for Lower Lip to E-Plane for boys

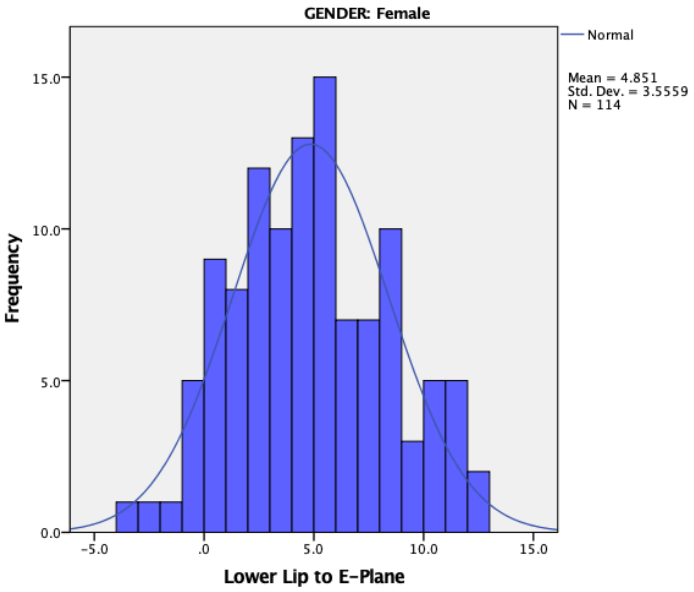


Figure 9.70 Histogram and normality curve for Lower Lip to E-Plane for girls

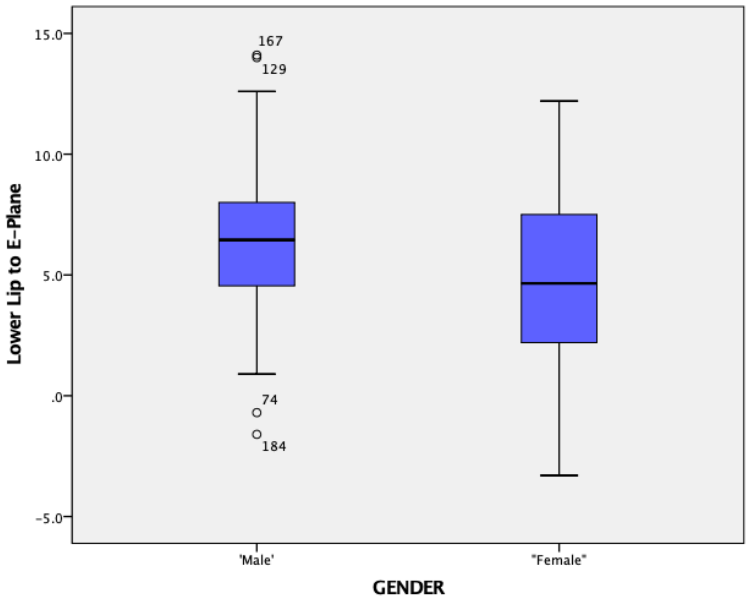


Figure 9.71 Box plots for Lower Lip to E-Plane by gender

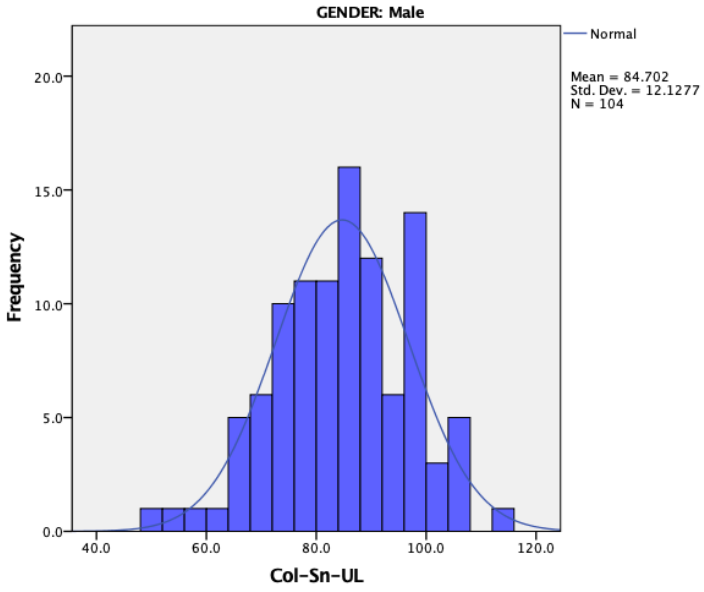


Figure 9.72 Histogram and normality curve for Col-Sn-UL for boys

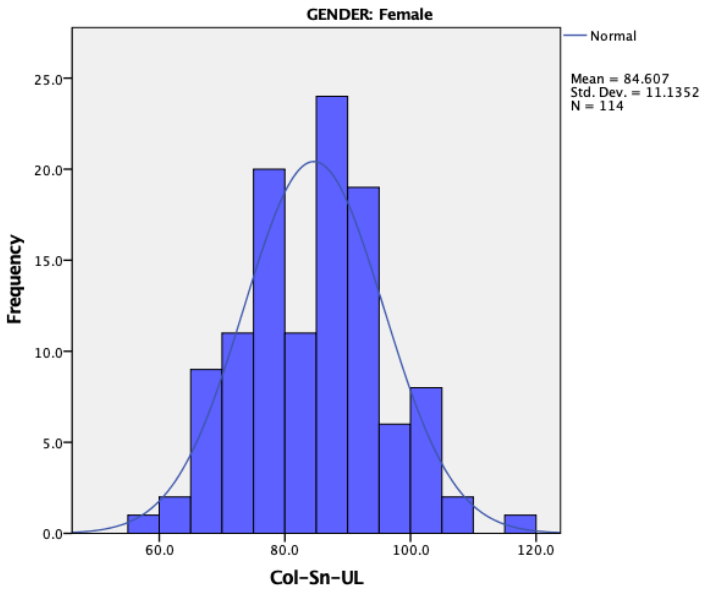


Figure 9.73 Histogram and normality curve for Col-Sn-UL for girls

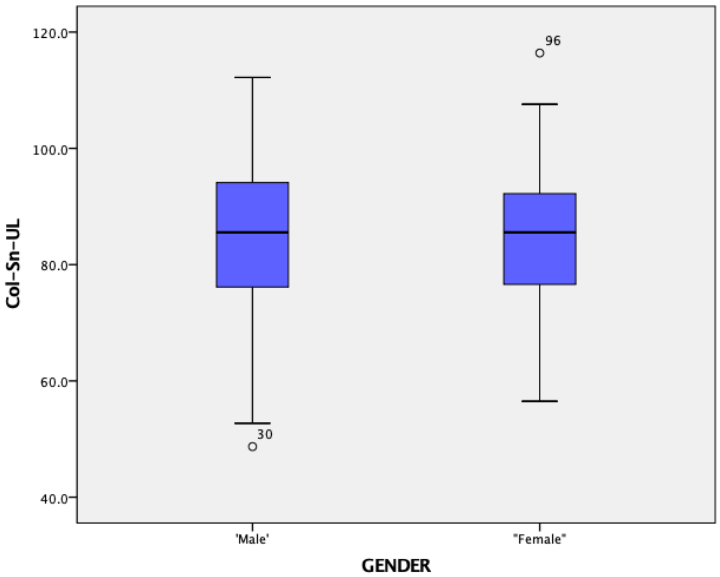


Figure 9.74 Box plots for Col-Sn-UL by gender

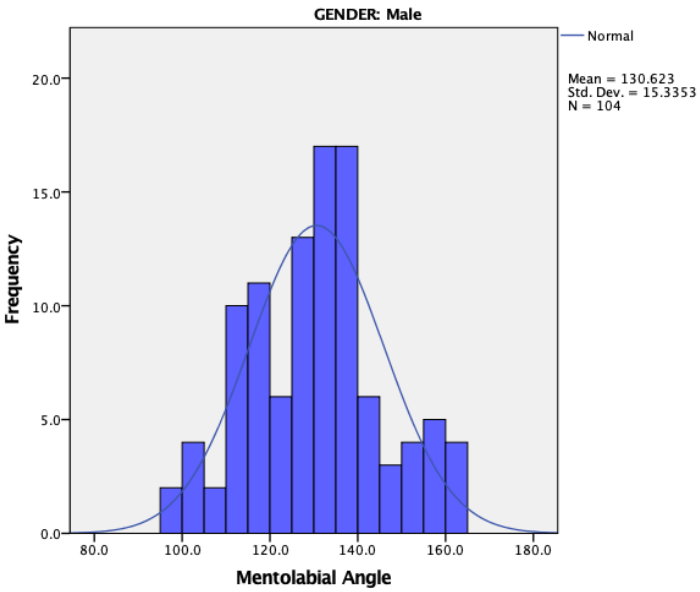


Figure 9.75 Histogram and normality curve for Mentolabial Angle for boys

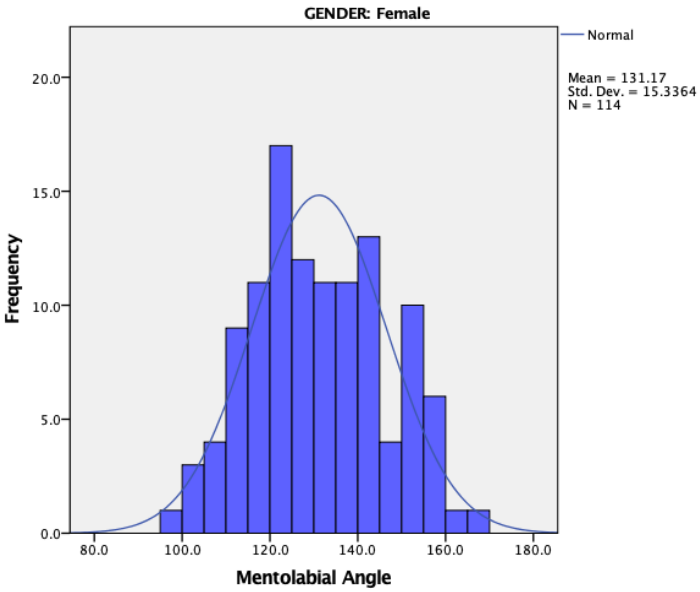


Figure 9.76 Histogram and normality curve for Mentolabial Angle for girls

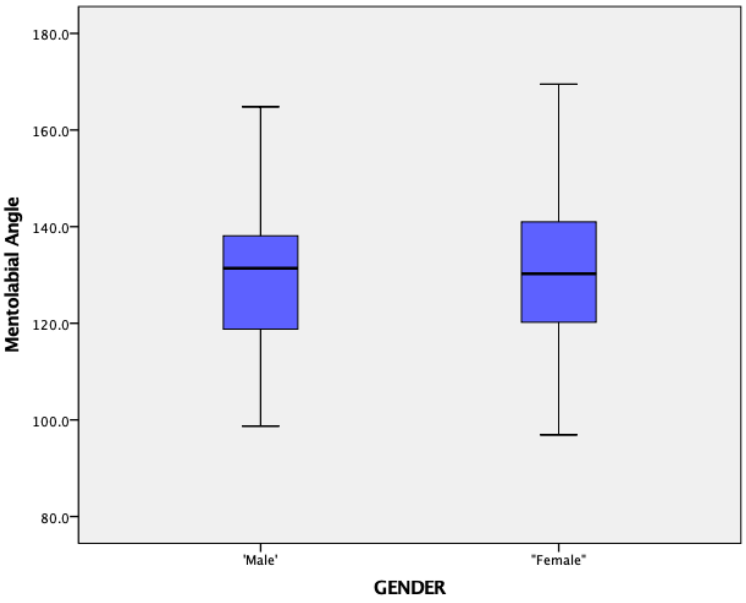


Figure 9.77 Box plots for Mentolabial Angle by gender

Appendix 6: Histogram, normality curves and box plots showing norms for the Trinidad and Tobago population

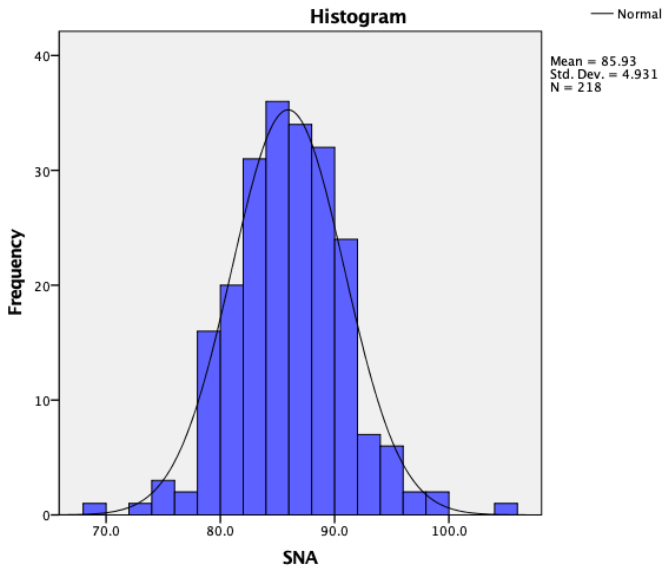


Figure 9.78 Histogram and normality curve for SNA showing norm for bimaxillary protrusion population in Trinidad and Tobago

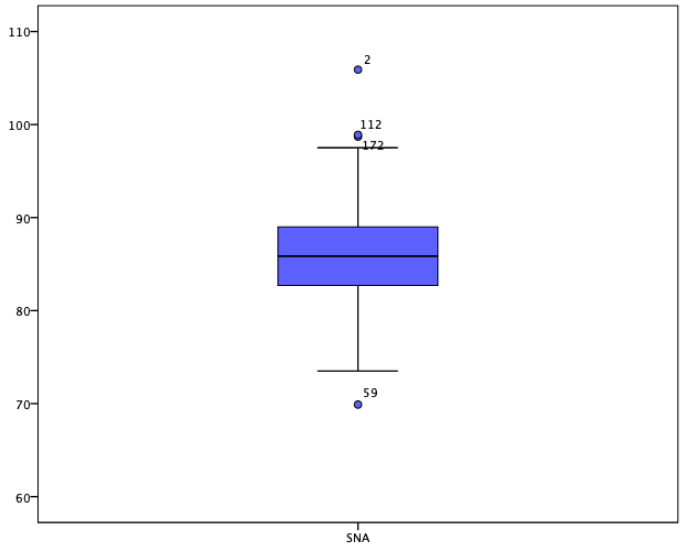


Figure 9.79 Box plot for SNA showing norm for bimaxillary protrusion population in Trinidad and Tobago

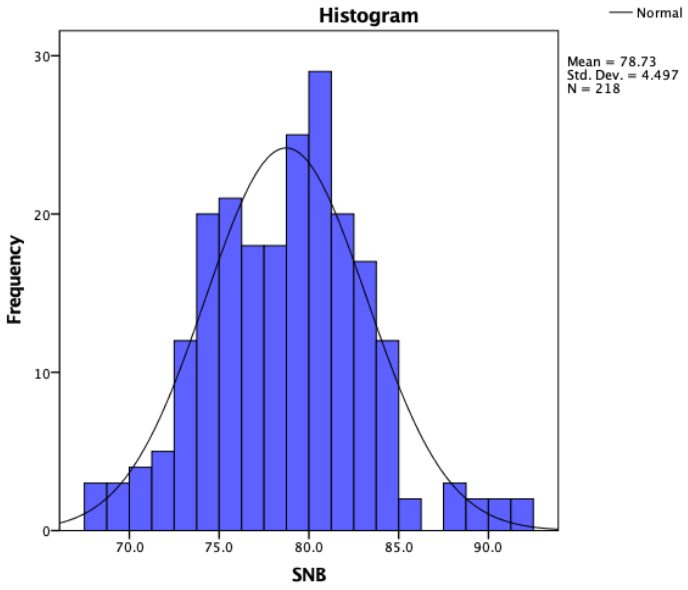


Figure 9.80 Histogram and normality curve for SNB showing norm for bimaxillary protrusion population in Trinidad and Tobago

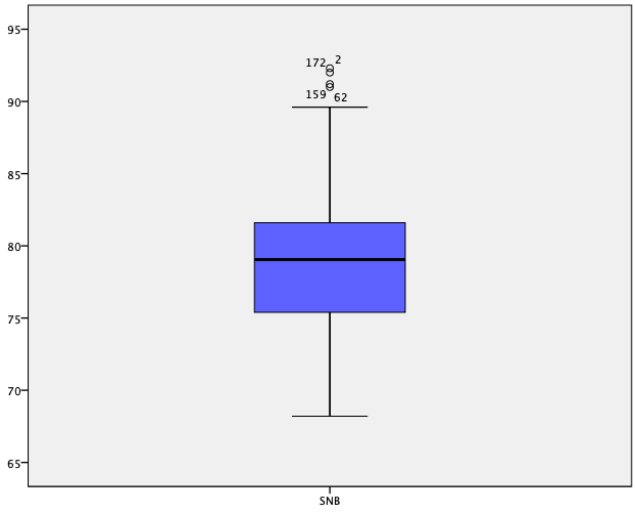


Figure 9.81 Box plot for SNB showing norm for bimaxillary protrusion population in Trinidad and Tobago

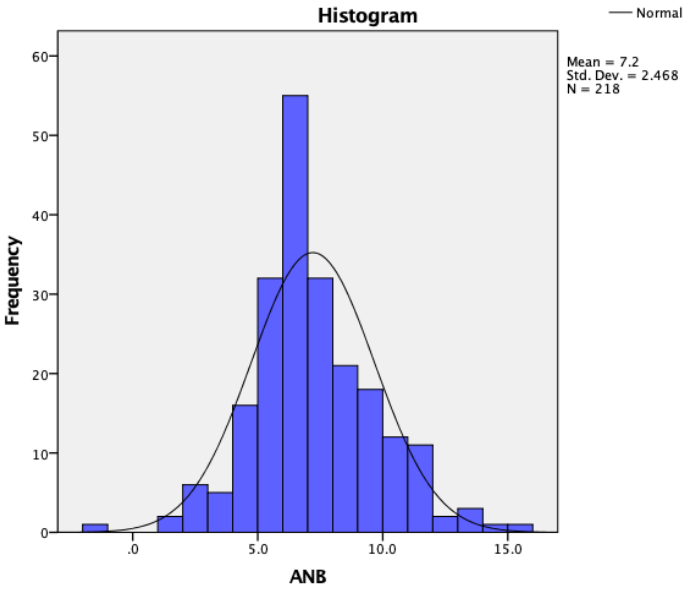


Figure 9.82 Histogram and normality curve for ANB showing norm for bimaxillary protrusion population in Trinidad and Tobago

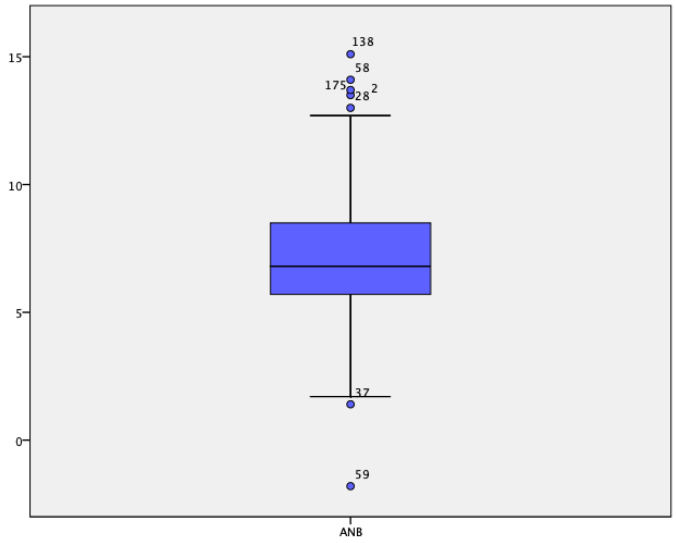


Figure 9.83 Box plot for ANB showing norm for bimaxillary protrusion population in Trinidad and Tobago

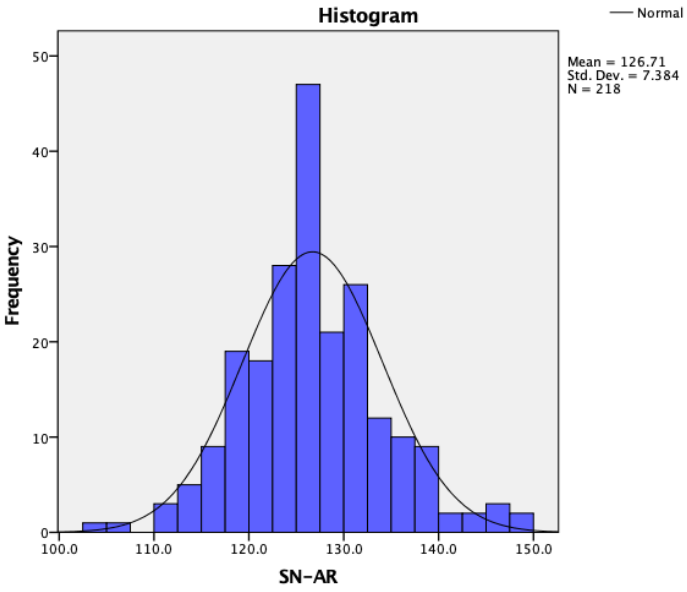


Figure 9.84 Histogram and normality curve for SN-AR showing norm for bimaxillary protrusion population in Trinidad and Tobago

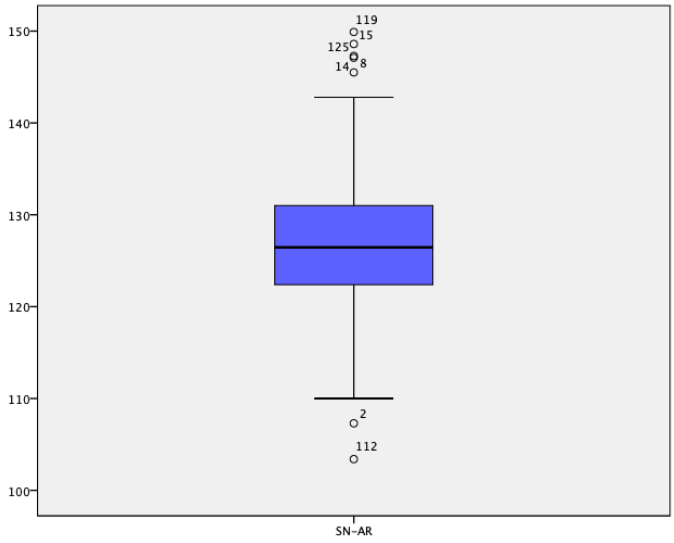


Figure 9.85 Box plot for SN-AR showing norm for bimaxillary protrusion population in Trinidad and Tobago

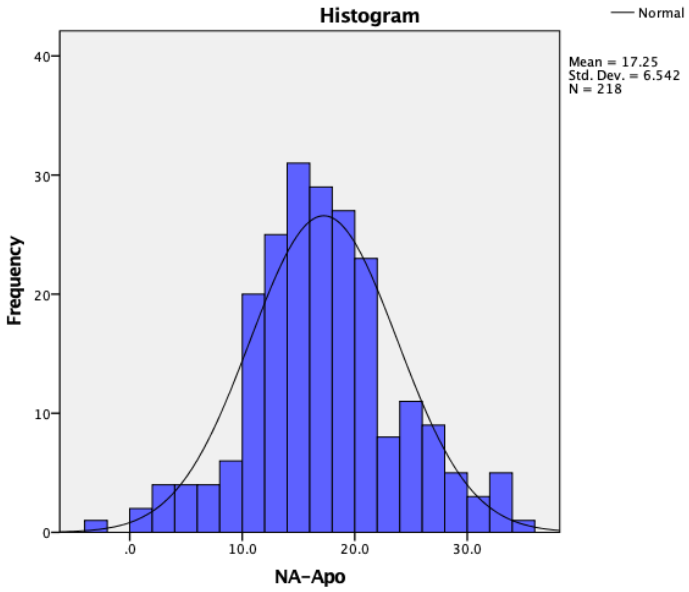


Figure 9.86 Histogram and normality curve for NA-Apo showing norm for bimaxillary protrusion population in Trinidad and Tobago

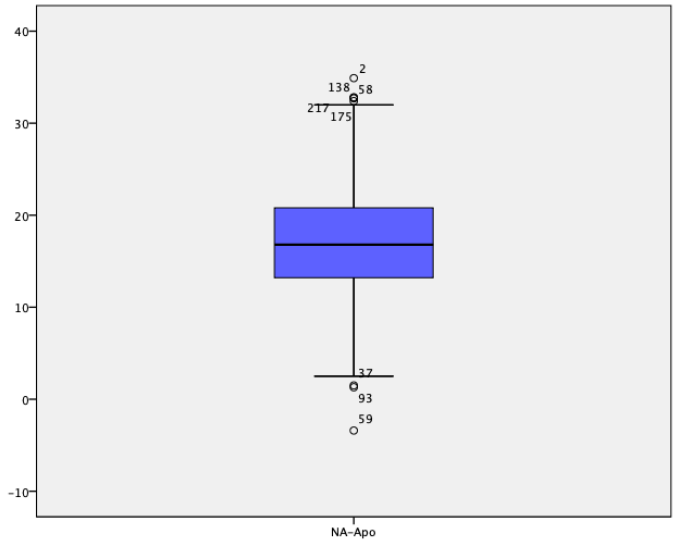


Figure 9.87 Box plot for NA-Apo showing norm for bimaxillary protrusion population in Trinidad and Tobago

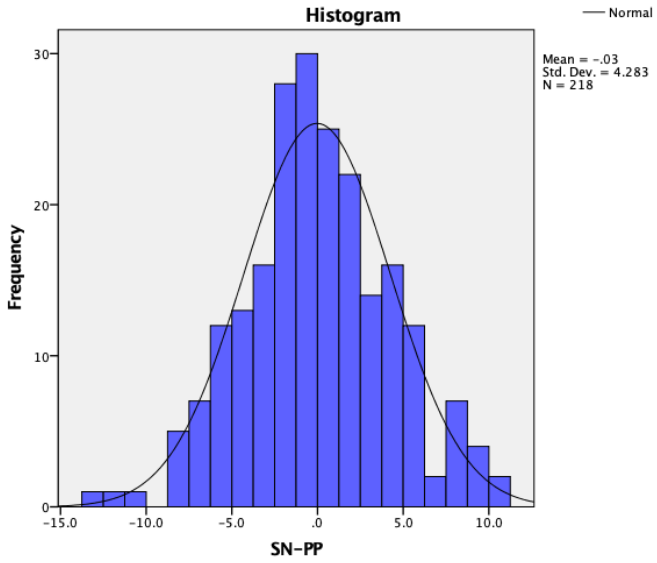


Figure 9.88 Histogram and normality curve for SN-PP showing norm for bimaxillary protrusion population in Trinidad and Tobago

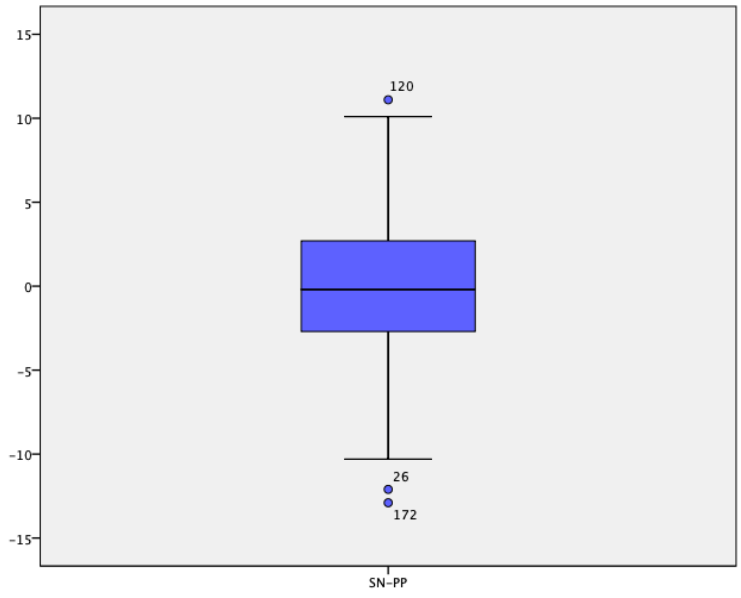


Figure 9.89 Box plot for SN-PP showing norm for bimaxillary protrusion population in Trinidad and Tobago

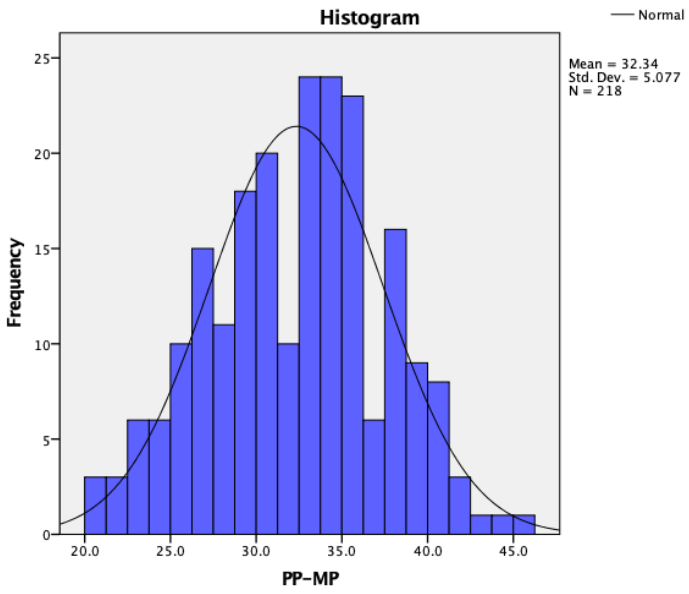


Figure 9.90 Histogram and normality curve for PP-MP showing norm for bimaxillary protrusion population in Trinidad and Tobago

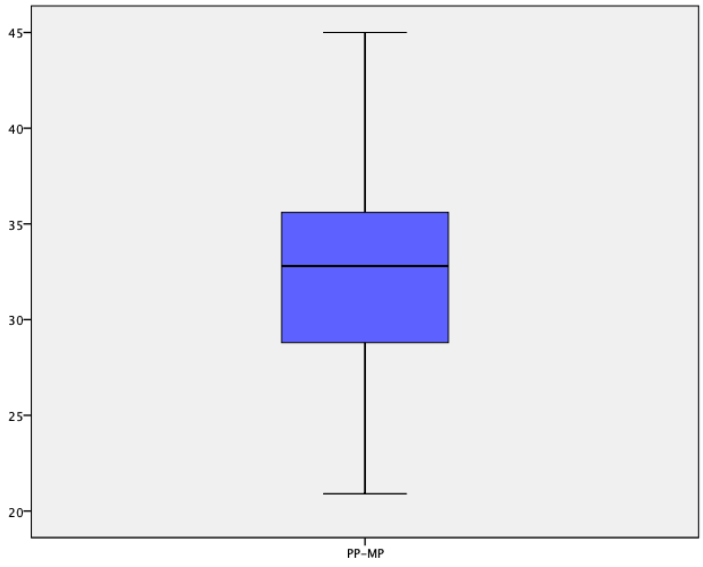


Figure 9.91 Box plot for PP-MP showing norm for bimaxillary protrusion population in Trinidad and Tobago

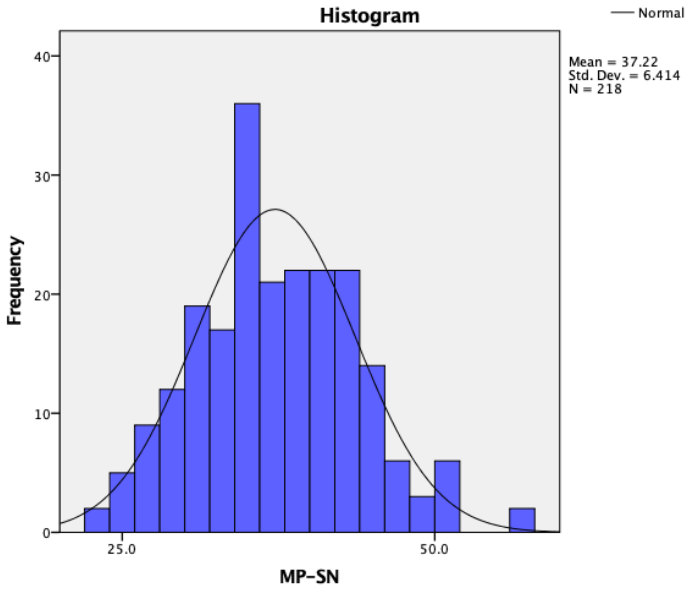


Figure 9.92 Histogram and normality curve for MP-SN showing norm for bimaxillary protrusion population in Trinidad and Tobago

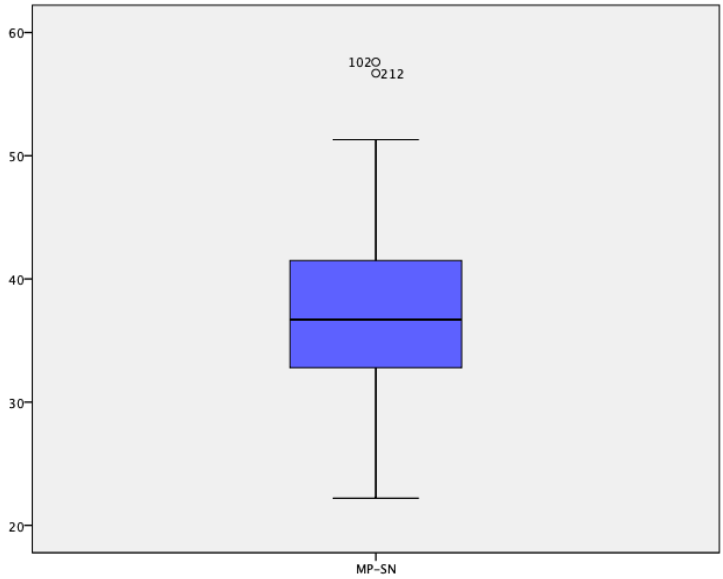


Figure 9.93 Box plot for MP-SN showing norm for bimaxillary protrusion population in Trinidad and Tobago

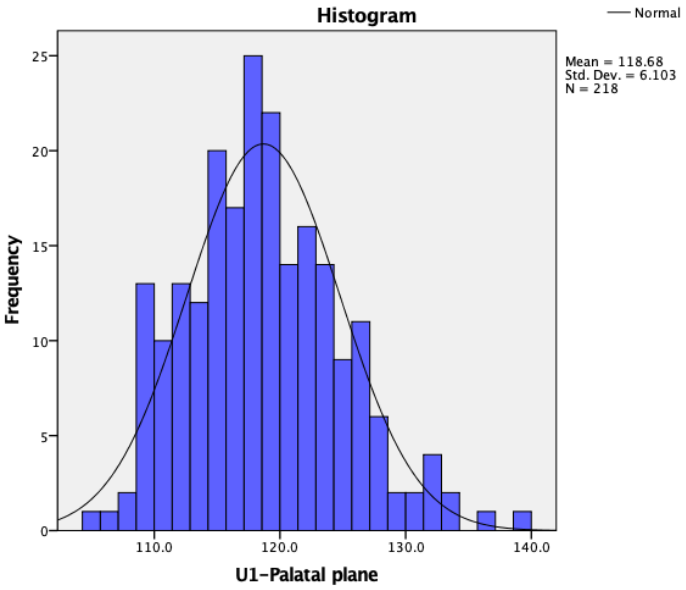


Figure 9.94 Histogram and normality curve for UI- Palatal Plane showing norm for bimaxillary protrusion population in Trinidad and Tobago

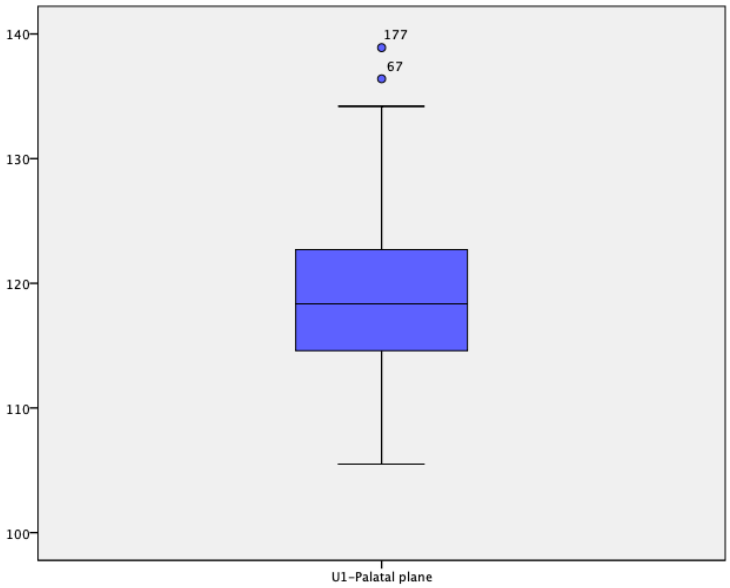


Figure 9.95 Box plot for UI- Palatal Plane showing norm for bimaxillary protrusion population in Trinidad and Tobago

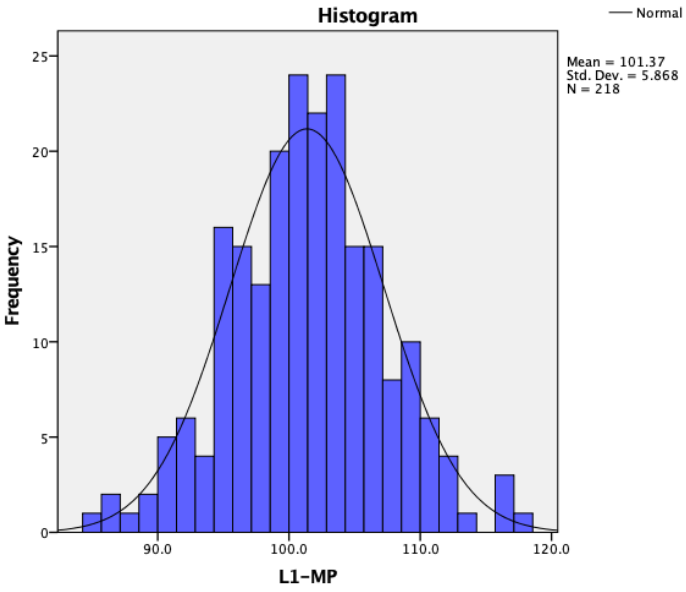


Figure 9.96 Histogram and normality curve for L1- MP showing norm for the bimaxillary protrusion population in Trinidad and Tobago

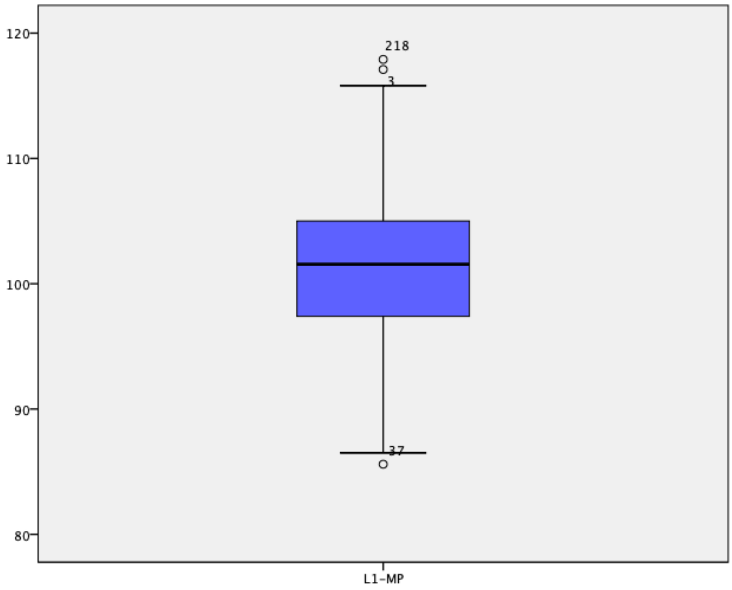


Figure 9.97 Box plot for LI- MP showing norm for the bimaxillary protrusion population in Trinidad and Tobago

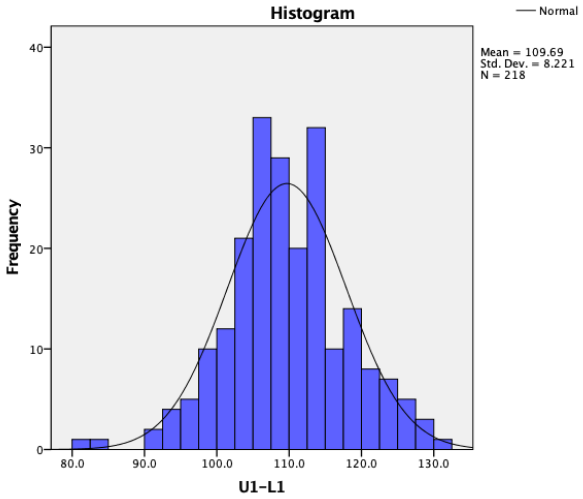


Figure 9.98 Histogram and normality curve for UI-LI showing norm for the bimaxillary protrusion population in Trinidad and Tobago

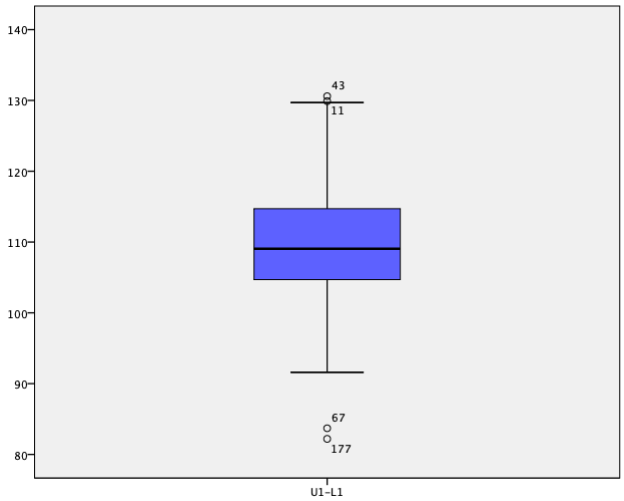


Figure 9.99 Box plot for UI- LI showing norm for the bimaxillary protrusion population in Trinidad and Tobago

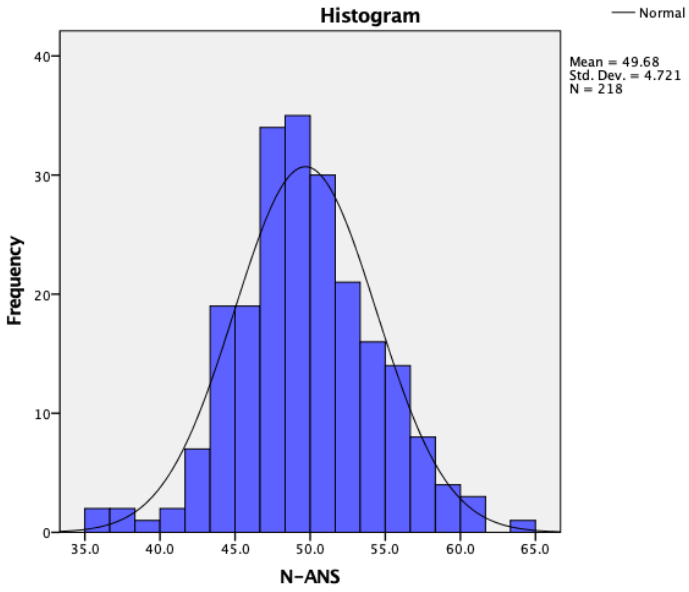


Figure 9.100 Histogram and normality curve for N-ANS showing norm for the bimaxillary protrusion population in Trinidad and Tobago

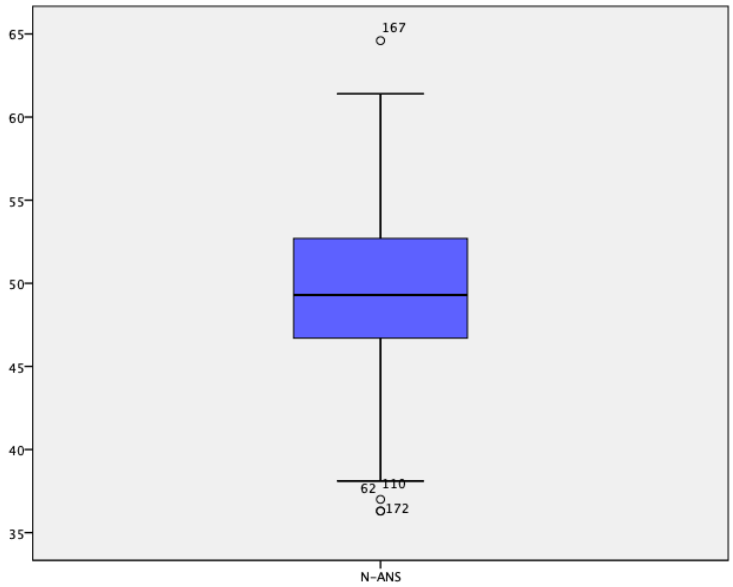


Figure 9.101 Box plot for N-ANS showing norm for the bimaxillary protrusion population in Trinidad and Tobago

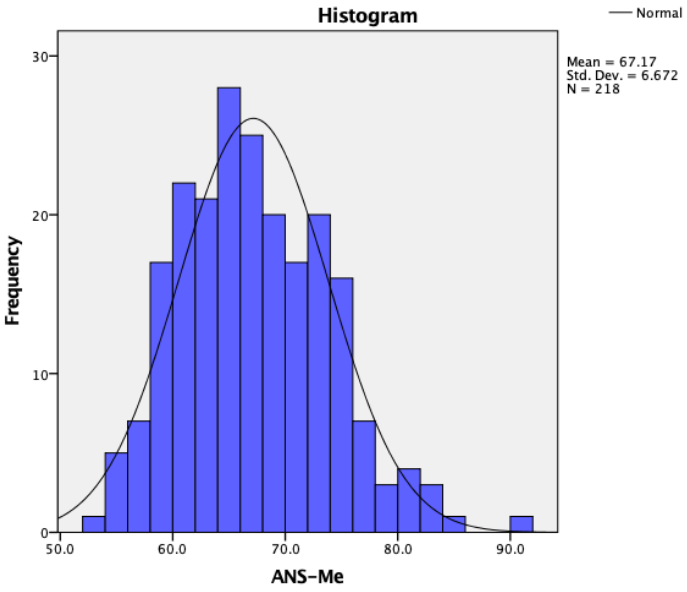


Figure 9.102 Histogram and normality curve for ANS-Me showing norm for the bimaxillary protrusion population in Trinidad and Tobago

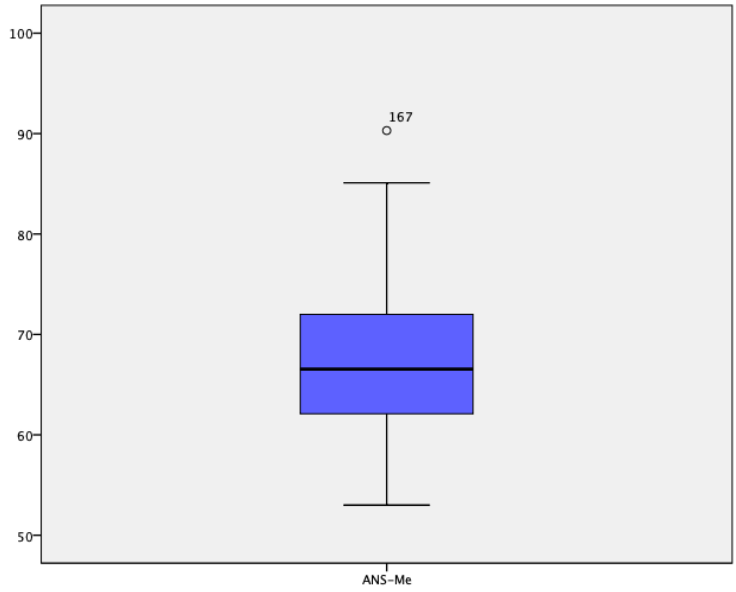


Figure 9.103 Box plot for ANS-Me showing norm for the bimaxillary protrusion population in Trinidad and Tobago

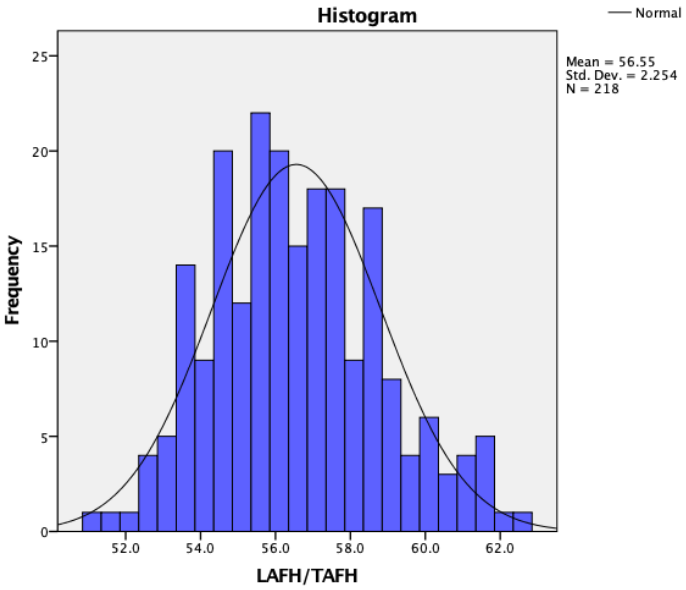


Figure 9.104 Histogram and normality curve for LAFH/TAFH showing norm for the bimaxillary protrusion population in Trinidad and Tobago

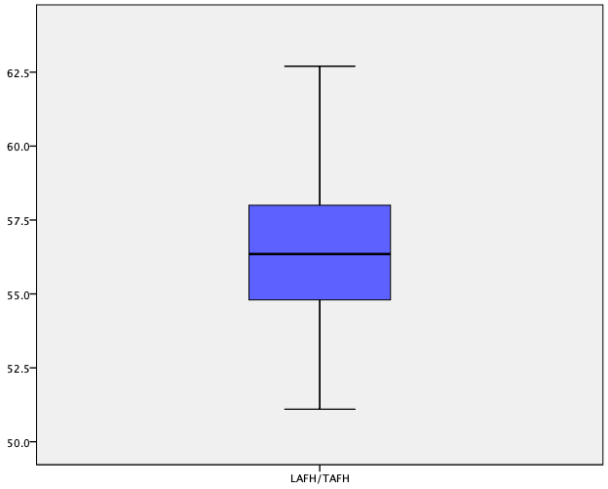


Figure 9.105 Box plot for LAFH/TAFH showing norm for the bimaxillary protrusion population in Trinidad and Tobago

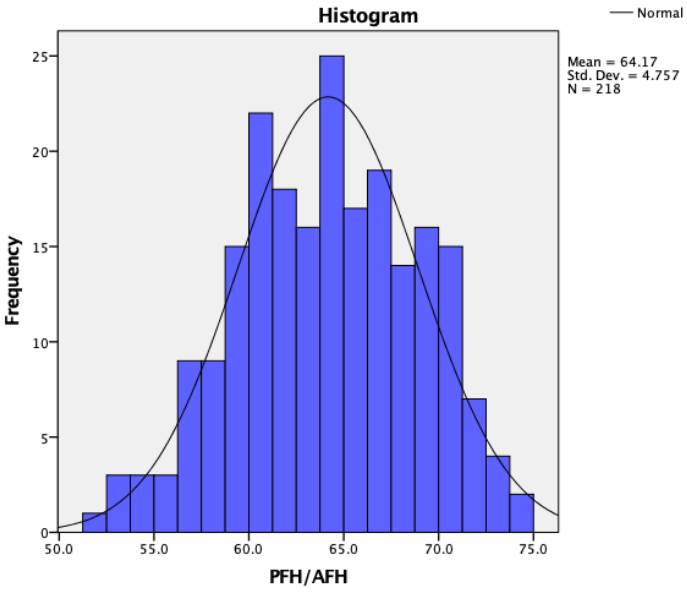


Figure 9.106 Histogram and normality curve for PFH/AFH showing norm for the bimaxillary protrusion population in Trinidad and Tobago

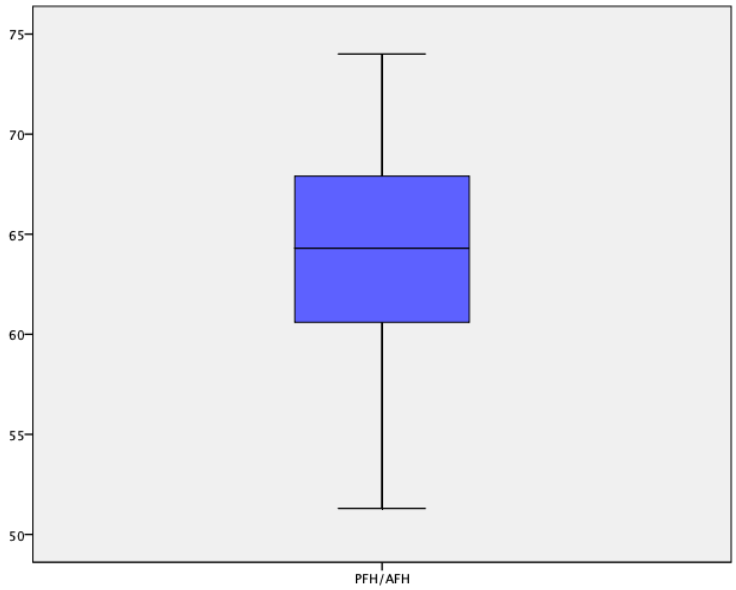


Figure 9.107 Box plot for PFH/AFH showing norm for the bimaxillary protrusion population in Trinidad and Tobago

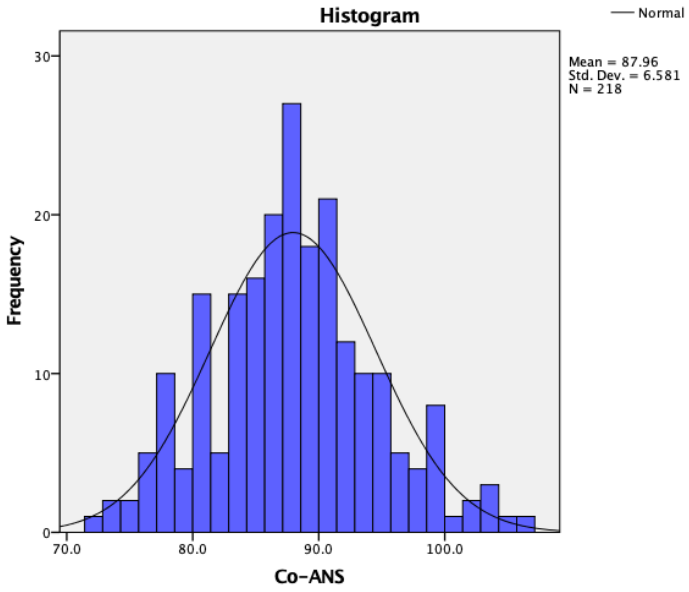


Figure 9.108 Histogram and normality curve for Co-ANS showing norm for the bimaxillary protrusion population in Trinidad and Tobago

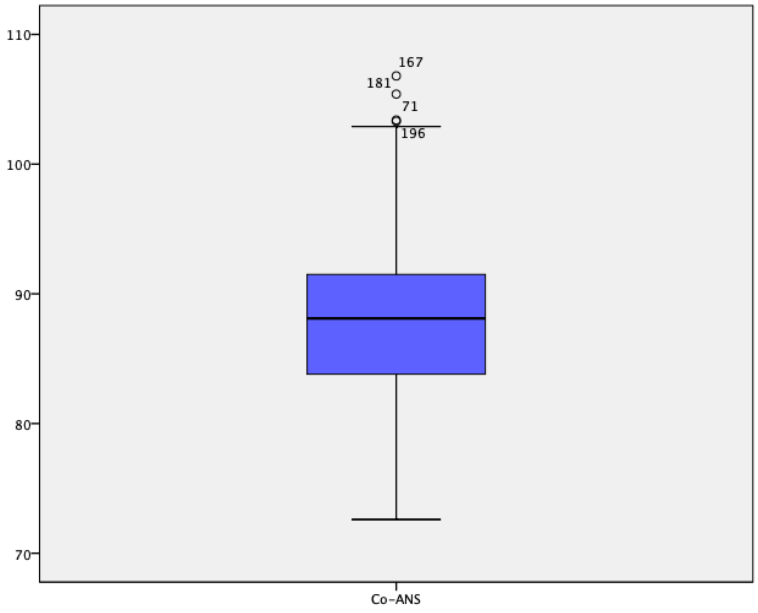


Figure 9.109 Box plot for Co-ANS showing norm for Trinidad and Tobago population

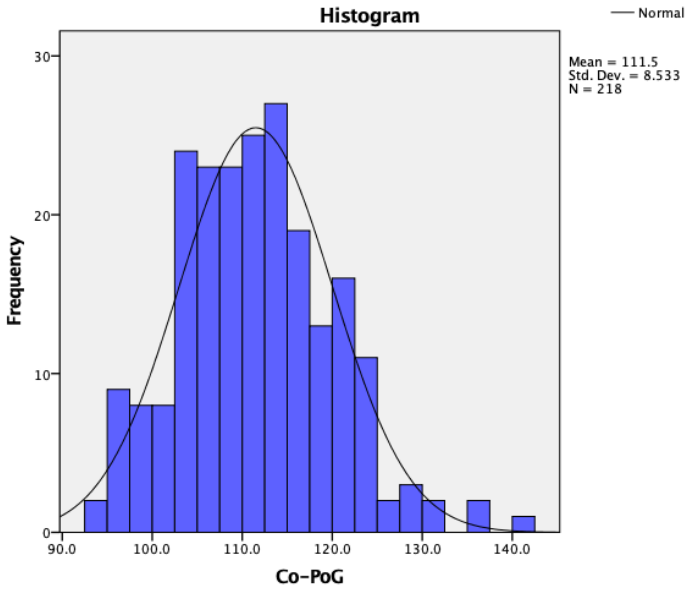


Figure 9.110 Histogram and normality curve for Co-Pog showing norm for the bimaxillary protrusion population in Trinidad and Tobago

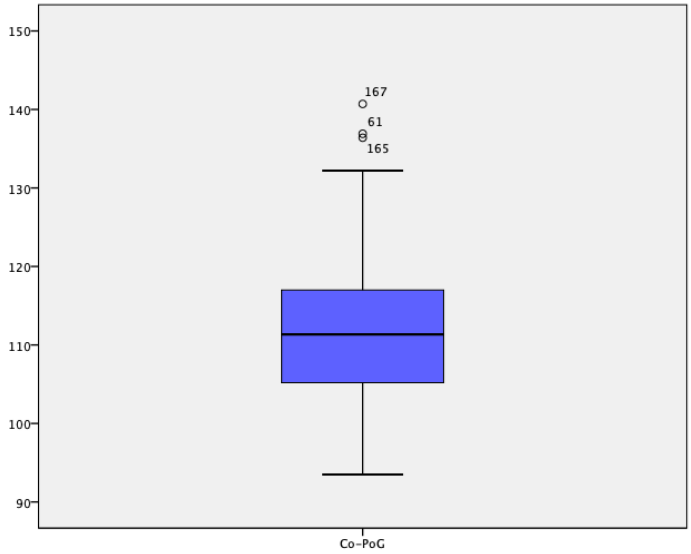


Figure 9.111 Box plot for Co-Pog showing norm for the bimaxillary protrusion population in Trinidad and Tobago

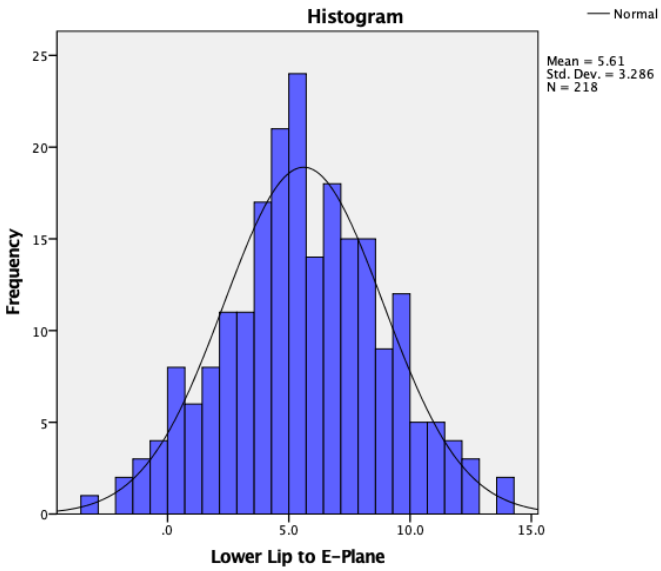


Figure 9.112 Histogram and normality curve for Lower Lip to E-Plane showing norm for the bimaxillary protrusion population in Trinidad and Tobago

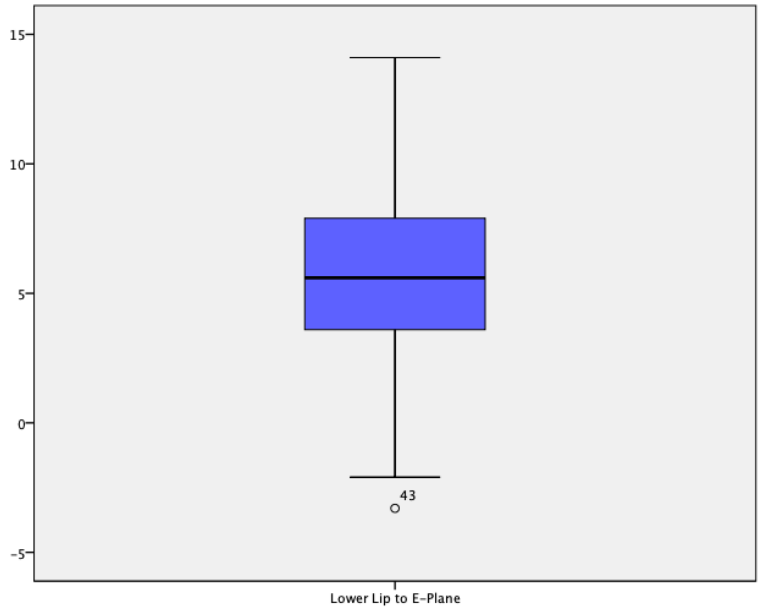


Figure 9.113 Box plot for Lower Lip to E-Plane showing norm for the bimaxillary protrusion population in Trinidad and Tobago

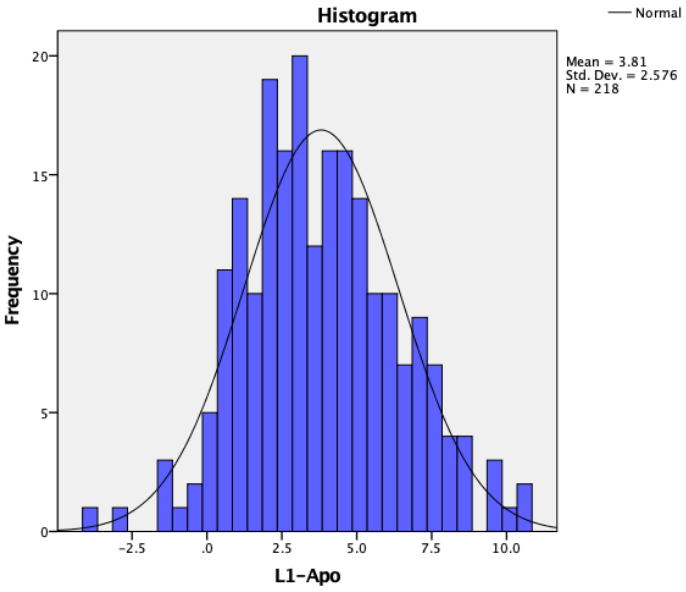


Figure 9.114 Histogram and normality curve for L1-Apo showing norm for the bimaxillary protrusion population in Trinidad and Tobago

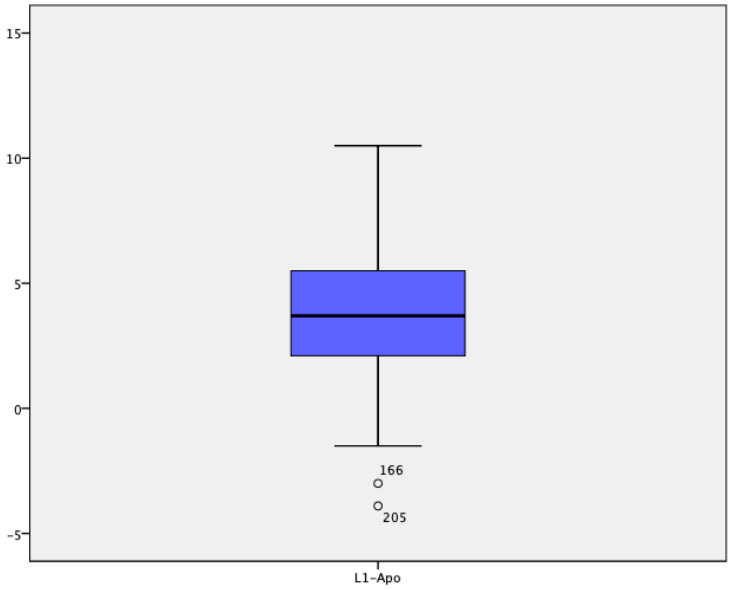


Figure 9.115 Box plot for L1-Apo showing norm for the bimaxillary protrusion population in Trinidad and Tobago

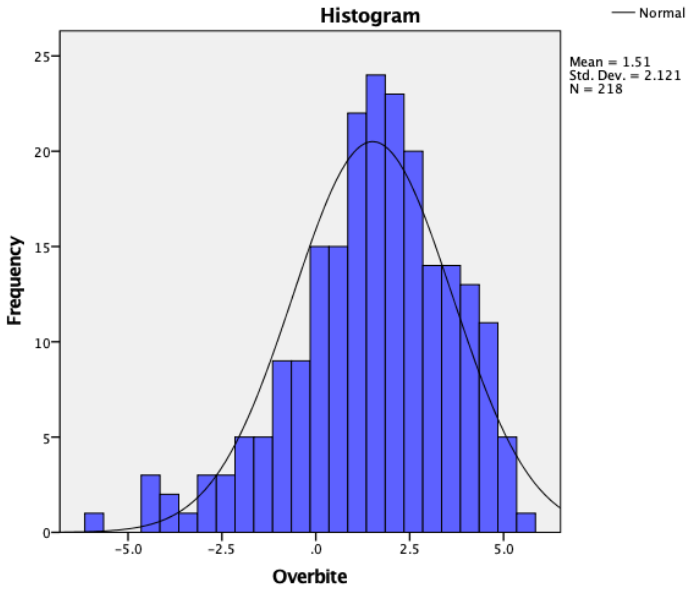


Figure 9.116 Histogram and normality curve for Overbite showing norm for the bimaxillary protrusion population in Trinidad and Tobago

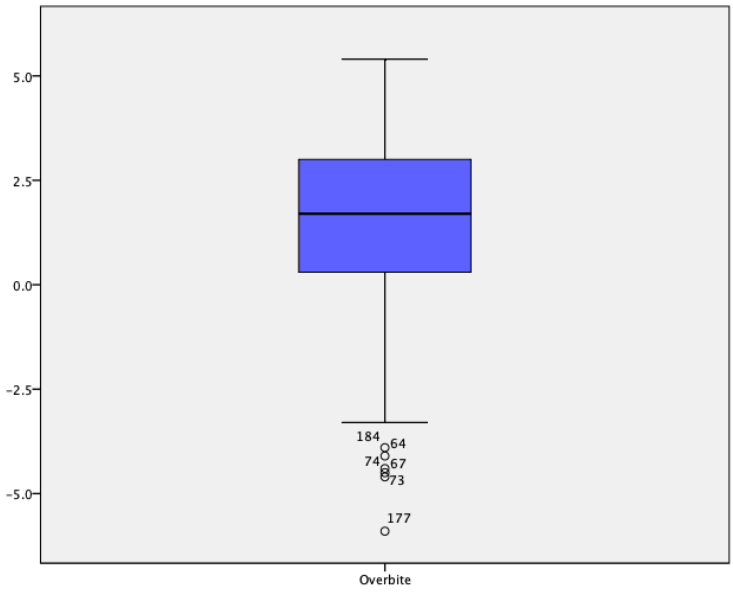


Figure 9.117 Box plot for Overbite showing norm for the bimaxillary protrusion population in Trinidad and Tobago

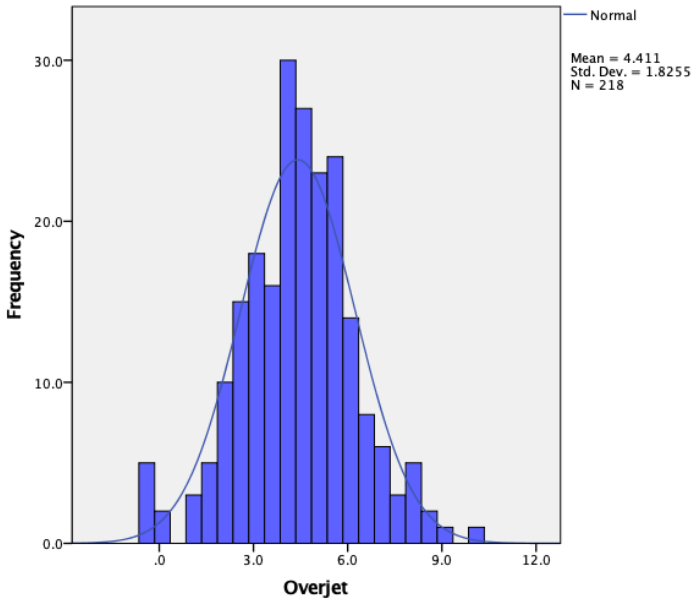


Figure 9.118 Histogram and normality curve for Overjet showing norm for the bimaxillary protrusion population in Trinidad and Tobago

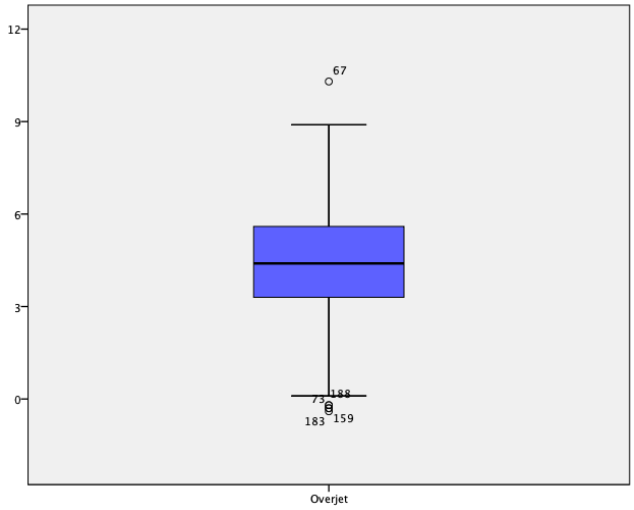


Figure 9.119 Box plot for Overjet showing norm for the bimaxillary protrusion population in Trinidad and Tobago

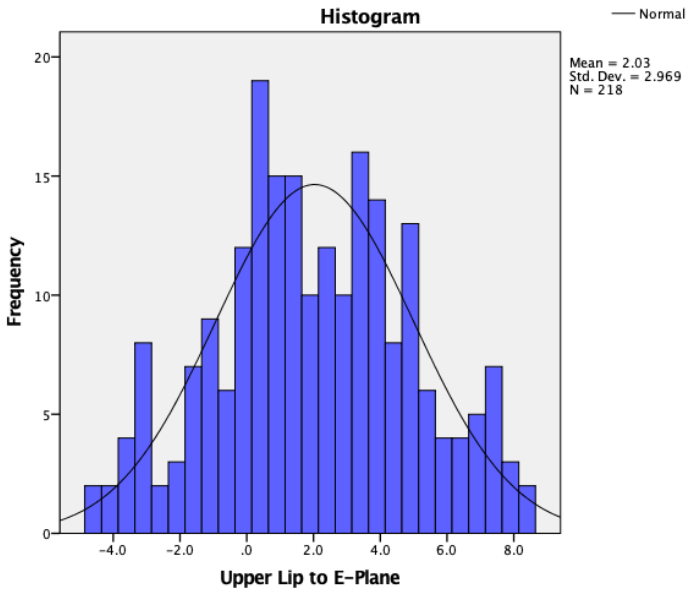


Figure 9.120 Histogram and normality curve for Upper Lip to E-Plane showing norm for the bimaxillary protrusion population in Trinidad and Tobago

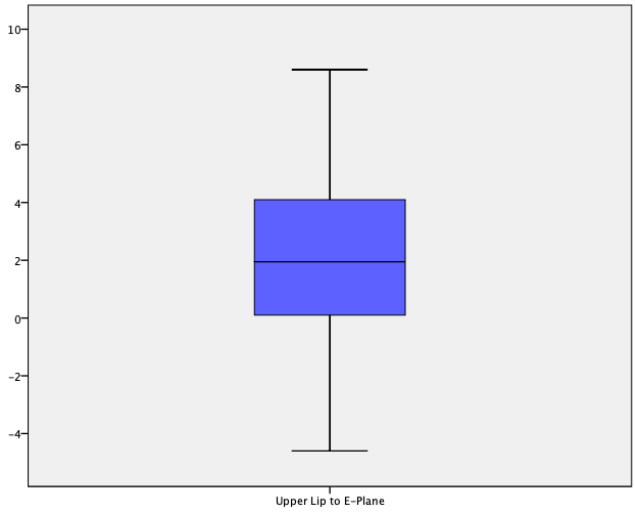


Figure 9.121 Box plot for Upper Lip to E-Plane showing norm for the bimaxillary protrusion population in Trinidad and Tobago

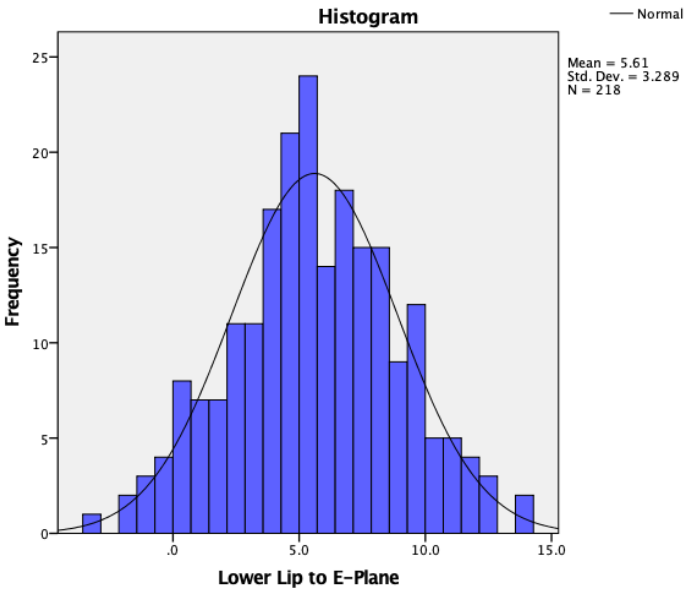


Figure 9.122 Histogram and normality curve for Lower Lip to E-Plane showing norm for the bimaxillary protrusion population in Trinidad and Tobago

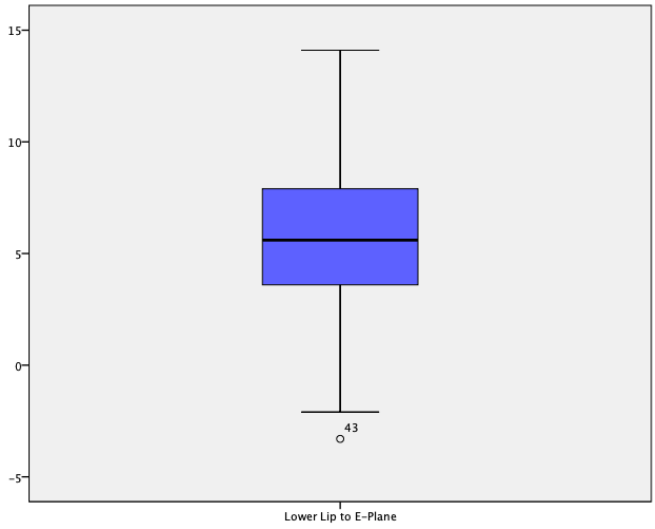


Figure 9.123 Box plot for Lower Lip to E-Plane showing norm for the bimaxillary protrusion population in Trinidad and Tobago

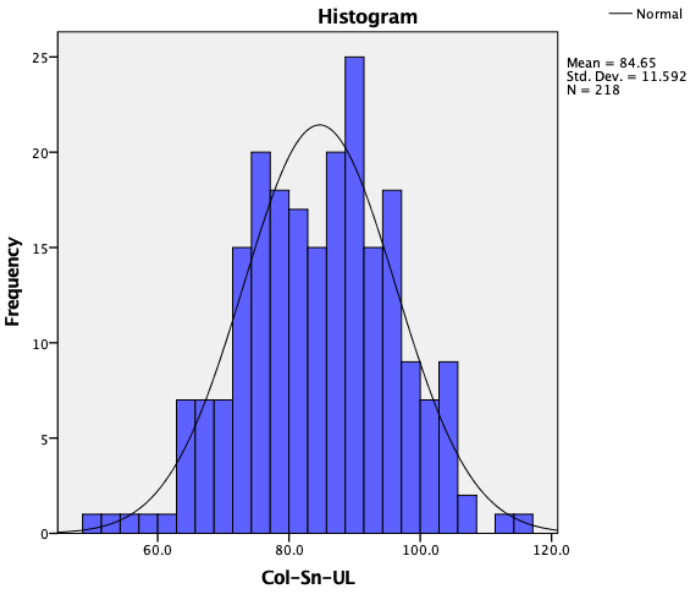


Figure 9.124 Histogram and normality curve for Col-Sn-UL showing norm for the bimaxillary protrusion population in Trinidad and Tobago

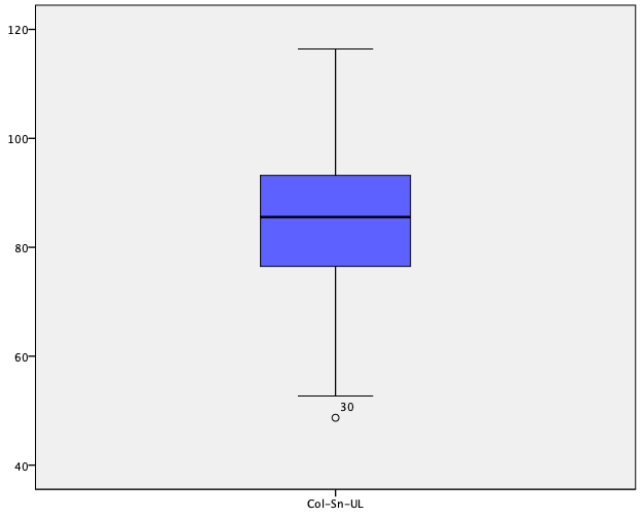


Figure 9.125 Box plot for Col-Sn-UL showing norm for the bimaxillary protrusion population in Trinidad and Tobago

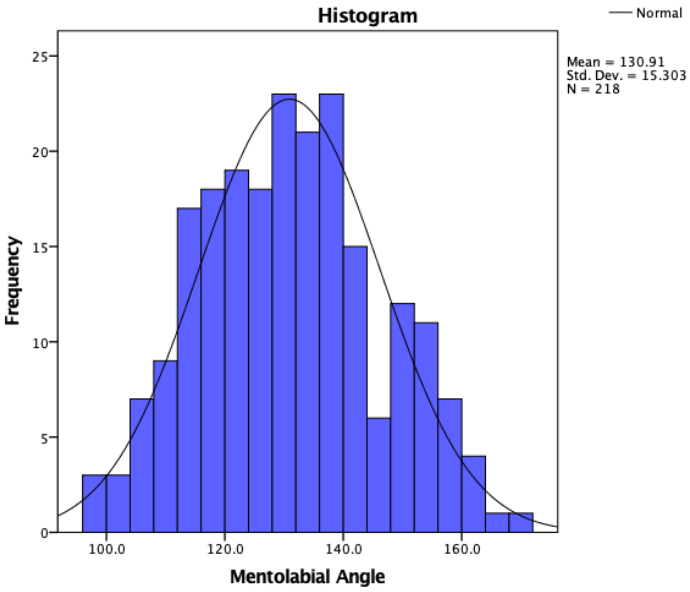


Figure 9.126 Histogram and normality curve for Mentolabial Angle showing norm for the bimaxillary protrusion population in Trinidad and Tobago

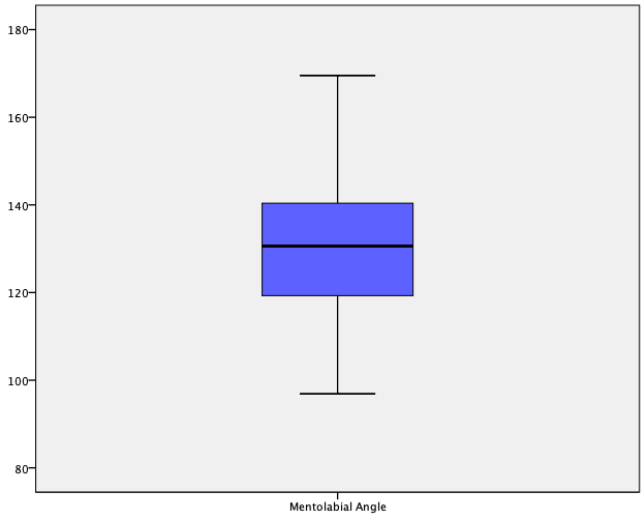


Figure 9.127 Box plot for Mentolabial Angle showing norm for the bimaxillary protrusion population in Trinidad and Tobago

Appendix 7: Publications

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Research Article

Bimaxillary Protrusion: Prevalence And Associated Factors In The Trinidad And Tobago Population

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Abstract

Introduction: Bimaxillary protrusion is a malocclusion characterized by proclined upper and lower incisors and prognathic jaws which has been identified in different ethnic groups and populations. Trinidad and Tobago have a mixed ethnicity population suitable to assess the prevalence of bimaxillary protrusion and associated factors in different ethnicities.

Method: An epidemiological survey of 972 children, 566 females (58.2%) and 406 males (41.8%) was conducted. The sample population was 11 - 12-year-old (mean age 11.84 years) in high schools across the country. None of the subjects were undergoing or had previous orthodontic treatment. Occlusal and anterior posterior relationships were assessed based on BSI 1983 definitions. The two conditions that made up bimaxillary protrusion, bimaxillary prognathism and bimaxillary proclamation, were assessed using extra- oral and intraoral parameters respectively.

Results: Bimaxillary prognathism and proclination were found with 64.4% and 68.8% prevalence respectively. Both conditions were found across all ethnic groups but with significantly different prevalence rates. There was an association between oral habits and ethnicity. Class 1 incisor relationship, class 1 canines and average overbite were the most common occlusal relationships found.

Conclusion: Bimaxillary protrusion is prevalent in the population of Trinidad and Tobago. Prevalence of bimaxillary protrusion is related to ethnicity. There is an association between ethnicity and oral habits.

Keywords: Bimaxillary Protrusion; Prevalence; Ethnicity; Oral Habits; Trinidad and Tobago

Introduction

In bimaxillary protrusion the characteristic facial profile may be a result of the prognathic maxilla and mandible (bimaxillary prognathism) and/or proclined upper and lower incisors (bimaxillary proclination) [1]. The face is convex and lips procumbent.1-3. Bimaxillary protrusion has long been reported to be prevalent in Afro-Caribbean, African-American, Asian and other populations [1-7]. It is not known how prevalent this condition is in ethnically di- verse populations, such as that found in Trinidad and Tobago. The central statistical office reports that three major ethnic groups can be recognized in Trinidad and Tobago, namely Afro-Trinidadian, Indo- Trinidadian and Mixed. Studies have shown that there is an increase in mixing of ethnicities across the Caribbean and world- wide. It is therefore important to identify if there is an increased proportion of bimaxillary protrusion in such populations and any associated factors.

This epidemiologic survey was conducted to obtain this prevalence data and so provide data on the need for orthodontic treatment due to bimaxillary protrusion in ethnically diverse populations. The demand for orthodontic treatment is increasing not just in Trinidad and Tobago but in most countries and publicly funded healthcare systems have introduced methods to prioritize treatment based on objective measures of need. One such measure widely used is the Index of Orthodontic Treatment Need, but this was not

developed for populations where bimaxillary protrusion is prevalent and may not be appropriate in these settings. Appropriate provision of orthodontic services for Trinidad and Tobago and other areas where this is increased prevalence of bimaxillary protrusion require such data to allocate and plan access to limited government health service resources and inform manpower planning decisions in the public and private dental sector [7-10].

Therefore, the aim of this study was to identify the prevalence of bimaxillary protrusion and associated factors in the ethnically diverse population found in Trinidad and Tobago.

Methods

Ethical approval from The University ethics committee was obtained for this epidemiological survey. Approval was then obtained from the Ministry of Education in Trinidad and Tobago to conduct this research in high schools across the country. Principals of high schools were contacted for permission to conduct the research. In the schools that gave permission, consent forms were given out to the students in the first year of high school. Only students from whom consent was obtained from both parents and child were examined.

The sample

This epidemiological survey comprised 1000 high school children. The sample size was determined from an estimate of prevalence of 40% and a population of 20,000 to give a confidence level of 0.95 and precision of 2.5 to be 1006 (Epitools epidemiological calculators. Ausvet Pty Ltd. Available at: http://epitools.ausvet.com.au). One orthodontist (TH) examined the students which were selected from forty-one high schools out of 141 public high schools which gave permission to conduct the research, located across the twin island republic representing both rural and urban populations. Inclusion criteria included all ethnicities including the mixed race population, and all males and females aged 11or 12 years at the time of examination. Exclusion criteria included any craniofacial abnormality and current or previous orthodontic treatment.

Recording procedure

Data was collected on individual data collection forms including school attended, age, gender and self-reported ethnicity. The presence of any self-reported habits was also noted (digit sucking, tongue sucking, tongue thrusting, nail biting, lip licking or lip sucking).

The students were then examined at school in a well-lit area. The candidates were seated on a chair and placed in Natural Head Position.

Extra-oral assessment included presence or absence of bimaxillary prognathism, the anterior posterior, vertical (lower face height and maxillomandibular planes angle) and transverse skeletal pat- tern. Intraoral assessment included incisor classification (assessed using British Standards Institute 1983 definitions), overbite, over- jet, canine and molar relationship, and incisor inclination.

Standardized extra-oral profile photographs and orthodontic intra-oral photographs were taken.

The intraoral assessment was done with the use of a dental mirror and the incisor inclination was measured using the Tooth Inclination Protractor (TIP) [11], shown in figure 1.

Figure 1: Tooth Inclination Protractor.

The TIP has a plastic platform which was placed intraorally against the occlusal surfaces of the maxillary dentition. The plat- form has a stainless steel pin whose length can be adjusted and rests on the labial surface of the upper incisor. The upper right central incisor was used to measure the incisor inclination [11,12]. The stainless steel pin was adjusted so that contact was made with the most convex portion of the incisor to record the incisor inclination. The other end of the steel pin rests on a graduated scale of the protractor [12]. In cephalometric analysis the normal value for the upper incisor to maxillary plane angle is 109º ± 5º. Therefore, any degree above 114º would be considered proclined. The TIP has been shown to underscore the upper incisor to maxillary plane by 10.46 degrees [11]. Therefore, using the TIP an

incisor inclination greater than 105 degrees was considered proclined.

The data was coded, entered into a computer and analyzed by a statistical package (IBM SPSS Statistics for Windows, version 22 (IBM Corp., Armonk, N.Y., USA)). The data was then cleaned. It was first checked for any inclusion errors. Candidates outside the age range of 11 - 12 years were removed. In addition, based on ethnicity, there was one Chinese subject and this subject was also removed from the sample as it was not possible to include such a small group in the analysis. The final sample size was therefore 972. Any other missing data entry was completed by manually checking the clinical data recording sheet and checked against the clinical photographs by two investigators (TH and DB).

Recording procedure

1. Bimaxillary Prognathism. An extra oral diagnosis of bimaxillary prognathism was made if all of the following features were present: lower face height and maxilla- mandibular planes angle average or increased, decreased nasolabial angle, lips full and everted and a convex profile [1].
2. Bimaxillary Proclination. An intra oral diagnosis of bimaxillary proclination was made if all the following features were present: proclined upper and lower incisors, overbite reduced or presence of an anterior open bite, incisor inclination of greater than 105º as measured by the TIP [1,11].

Statistical analysis

Descriptive analysis was undertaken. Pearson chi-square and z statistic was used to assess the distribution of bimaxillary prognathism and bimaxillary protrusion in the different ethnicities and p values of less than 0.05 were considered as statistically significant. A binary logistic regression analysis explored other explanatory variables alongside ethnicity to predict the diagnosis of bimaxillary prognathism.

Results

The sample included 58.2% female and 41.8% male subjects. Eleven year olds comprised 15.5% of the sample and twelve year olds 84.5%, with a mean age of 11.84 years. Afro-Trinidadians made up 46.4%, Indo-Trinidadians 35.3% and mixed subjects 18.3% of the sample. Bimaxillary prognathism diagnosis was made in 64.9% of subjects and bimaxillary proclination in 68.8%.

Table 1 shows the distribution of the presence of bimaxillary proclination and bimaxillary prognathism for the three ethnicity groups. Chi squared for bimaxillary prognathism showed a statistically significant difference between ethnicity groups ($p = 0.000$), but a non-significant difference in distribution for bimaxillary proclination ($p = 0.208$). A z test showed that for bimaxillary prognathism there was a statistically significant ($p < 0.05$) difference be- tween each of the three ethnicities.

		Bimaxillary Proclination			**Bimaxillary Prognathism**		
		Present	Absent	Total	Present	Absent	Total
Ethnicity	Afro-Trinidadian	319	132	451	412	39	451
	Indo-Trinidadian	237	106	343	98	244	342
	Mixed	113	65	178	120	57	177
Total		669	303	972	630	340	970

Table 1: Association between Ethnicity and Bimaxillary Proclination and Prognathism.

In order to explore further the relationship between the presence of bimaxillary prognathism and the other variables recorded a forward stepwise logistic regression was undertaken, with bimaxillary prognathism as the independent variable and the following dependent variables: ethnicity, skeletal pattern, gender, lip sucking, digit sucking, lip licking, tongue sucking and tongue thrusting. The final model included ethnicity, nail biting, tongue thrusting, finger sucking, lip licking and lip sucking and had a R squared value of 0.371. The details of the model are shown in Table 2 with a positive effect of Afro-Caribbean ethnicity (Ethnicity 1) and a negative effect of Indo-Caribbean ethnicity (Ethnicity 2), and a negative effect for the absence of each of the oral habits included in the model. Neither gender nor skeletal pattern were included in the model.

	B	Standard Error	Wald	df	Sig	Exp (B)
Step 1 Ethnicity			260.115	2	.000	
Ethnicity (1)	1.613	.232	48.231	1	.000	5.018
Ethnicity (2)	-1.653	.200	67.938	1	.000	.192
Constant	.744	.161	21.416	1	.000	2.105
Step 2 Ethnicity			219.709	2	.000	
Ethnicity (1)	1.553	.241	41.527	1	.000	4.724
Ethnicity (2)	-1.555	.210	54.667	1	.000	.211
Tonguethrust (1)	-1.670	.224	55.639	1	.000	.188
Constant	1.056	.174	36.688	1	.000	2.876
Step 3 Ethnicity			211.875	2	.000	
Ethnicity (1)	1.551	.243	40.784	1	.000	4.715
Ethnicity (2)	-1.524	.213	51.462	1	.000	.218
Nailbiting (1)	-.635	.180	12.449	1	.000	.530
Tonguethrust (1)	-1.512	.228	44.009	1	.000	.220
Constant	1.377	.201	46.796	1	.000	3.961
Step 4 Ethnicity			201.664	2	.000	
Ethnicity (1)	1.515	.243	38.735	1	.000	4.551
Ethnicity (2)	1.505	.213	49.902	1	.000	.222
Nail biting (1)	-.560	.183	9.364	1	.002	.571
Tongue thrust (1)	-1.418	.231	37.838	1	.000	.242
Liplicking (1)	-.561	.202	7.698	1	.006	.571
Constant	1.716	.239	51.443	1	.000	5.562
Step 5 Ethnicity			202.064	2	.000	
Ethnicity (1)	1.493	.245	37.179	1	.000	4.450
Ethnicity (2)	-1.561	.216	52.368	1	.000	.210
Nail biting (1)	-.540	.184	8.617	1	.003	.583
Tongue thrust (1)	-1.483	.232	40.903	1	.000	.227
Digitsucking (1)	-.481	.196	6.025	1	.014	.618
Liplicking (1)	-.536	.204	6.915	1	.009	.585
Constant	2.065	.283	53.152	1	.000	7.882
Step 6 Ethnicity			203.112	2	.000	
Ethnicity (1)	1.517	2.46	37.998	1	.000	4.558
Ethnicity (2)	-1.567	.217	52.247	1	.000	.209
Nailbiting (1)	-.539	.184	8.548	1	.003	.583
Tonguethrust (1)	-1.544	.235	43.023	1	.000	.214
Digitsucking (1)	-.466	.197	5.619	1	.018	.627
Liplicking (1)	-.520	.205	6.462	1	.011	.594
Lipsucking (1)	-1.588	.742	4.584	1	.032	.204
Constant	3.614	.785	21.191	1	.000	37.121

Table 2: Logistic regression models (forward stepwise) for Bimaxillary Prognathism.
Ethnicity (1) Afro-Caribbean
Ethnicity (2) Indo-Caribbean

Table 3 shows the association between ethnicity and oral habits. Chi squared showed a significant difference between ethnicities for the presence of finger sucking (p = 0.035), tongue sucking (p= 0.00) and tongue thrusting (p = 0.00). Afro-trinidadian subjects were more likely to have these habits and mixed ethnicity least likely to have a finger sucking habit. There was no association between these oral habits and bimaxillary proclination

Absent		Digit Sucking			Tongue Sucking			Tongue Thrusting		
		Present	Total	Absent	Present	Total	Absent	Present	Total	
Ethnicity	Afro-Trinidadian	286	165	451	347	104	451	38	413	451
	Indo-Caribbean	217	126	343	314	29	343	119	230	343
	Mixed	131	47	178	155	23	178	29	149	178
Total		634	338	972	816	156	972	180	792	972

Table 3: Association between Ethnicity and Oral Habits.

We then looked at occlusal characteristics of the population. Table 4 shows 46.6% of the sample had Class 1 incisor relationship, 16.6% had Class 2 division 1 and 1% had Class 2 division 2 incisor relationship. Class 3 incisor relationship was present in 35.8% of the sample. 45.8% had an average overbite, 17.4% had increased overbite, 29.8% had decreased overbite and 6.7% had an open bite. Class 1 canine relationship was the most common canine relation- ship (41% right side, 47.1% left side), class 2 was less represented (38.4% right side and 32.8% left side) and class 3 was the least common canine relationship (12.8% right side, 11.6% left side).

	Frequency	Percentage
Class 1	453	46.6
Class2 division 1	161	16.6
Class 2 division 2	10	1.0
Class 3	348	35.8
Total	972	100

Table 4: Incisor Relationship.

Discussion

This study is the first to determine the prevalence of bimaxillary protrusion in a mixed ethnicity population such as found in Trinidad and Tobago. Several studies have shown that bimaxillary protrusion is present in various ethnicities [1-7,13]. This study agrees with the findings of these studies in that bimaxillary protrusion was found in all ethnic groups in Trinidad and Tobago. The prevalence in this study however was much higher than those re- ported in other countries. The prevalence of bimaxillary protrusion has been reported between 4.09% to 20% [14,15] in other countries. The prevalence of bimaxillary proclination in a Nigerian study was reported to be 3.7% [16].

Associations were looked at because causations cannot be proven in cross-sectional studies. Both chi-squared and linear regression models showed ethnicity to be associated with bimaxillary prognathism, with Afro-Caribbean ethnicity being a predictor for the presence of bimaxillary prognathism and Indo-Caribbean ethnicity being a predictor for the absence of bimaxillary prognathism. A range of oral habits were also predictors of bimaxillary prognathism and were also associated with Afro-Caribbean ethnicity. This study showed no association between bimaxillary proclination and oral habits. This was in contrast to oral habits being reported as an etiologic factor by one author [3].

The prevalence of Class 2 division 1 incisor relationship was lower than that reported in White Caucasian populations [17]. The prevalence of Class 3 incisors was a lot higher than reported by most authors [17-20]. This is possibly a reflection of the high incidence of tongue sucking and tongue thrusting habits leading to proclination of the lower incisors. Class 2 division 2 prevalence was comparable to Isiekwe's findings in a West African population [18], and Class 1 incisor relationship was the most prevalent but less common than reported in most populations [17,18,21]. The decreased overbite in the population

reported was higher than previously reported [7]. This increased prevalence of this occlusal feature is however expected in populations where bimaxillary proclination is prevalent [1].

Use of lateral cephalometric radiographs is the most common method used to assess incisor inclination. Use of the TIP is a preferred non-invasive technique [11,12] and was shown to be effective for epidemiological surveys in this study. Lateral cephalometric radiographs have errors associated with landmark identification [27] and measurement of angles [27] and in addition, there is an increase in risk of mitotic changes with the radiation dose [11,28]. The TIP has been shown to be valid, reliable, simple, inexpensive and noninvasive method to ascertain incisor inclination [11,12] and would therefore be the preferred method to use in this type of field research.

These findings have a profound impact on the manner in which care is planned in this and similar populations. The Index of Treatment Need (IOTN), used extensively in the UK and Europe would appear to not be a useful measure of treatment need in this setting. Both the Aesthetic Component and Dental Health Component of IOTN are skewed against scoring class 3 malocclusion, reduced overbite and anterior open bite or bimaxillary proclination as features in need of orthodontic treatment [22-24]. The functional problems and occlusal loading found in Class 3 malocclusion are not considered in the index. In addition, the IOTN does not account for extra-oral features including bimaxillary prognathism, and other related soft tissue features [22,24]. Patients with these features present due to aesthetic concerns related to the bimaxillary protrusion and with functional problems associated with the combination of Class 3 and reduced overbite or open bite. In addition, there are also cultural differences in what is considered attractive. Africans and Caucasians have been shown to differ in their perceptions of dental aesthetics [25]. Ngom reported that Caucasian judges rated the dental aesthetics of African subjects lower than African judges in his study.

Therefore, we propose that IOTN is not a useful tool for planning allocation of resources in Trinidad and Tobago or similar mixed ethnicity populations where bimaxillary protrusion has a high prevalence. Ngom suggested that ICON was marginally better than IOTN for assessing treatment need [25]. Another alternative to IOTN is to conduct a full orthodontic diagnosis to assess treatment need, but this requires greater resources. Some authors have proposed a facial aesthetic index for subjects with bimaxillary protrusion26 and our findings would support this proposal. Further research is required in this field.

Conclusion

- Bimaxillary prognathism has a prevalence of 64.4% and bimaxillary proclination has a prevalence of 68.8% in Trinidad and Tobago.
- The prevalence is much higher in Trinidad and Tobago than reported in other studies
- There is evidence that there is an association between bimaxillary prognathism and ethnicity and a range of oral habits.
- There is no evidence that there is an association between bimaxillary proclination with ethnicity.
- There is an association between ethnicity and digit sucking, tongue sucking and tongue thrusting. Afro-Trinidadians were more likely to have all three habits.
- IOTN may not be the most appropriate tool for assessing treatment need in this and similar populations.

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Article

Prevalence and Occlusal Risk Factors for Fractured Incisors among 11–12-Year-Old Children in the Trinidad and Tobago Population

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Abstract: This cross-sectional survey was carried out to ascertain the prevalence of fractured incisors in 11–12-year-olds. In addition we explored the relationship with overjet, incompetent lips, incisor inclination and to determine if there was any association with ethnicity and gender. All permanent incisors were examined in 672 children comprising 356 females (53.1%) and 315 males (46.9%). The sample comprised 11–12-year-olds in high schools across Trinidad and Tobago. Statistical analysis was undertaken using Chi-square test, independent t-test, and binary logistic regression. The prevalence of fractured incisors was 18.9%. Boys presented with an increased incidence of fractured incisors than girls. 86.3% of dental trauma was untreated. The average overjet of subjects with fractured incisors was 4.2 mm. 18.62% of subjects with fractured incisors had incompetent lips. The most common malocclusion (18.81%) with fractured incisors was class 2 division 1. The Afro-Trinidadian ethnicity had the highest prevalence of fractured incisors (11.0%) when compared to mixed ethnicities, which was statistically significant. Maxillary central incisors were the most commonly injured teeth. Most patients delayed in seeking dental treatment for fractured incisors in our population. Early orthodontic treatment is recommended to help reduce the risk of dental trauma.

Keywords: cross-sectional survey; prevalence; occlusal risk factors; fractured incisors; Trinidad and Tobago

1. Introduction

Oral injuries are the fourth most common area of bodily injuries among 7–30-year-old individuals [1]. Dental trauma (traumatic dental injury) results from an impact to the teeth and/or other hard and soft tissues within and around the vicinity of the mouth and oral cavity [2]. These injuries are common in certain groups, no individual is ever at zero risk through their activities of daily living [2].

It is a serious condition among young children as dental injuries result in aesthetic, and functional problems involving the maxilla and mandible. Dental injuries can also cause psychological disturbances for the child, parent and the dentist.

Dental trauma presents as a public health problem and in some countries where caries have decreased, it can be considered the major risk to the anterior teeth [3,4].

The expense to the injured person and the community throughout the world has been substantial in terms of time and cost [2,5,6]. The average number of visits during one year due to sustaining dental trauma ranges from 1.9 to 9.1 [7]. It has also been discovered in Australia that only one-third of the patients presented for dental treatment within 24 hours of the injury, while the remainder delayed seeking treatment for varying times up to 1 year [8].

Trinidad and Tobago is a cosmopolitan country where according to the central statistical office, the three main ethnic groups are Afro-Trinidadian, Indo-Trinidadian, and mixed ethnicity. Bimaxillary proclination is the most prevalent malocclusion found in 68.8% of the population [9]. Clinical features of bimaxillary proclination include incompetent lips and an increase in overjet. In most societies, these features have been identified as risk factors for trauma [10,11].

Most studies however, have examined the relationship between incisor fracture and single features like sex, age, and overjet using univariate statistical methods.

The hypotheses for this cross-sectional study are

1. There is a high prevalence of fractured incisors in the Trinidad and Tobago society.
2. Fractured incisors prevalence is not equal in all ethnic groups in Trinidad and Tobago.
3. The is no gender predilection with fractured incisors in Trinidad and Tobago.
4. There is a high prevalence of occlusal risk factors for fractured incisors in Trinidad and Tobago.

Currently, there is little epidemiological data on dental trauma in Trinidad and Tobago. The aim of this study was to firstly, investigate the prevalence and occlusal risk factors for dental trauma in high school children in Trinidad and Tobago. Also, to asses any association with ethnicity and gender.

2. Patients and Methods

A cross-sectional survey was carried out on 672 high school children aged 11 to 12 years old in 141 public schools in the twin island republic of Trinidad and Tobago. These schools were located across the twin island republic representing both rural and urban populations during the period June 2013 to April 2016. This study is reported in accordance with STROBE guidelines.

The ethics committee of The University of The West Indies granted approval for this cross-sectional survey in April 2013. The Trinidad and Tobago Ministry of Education gave approval for the research to be conducted in high schools across the country. A letter was sent to school Principals requesting permission to conduct the research. Another letter was sent to parents asking for permission for their children's participation. Only students from whom consent was obtained from both parents and child were examined.

For the purpose of determining the adequacy of the sample size, the Chi Square analysis with fractured incisors and lip competence was treated as the main analysis. Using the G* Power (Fau et al. 2007) [12] it was calculated that a 2 × 2 Chi Square with 1 degree of freedom and our sample size of 672 achieved a power (to 7 decimal places) of 100% to detect medium effect sizes (w = 0.3) and 73.4%

power to detect small effects (w = 0.1). Accordingly, this study was more than adequately powered to detect all but the smallest effects.

Dental examination was carried out by a single dentist (TH) supported by a recorder. The students were seated on a chair in a well-lit area. Traumatic injuries to the incisors were recorded. Students who had already undergone previous orthodontic treatment were excluded from this cross-sectional survey so that orthodontic treatment for an unknown reason and as a confounding factor was removed.

The following data were recorded

- Patient demographics: Information included age, sex, ethnicity
- Trauma History: Trauma was recorded when there was
    - Fracture involving enamel
    - Fracture involving enamel and dentine
    - Fracture involving enamel and dentine and pulp
    - Discoloration of the crown as a result of traumatic injury (verified by an interview)
    - Presence of a restoration done on a tooth as a result of traumatic injury (verified by an interview)
- Skeletal Relationships: The patients were assessed in profile view into Class1, Class 11, Class 111.
- Morphologic malocclusion: The following were assessed with the subjects in centric occlusion.

1. Overjet was measured with a millimeter ruler as from the incisal edge of the most labial maxillary central incisor to the most labial mandibular central incisor distance to the occlusal plane.
2. Lip competence was evaluated with the lips in rest position and scored as competent once there was no strain. If lip strain was evident on closure the lips were scored as incompetent.
2. Assessment of malocclusion was done with teeth in centric occlusion, the relationship between the upper and lower incisors were assessed (British Standards Institute 1983).

3. Statistical Analysis

The data was analyzed using IBM SPSS Statistics for Windows version 22 (IBM Corp., Armonk, NY, USA).

Descriptive analysis was undertaken and statistical associations for dental injuries with sex, ethnicity, incisal overjet, lip competence and skeletal pattern were calculated using Chi-square test and independent t-test. These analyses were used to test associations between occurrence of occlusal features and dental trauma. Binary logistic regression was then performed to estimate the predictive value of ethnicity, overjet and lip competence for the probability of incisor injury.

4. Results

A total of 672 children across high schools in Trinidad and Tobago aged 11–12 participated in this cross-sectional survey. The overall prevalence of fractured incisors was 18.9%. Fracture of the upper incisors showed a prevalence of 18.5% and lower incisors 0.4%. Among the children who had experienced traumatic dental injuries to the teeth 86.3% of children had untreated fractured incisors. There were more girls (n = 356, 53.1%) than boys (n = 315, 46.9%). Boys (9.52%) experienced more fractured incisors than girls (7.58%) however, this difference was not statistically significant, $p > 0.05$.

Afro–Trinidadian ethnicity had the highest prevalence of fractures at 11.0%, the Indo-Trinidadian ethnicity had a prevalence of 6.19% and the Mixed ethnicity had the lowest prevalence, 5.93%. The differences in prevalence associated with ethnicity was however not statistically significant ($p = 0.15$).

18.62% of subjects with incompetent lips had fractured upper incisors compared with 8.54% with competent lips. This difference was statistically significant $p = 0.001$ (Table 1). The mean overjet of subjects with fractured incisors was 4.2 mm ± 2.1. The mean overjet of subjects in the non-fractured incisors group was 3.48 mm ± 2.01. An independent sample t-test for equality of means showed the difference with overjet between fractured and sound incisors was statistically significant $p = 0.03$.

Table 1. Relationship between fractured incisors and lip competence.

Lip Competence	Competence	Incompetence	Total
Fractured Incisors	45	27	72
Sound Incisors	482	118	600
Total	527	145	672
	P = 0.01		

Children with a class 2 division 1 incisor relationship were more likely to have a fractured incisor compared with other malocclusions (Table 2). The difference was statistically significant $p = 0.021$.

Table 2. Relationship between malocclusion and fractured incisor.

Incisor Relationship	Class1	Class 2 Division 1	Class2 Division 2	Class 3	Total
Fractured Incisor	33(10.54%)	19(18.81%)	0	20 (7.97%)	72
Sound	280	82	7	231	600
Total	313	101 P=0.021	7	251	672

Binary Logistic regression was suggestive of a relationship between fractured incisors and mean overjet, ethnicity (Afro-Trinidadian and Mixed ethnicity Trinidadian), and incompetent lips. The above were shown to be predictors of fractured incisors. The odds ratio showed that as the overjet increased the chances of a fractured incisor increased. This association was statistically significant, $p = 0.004$. In terms of ethnicity, moving from Afro-Trinidadian to Indo-Trinidadian the increase of fractured incisors was not statistically significant, $p = 0.59$. Comparing Afro-Trinidadians to Mixed ethnicity Trinidadians the difference in fractured incisors was however statistically significant, $p = 0.035$. Moving from competent to incompetent lips the odds of a fractured incisor increased and this was statistically significant, $p = 0.02$ (Table 3). Mean overjet, incompetent lips, and moving from Afro-Trinidadian to Mixed ethnicity Trinidadian were all statistically significant, $p < 0.05$. This suggests that you can make an educated guess if a subject is susceptible to incisal fracture based on these three parameters.

Table 3. Binary Logistic Regression model containing the variables, mean overjet, ethnicity, lip competence.

Explanatory Variable	B	Relative Odds	95% Confidence Limits for Relative Odds	Significance
Mean overjet	0.137	1.147	1.044, 1.260	0.004
Afro-Trinidadian to Indo-Trinidadian	-0.124	0.883	0.565, 1.381	0.587
Afro-Trinidadian to Indo-Trinidadian	-0.640	0.527	0.291, 0.955	0.035
Lips	0.704	2.022	1.286, 3.180	0.02

The 95% confidence interval showed that mean overjet and incompetent lips are the more significant predictors of dental trauma. The classification table showed that fractured incisors would be mis-classified in nearly all but 1.6% fractured incisor patients (Table 4).

Table 4. Classification Table showing predictive power of sample.

Observed	Predicted		
	Fracture		Percentage Correct
	No Fracture	Fracture	
No Fracture	542	3	99.4
Fracture	125	2	1.6
Overall Percentage			81.0

5. Discussion

The prevalence of fractured incisors in 11–12-year-old school children in Trinidad and Tobago was 18.9%. This is comparable to another study in the Caribbean on Dominican school children which found a prevalence of 18.1% [13] and in the United States which found a prevalence of 18% [14]. In other studies, the reported prevalence rates varied from 4.1% in Malaysian children [15] to 19.8% in Finish children [16]. Differences in sampling techniques and application of diagnostic criteria could be responsible for the varying prevalence rates among studies [17]. This study confirms findings in other studies that the maxillary

incisors were more often affected with traumatic injuries than mandibular incisors and maxillary central incisors were affected more than lateral incisors [14,18–20].

This is possibly due to the maxillary central incisors having a prominent position in the arch, this is in agreement with several studies [13,15,16,21,22]. Most of the children in this study did not seek treatment, 86.3% of the fractures were unrepaired. This confirms findings by other studies [13,23]. There are several possible reasons why a patient would delay in seeking treatment. This can be explained by the lack of pain or any symptoms, patients giving a low priority to their dental injuries, unavailability of dentist due to travel, sickness, or other commitments, long wait periods at the dental hospital and patients being unaware of dentist after hours service [8].

In this study, boys were affected by fractured incisors more than girls and this confirms the findings of numerous studies [14–16,24–26] but the difference was not statistically significant. Noteworthy is the Dominican study which reported higher levels in girls but this difference was not statistically significant [13]. One explanation for both results is the increased participation of girls in risk activities and sports [10].

In this study there was a higher prevalence of subjects of African descent with fractured incisors as in other studies [14,19]. However, the difference was not statistically significant.

The reported predisposing factors for dental trauma include an increased overjet, protrusion of upper incisors, lip incompetence, inadequate lip coverage and accidental proneness [1,10,24]. This study found 37.5% of patients with fractured incisors had incompetent lips which was significantly more than reported by other authors [27]. This confirms the opinion that persons with incompetent lips are more likely to injure their incisors [21].

Class 2 division 1 incisors where the upper incisors are protrusive were found to be more likely to have a fractured incisor compared to other malocclusions, also children with a mean overjet of 4mm and above were found to have a higher prevalence of fractured incisors. This study confirms the findings in other studies that children with protrusive incisors and an increase in overjet have a higher incidence of trauma [10,21,22].

The binary logistic regression model showed that mean overjet and incompetent lips had a clear association with fractured incisors but the predictive value was low.

Dearing [11] stated that children with an overjet greater than 6mm should receive prophylactic orthodontic treatment. Two methods of prevention of dental trauma are available, wearing of mouthguards and orthodontic treatment. Early orthodontic treatment before age 11 has been recommended to prevent dental trauma [10,20,28,29]. The benefits of early class 2 division 1 treatment have been documented in randomized clinical trials [29]. Noteworthy is that growth modification was the objective of this early treatment and with the growth modification there was a decrease in overjet. This early reduction in overjet greatly reduces the cost to public health care for dental trauma. Koroluk [29] reported 29.1% of patients at the start of his randomized clinical trial (before age 9) had already had incisor trauma. He asserted shortly after incisor eruption overjet reduction should begin. Other prevention techniques that can be undertaken by patients include wearing of mouthguards, seatbelts, protective gear and participation in oral health promotion [8].

Understanding the epidemiology of dental trauma in Trinidad and Tobago requires more local studies. Oral health programs should include education on the need to seek immediate treatment.

6. Conclusions

- Males presented with more dental injuries than females but this was not statistically significant
- Differences in prevalence with ethnicity were only significant when Afro-Trinidadian and mixed ethnic groups were compared
- The most common injured tooth was the maxillary central incisor

- Increased overjet and incompetent lips, were clearly associated with incisor trauma but their predictive value was low.
- Use of mouthguards and early orthodontic treatment are recommended in these patients
- Many patients delayed seeking treatment for their injuries.

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Research Paper

A cross-sectional survey to ascertain the prevalence of oral habits among eleven to twelve year old children in Trinidad and Tobago

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ABSTRACT

Objective: The aim of this study was to determine the prevalence of oral habits in eleven to twelve year old children in Trinidad and Tobago and to determine if there is any association with ethnicity and gender.

Design: Cross-sectional survey.

Methods: An epidemiological survey of 975 high school students (566 females (58.1%) and 409 males (41.9%)) was conducted. A questionnaire was developed to record information on the presence of oral habits. A clinical examination was also conducted at the school site. Statistical analysis was undertaken using Chi-square test and binary logistic regression.

Results: There was a high prevalence of oral habits. The overall prevalence of habits was 93%. 81.3% of children had a tongue thrust, 46.3% nail biting habit, and 34.9% digit sucking habit. Afro-Trinidadian subjects and female subjects were more likely to have habits with tongue sucking and lip licking in particular exhibiting a female Afro-Trinidadian ethnic predilection.

Conclusion: The prevalence of oral habits in eleven and twelve year old children in Trinidad and Tobago is high, with higher prevalence in females and Afro-Trinidadians with tongue thrusting being the most prevalent oral habit overall.

1. Introduction

A habit is a practice acquired by the frequent repetition of the same act, this occurs consciously at first, then unconsciously [(Moimaz et al., 2014)]. Oral habits can be defined as learned patterns of muscle contraction and they have a very complex nature[(Sharma et al., 2015)]. Oral habits can also be defined as any repetitive behavior pattern which utilizes the oral cavity. An oral habit in infancy and early childhood is normal, and is associated with the need to satisfy the urge for contact and security but should disappear between the age of 1 to 3 ½ years [(Dhull K et al., 2018, Majorana et al., 2015)]. Noteworthy, is that some situations may stimulate sucking habits, these include hunger, fear, physical and emotional stress[(Moimaz et al., 2014)].Oral habits can be classified as pressure habits, non-pressure habits, and biting habits. Pressure habits include lip sucking, digit sucking, tongue thrusting; non-pressure habits include mouth breathing; and biting habits

include nail biting, lip biting, and pencil biting. Pressure habits are mainly responsible for the deleterious effects on the occlusion. The persistence of deleterious oral habits play a significant role in altering the position of teeth, interarch relationships, and hinder the normal growth of the jaws. The persistence of these habits have little effect on a child's overall health. Function of the oral musculature in addition, has an indirect effect on the swallowing pattern [(Khan I, 2015, Melsen et al., 1979)]. There is a recognised association between oral habits and malocclusion [(Larsson, 1975)] and children with sucking habits are more likely to develop a malocclusion [(Moimaz et al., 2014, dos Santos et al., 2012, Bowden, 1966, Farsi and Salama, 1997, Mistry et al., 2010)]. The trident factors affecting digit sucking are frequency, duration and intensity and these correlate with the severity of the resulting malocclusion [(Majorana et al., 2015, Proffit et al., 2013)]. The duration of the force is more important than intensity; the resting pressure from the tongue, cheeks and lips are maintained most of the time and therefore has the greatest impact on tooth position [(Majorana et al., 2015)].

Prevalence of oral habits in the literature shows differences based on population, ethnicity and location or geography [(Sharma et al., 2015, Khan I, 2015, Farsi and Salama, 1997, Al-Hussyeen and Baidas, June 2009)]. It is reported to be influenced by a lot of factors including, education, gender, feeding methods, maternal occupation, rank of the child in the family, maternal age and socioeconomic status [(Al-Hussyeen and Baidas, June 2009)]. Al-Hussyeen et al [13] also reported a trend towards an increase in prevalence due to a change in family and social environment.

Epidemiological data regarding the prevalence of oral habits in Trinidad and Tobago is needed. Trinidad and Tobago is a developing nation where there are restraints due to the high cost of orthodontic treatment; it is important to recognize the need for orthodontic treatment not only according to severity but also to identify modifiable factors that can be managed through preventative orthodontics [(Moimaz et al., 2014)]. Prolonged oral habits have been shown to require significant health system resources for correction [(Borrie et al., 2013)].

The hypotheses for this cross-sectional study are

1. There is a high prevalence of habits in the Trinidad and Tobago society
2. Oral habits prevalence is not equal in all ethnic groups in Trinidad and Tobago
3. The is no gender predilection with oral habits in Trinidad and Tobago

This epidemiological survey was undertaken to determine the prevalence of oral habits among 11 and 12 year old children in Trinidad and Tobago and to determine if there is any association with ethnicity and gender.

2. Materials and methods

2.1 Sample

This survey comprised 1004 high school children. The sample size was determined from a prevalence

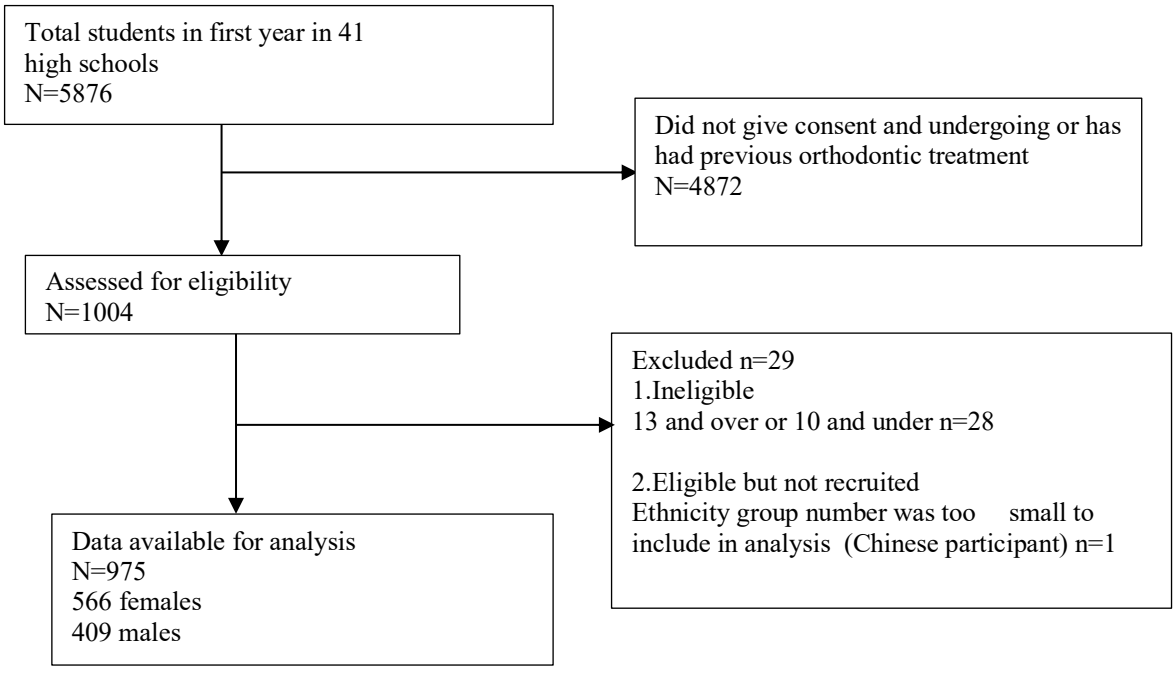

Fig. 1 - Flow diagram showing participants recruitment in study

Table 1 - Total and individual prevalence of oral habits in 11 to 12 year olds

Type of Oral Habit	Boys	Girls	Total	Chi-Square	p-value
Total	409 (41.9%)	566 (58.1%)	975		
Digit Sucking	126 (37.1%)	214 (62.9%)	340 (34.9%)	5.126	0.024
Tongue sucking	41 (26.3%)	115 (73.7%)	156 (16%)	18.718	0.000
Tongue thrusting	320 (40.2%)	473 (59.8%)	793 (81.3%)	4.442	0.035
Nail Biting	179 (39.7%)	272 (60.3%)	451 (46.3%)	1.759	0.185
Lip biting/licking	105 (31.9%)	224 (68.1%)	329 (33.7%)	20.529	0.000
Lip Sucking	8 (57.1%)	6 (42.9%)	14 (1.4%)	1.347	0.246

estimate of 40% and a population of 20,000 to give a confidence level of 0.95 and precision of 2.5 to be 1006 (Epitools epidemiological calculators. Ausvet Pty Ltd. Available at http:// epitools.ausvet.com.au). Of all the participants, 29 examined children were removed from the final sample. The final sample consisted of 975 children aged 11-12 years from 41 out of 141 high schools across the twin island republic of Trinidad and Tobago representing rural and urban populations, during the period June 2013 to April 2016. Figure 1 is a flow diagram showing participants recruitment in study.

2.2 Ethics

The ethics committee of The University of the West Indies gave permission to conduct the research. The Trinidad and Tobago Ministry of Education gave permission to conduct the cross- sectional survey in public high schools. A letter was sent to principals of high schools across the twin island republic requesting permission to conduct the research. Another letter was sent to parents asking for consent for their child to participate in the survey.

2.3 Inclusion and Exclusion criteria

Included in the study were males and females of all ethnicities including mixed race. Children who were attending school and had attained their 11^{th} or 12^{th} birthday by the day of examination were considered eligible for inclusion in the study. Children with a history of orthodontic treatment or undergoing orthodontic treatment at the time were excluded.

2.4 Method

This study is reported in accordance with STROBE guidelines.

A single examiner (TH) carried out all the interviewing and examinations. First, data regarding demographic profile, age, ethnicity, gender and history of orthodontic treatment was obtained through an interview with participating children. Presence or absence of habits like nail biting, digit sucking, tongue sucking and thrusting, lip sucking and biting were recorded via self report. The children were assessed for nail biting, digit sucking, tongue sucking, tongue thrusting, lip sucking, lip licking, lip biting. The children were then examined extra and intraorally in a well-lit room seated upright in a chair. Clinical examination was also done for the presence or absence of tongue thrust while swallowing and the digits and oral cavity were examined for signs of digit sucking. The collection of data by a single examiner aimed to reduce bias that could have occurred between different examiners.

2.5 Statistical Analysis

Prevalence of different oral habits was calculated using a statistical package (IBM SPSS Statistics for windows version 22 (IBM Corp., Armonk N.Y., USA)). Chi square was used to test differences in gender and ethnicity for statistical significance, a value of $p<0.05$ was regarded as significant. Forward entry binary logistic regression was used with the oral habit as the dependent variable and ethnicity and gender as explanatory variables. The model was checked for overall statistical significance and Exp(B) (odds ratio) and 95% confidence intervals calculated.

3. Results

The sample consisted of 566 (58.1%) females and 409 (41.9%) males . Eleven year olds comprised 15.6% and twelve year olds 84.4% with a mean age of 11.84 years. The sample included 451 Afro-Trinidadians, (46.3%), 343 Indo Trinidadians (35.2%) and 181 of mixed ethnicity (18.6%).

Tongue thrusting was present in 81.3% of children, nail biting in 46.3%, digit sucking in 34.9%, lip licking in 33.7%, tongue sucking in 16%, and lip

sucking in 1.4% (Table 1). Females were more likely than males to have habits. Sex wise prevalence showed girls were more likely to have these habits compared with boys (pvalue <0.05). Nail biting and lip sucking showed no statistically significant difference between the genders.

Table 2 - Association between Ethnicity and Oral Habits

Ethnicity	Digit sucking	Nail biting	Tongue sucking	Tongue thrusting	Lip sucking	Lip licking/biting
Afro-Trinidadian	165 (48.5%)	246 (54.5%)	104 (66.7%)	413 (52.1%)	3 (21.4%)	203 (61.7%)
Indo-Trinidadian	126 (37.1%)	118 (26.2%)	29 (18.6%)	230 (29%)	7 (50%)	68 (20.7%)
Mixed	49 (14.4%)	87 (19.3%)	23 (14.7%)	150 (18.9%)	4 (28.6)	58 (17.6%)
p value	0.051	0.000	0.000	0.000	0.170	0.000

Table 3 - Binary logistic Regression for Oral habits with gender and ethnicity

		B	S.E.	Wald	df	Sig	Exp(B)	95% C.I.	
								Lower	Upper
Nail biting	Gender (1)	-.146	.133	1.201	1	.273	.864	.666	1.122
	New Ethnicity			31.052	2	.000			
	New Ethnicity (1)	-.823	.148	30.905	1	.000	.439	.329	.587
	New Ethnicity (2)	-.271	.177	2.355	1	.125	.762	.539	1.078
	Constant	.244	.110	4.902	1	.027	1.276		
Tongue thrusting	Gender (1)	-.312	.173	3.259	1	.071	.732	.522	1.027
	New Ethnicity			68.082	2	.000			
	New Ethnicity (1)	-1.668	.205	66.152	1	.000	.189	.126	.282
	New Ethnicity (2)	-.836	.261	10.255	1	.001	.434	.260	.723
	Constant	2.526	.189	178.607	1	.000	12.507		
Finger sucking	Gender (1)	-.341	.139	6.037	1	.014	.711	.542	.933
	New Ethnicity			6.780	2	.034			
	New Ethnicity (1)	.021	.149	.019	1	.890	1.021	.762	1.368
	New Ethnicity (2)	-.469	.195	5.810	1	.016	.625	.427	.916
	Constant	-.411	.112	13.370	1	.000	.663		
Tongue sucking	Gender (1)	-.839	.198	17.892	1	.000	.432	.293	.637
	New Ethnicity			30.856	2	.000			
	New Ethnicity (1)	-1.166	.226	26.699	1	.000	.311	.200	.485
	New Ethnicity (2)	-.796	.252	9.953	1	.002	.451	.275	.740
	Constant	-.900	.129	48.789	1	.000	.407		
Lip licking	Gender (1)	-.647	.147	19.445	1	.000	.524	.393	.698
	New Ethnicity			52.767	2	.000			
	New Ethnicity (1)	-1.195	.167	51.334	1	.000	.303	.218	.420
	New Ethnicity (2)	-.613	.188	10.640	1	.001	.542	.375	.783
	Constant	.065	.112	.335	1	.563	1.067		

Table 2 shows the relationship between ethnicity and oral habits. Afro –Trinidadians were more likely to have habits and chi-square showed that this association was significant (pvalue <0.05).

The overall prevalence of habits was 93%. However, 68.6% presented with more than one habit and 36.4% presented with more than two habits.

All regression models with the exception of lip sucking (p=0.159) were statistically significant (p<0.01). The results of the regression models are shown in Table 3 for all significant models. For nail biting the odds ratio (Exp(B)) was statistically significant for ethnicity when comparing Afro-Trinidadians to Indo-Trinidadians (0.43995% CI 0.329,0.587) but not for gender. This means that in stepping from Afro-Trinidadian to Indo-Trinidadian the odds of nail biting were 0.4, that is reduced likelihood of the habit being present. For tongue thrusting the odds ratio for gender was not statistically significant, p>0.01,but for ethnicity when comparing

Afro-Trinidadians with Indo-Trinidadians was statistically significant (0.189 95% CI 0.126, 0.282) and Afro-Trinidadian to Mixed ethnicity was also statistically significant (0.434, 95% CI .260,.723), indicating moving from Afro-Trinidadian to Indo-Trinidadian to Mixed ethnicity there is a reduced likelihood of the habit being present. The smallest odds ratio was for the effect of ethnicity for a tongue thrusting habit where moving from Afro-Trinidadian to Indo-Trinidadian to reduce the odds of the habit being present by 0.189. These results were consistent with the findings of the chi-squared analysis.

4. Discussion

Tongue thrusting habit is attributed to the changeover of teeth in the mixed dentition often leading to open spaces anteriorly in the dental arch, thereby prompting a habit of tongue thrusting[(Sharma et al., 2015)]. Another author reported that tongue thrusting takes place because of delayed transition between the infantile and adult swallow pattern[(Kamdar and Al-Shahrani, 2015)]. Tongue thrusting was the most prevalent habit (81.3%). These findings agree with previous studies [(Sharma et al., 2015, Guaba et al., 1998)] but the prevalence was much higher in our sample than that reported in these studies. This can be explained due to the high prevalence of bimaxillary protrusion in Trinidad and Tobago, which is 68.8% of the population [(Hoyte, 2018)]. Several authors have noted the high prevalence of tongue habits in bimaxillary protrusion malocclusion [(Bills et al., 2005, Lamberton et al., 1980)].

Lip biting and sucking happens in almost all cases with the lower lip [(Vogel, 1998)]. Lip sucking and biting places a lingually directed force on mandibular teeth and labial force on maxillary teeth resulting in upper incisor protrusion [(Khan I, 2015)]. Lip biting can produce dryness and inflammation of the lip and in severe cases will cause vermillion hypertrophy and in some people chronic cold sore or lip crack [(Massler and Chopra, 1950, Shahraki et al., 2012)]. Thirty- five percent of children in this study had lip related habits (33.7% lip licking and 1.4% lip sucking). The prevalence of lip habits was considerably higher when compared to prevalence in other studies [(Quashie-Williams et al., 2010)]. Again, this may be accounted for as a higher prevalence of lip habits have been reported in bimaxillary protrusion [(Bills et al., 2005, Lamberton et al., 1980)]. Logisitc regression revealed an odds ratio of 0.52 for gender for lip licking / biting with males being half as likely to report this habit. This gender difference has not been previously reported specifically for this habit, but does confirm the predilection of females to show oral habits.

Nail biting does not result in development of a malocclusion since the forces involved are similar to those with chewing, it is more likely to cause inflammation of nail beds [(Khan I, 2015)]. Nail biting was the second most prevalent habit (46.3%) in our sample and again this was similar to some previous reported studies [(Shetty and Munshi, 1998)] but again was higher than reported in other studies [(Sharma et al., 2015, Garde et al., 2014)]. Nail biting or onychophagia is thought to be a response to psychological disorders and some children will change their habits from digit sucking to nail biting[(Shahraki et al., 2012)]. Nail biting is however often associated with anxiety, stress, and can cause self-inflicted gingival injuries, alveolar destruction, tooth wear and apical root resorption [(Shahraki et al., 2012, Leung and Robson, 1990, Krejci, 2000, Odenrick and Brattstrom, 1985)], but this data did not find an association with gender.

One quarter of patients with temporomandibular joint pain and dysfunction have a nail biting habit [(Odenrick and Brattstrom, 1985)]. More than half of children with nail biting habit have a psychological disorder such as depression [(Leung and Robson, 1990)]. Boys with nail biting are more likely than girls to have attention hyperactivity disorder (ADHD) [(Shahraki et al., 2012)]. Further research into possible causes for this common practice in this population is required.

Digit sucking can lead to an imbalance between external and internal muscle forces [(Garde et al., 2014)]. The effects of digit sucking include, lingual inclination of lower and labial inclination of upper incisor, increased overjet, anterior open bite, increased overjet, compensatory tongue thrust, deep palate, narrowing of the maxillary arch with posterior crossbite, speech defects, and finger defects such as eczema and angulations of the finger [(Shahraki et al., 2012)]. The prevalence of Escherichia coli and Enterobacteria among children with nail biting and digit sucking habits is much higher compared to children without these habits [(Shetty and Munshi, 1998, Baydas et al., 2007)]. Digit sucking was seen in 34.9% of cases this was again higher than that reported by other studies [(Quashie-Williams et al., 2010, Garde et al., 2014)]. There has not been a direct cause and effect between non-nutritive sucking habits and malocclusion the effects of habits seem to be superimposed on a genetic predisposition to malocclusion [(Borrie et al., 2015)]. The high prevalence seems to be a reflection of cultural and social differences between Trinidad and Tobago children and developed western countries, with increasing development this pattern is likely to decrease, however this was not affected by ethnicity.

Looking at ethnicity, in this study Afro-Trinidadians were more likely to have an oral habit, although this was not found for lip or digit sucking habits. In Indo-Trinidadians the likelihood of oral habits was reduced with odds ratios varying from 0.189 (CI 0.126,0.282) for tongue thrusting to an odds ratio for nail biting of 0.439 (CI 0.329,0.587) when compared to Afro-Trinidadians. Further research into the possible causes for this association with ethnicity is required.

This study like other studies showed females were more likely to have habits [(Garde et al., 2014, Lagana et al., 2013b, Kharbanda et al., 2003)] with possible explanations being educational structures, hormonal changes and diet [(Garde et al., 2014)] . In Trinidad and Tobago at this age the children would have just completed The Secondary School Entrance Exam (SEA) and girls tend to perform highly at this exam and this high level of performance could lead to high levels of stress thus possibly causing the high level of habits in girls.

Most of the children examined had at least one oral habit with 36.4% having more than two habits. This suggests that factors such as cultural or environmental beyond gender and ethnicity are influencing the development of habits, and this is supported by the low overall predictive power of the regression models.

Limitations to this study include the use of self-reported data collected during face to face interviews, where it is possible that the child may not have reported accurately but given what they felt was the expected response. This could explain in part the high reporting of habits in the study. Parents of children did not provide or confirm the information on oral habits provided by them. This study was designed to investigate the prevalence and association with gender and ethnicity of oral habits and was not designed to identify risk factors. Therefore, the results of the regression analysis need to be interpreted with care.

Conflict of interest

There is no conflict of interest.

Conclusions

- The results showed a high prevalence of deleterious oral habits in 11 and12 year old children in Trinidad and Tobago.
- The overall prevalence of habits was 93%. 68.6% of children presented with more than one habit.
- Tongue thrusting, nail biting and digit sucking were the most prevalent oral habits.
- Oral habits were more prevalent in girls and Afro-Trinidadians.

This highlights the need for community based educational preventative and interceptive strategies to prevent the deleterious effects of oral habits.

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