Out of the great number of faces that have been form'd since the creation of the world, no two have been so exactly alike, but that the usual and common eye would discover a difference between them.

William Hogarth (Landau 1989)

CHAPTER 1
INTRODUCTION

1.1 GENERAL

The classification of people has been high on the priority list since the early ages of man. In the early years scientists attempted to classify the human body and face into different types (di Giovanni 1919, Lessa 1943, Comas 1957). This science is called bio-typological classification. Studies in these early years based their classifications on various groups that the researcher could identify by looking firstly at the person's body. Today these classifications are not entirely applicable, but the modern classification systems borrowed certain elements from these early methods.

The face has for a very long time fascinated the human mind, even as early as three million years ago. In 1997, archaeologists found a cobblestone with the distinct markings of a face at Makapansgat, South Africa (Bates and Cleese 2001). Tests done by Robert Bednarik showed that the stone was carried 32 km to the cave by one of our ancestors and that the markings on the stone were natural. The only reason for this event seems to be the resemblance of the rock to a human face and the fascination of our ancestors with its appearance (Bates and Cleese 2001).

The most common recognisable feature of an individual must be the face. American and British research showed that nine minutes after birth, babies can barely focus their eyes, but they already look at faces. They especially look at the eyes of any face present, more than at any other object (Bates and Cleese 2001). The face is also used everyday for identification by the general public. Everywhere people are identified by looking at their faces. Remembering someone's face is most important, next to remembering the person's name.

The variety of faces that is seen throughout the world can, to the same extent, be attributed to the region of origin. The facial features differ between various regions, for example, the 'well-padded' faces of the Eskimos in colder climates and the slender faces of Manchurians (Landau 1989). For thorough research in the field of facial identification, facial features from all these various regions should be analysed.

The face is also important to scientists and authorities, especially in cases of missing persons or mistaken identities. The characteristics of the face can be used as a good identification method for the dead, missing and criminals. Using both morphological features and measurements, the face can either be reconstructed (identifying the dead), superimposed or compared to a facial photograph (mistaken identities or a missing person). The most common forensic application of the face must be identikit, where a victim or eyewitness compiles the face of a suspect.

1.2 APPLICATIONS OF FACIAL IDENTIFICATION

Facial identification is the study of the face for forensic purposes, using different analytic techniques such as metrical analysis (measurements) and morphological analysis (shape of the features). These techniques can be used for comparisons between two facial photographs, or between an actual face and a photograph. The dimensions and characteristics of the face on the two photographs are compared to investigate if it belongs to the same person.

Today facial identification is a very relevant topic, as more and more security cameras are installed in banks, airports etc. for continuous surveillance and access control (Fraser *et al.* 2003). This is especially true after the September 11th tragedy, resulting in tightened security and access control in public areas. In these areas facial identification is used in conjunction with information technology. A facial photograph is created from the video taken by the camera. A sophisticated computer program, consisting of mathematical models, is often used to measure predetermined landmarks on the face from this facial photograph (Hancock *et al.* 1998; Sinha 1998). These measurements are compared to an existing database, which allows only certain individuals access to buildings. These identification programs are useful with small databases, but are unfortunately not as effective with very large databases. As a result of the immense human variation seen in the facial area, a number of false "hits" is found with a large database. There are also difficulties with facial expressions and the angle of the face. This may alter the values of the measurements and could result in a false negative. Therefore access control systems using facial identification is more beneficial in conjunction with a small database, where the individuals are aware of the analysis, and they can keep their faces expressionless, as well as optimise the angle between their face and the camera.

As crime rates soar in South Africa, it also becomes increasingly necessary to identify suspects involved in fraud involving identity documents. The suspect often uses a false identity document with his/her own photograph to commit a crime. The prosecutor must then prove that the suspect and photograph, in the identity document, are one and the same person (i.e. positively matching an individual with his/her photograph). Comparisons are also often made between images of perpetrators captured by security cameras, e.g. those installed in a bank, and facial photographs of suspects (pers comm. Inspector JE Naudé). Facial identification systems in South Africa are not as advanced as in other parts of the world. Up to date, all the cases in South Africa had been done by comparing each photograph in a case individually. Since 1994, 253 cases, consisting of a minimum of 628 comparisons, were done in South Africa alone (pers comm. Inspector JE Naudé). Of these 253 cases, only 35 cases have gone to court. About 80% of these cases were done on people of African origin. Only 1-2% of the cases could not be done due to poor quality of the evidence.

One of these cases was on public violence. In 1998, 2500 people protested outside a building in Sandton, Johannesburg. Damages estimated at R6 million were done to public property, as the crowd got violent. Surveillance cameras, in front of the building, caught the faces of the unidentified individuals who started the revolt. The individuals were identified from these photographs and 13 were found guilty on account of public violence (pers comm. SAPS case number 41/675/99).

1.3 DIFFICULTIES

Personal identification from an individual's facial features is a daunting task, and is fraught with problems. A variety of methods, including superimposition and morphometrics, have been investigated. Two facial photographs are superimposed and compared with each other, when the superimposition technique is used. With morphometrics, the face is analysed by using measurements between predetermined landmarks, as well as morphological descriptions of the facial features. The landmarks and features analysed must, at all times, be visible on both the facial photographs/images used (Farkas *et al.* 1980; İşcan 1993; Fraser *et al.* 2003). This is not always possible with actual cases, which could hamper the outcome.

To analyse the facial features, one must have standards to compare each feature with and classify it as small/large, intermediate or narrow/wide. However, up to date most of the facial research has been conducted in the US and Europe, predominantly on their population groups (e.g., Penry 1971; Farkas 1994; Vanezis 1996). In 2003, Fraser *et al.* showed that facial analysis across different ethnic groups influences the results, especially if the investigator is not trained in the analysis of a certain ethnic group (Fraser *et al.* 2003). Therefore the faces of a group of African males cannot currently be analysed sufficiently, due to the lack of research on the facial characteristics of this population group.

Other problems exist, such as the lack of clear descriptions of the standard landmarks as well as a standardised photographic technique. If the landmarks do not have concise descriptions, the various measurements cannot be repeated reliably. The photographic technique should be adjusted for the population that is to be photographed. For example, it is advised to use an additional light source when taking photographs of black individuals as to increase the visibility of all the landmarks on the face.

1.4 AIM AND OBJECTIVES

The aim of this study was to analyse the faces of a group of African males, in an attempt to create a basis which characterizes the male African face. This data was also used to investigate whether a significant difference exists between the facial features of South African males and other population groups.

From all the existing metrical and morphological characteristics of the face, only those that were predetermined by the author as being usable and repeatable characteristics were chosen to be analysed during this study.

The objectives of this study were thus to:

1) analyse the faces of a sample of African males
2) identify the common and rare features of the population group by analysing individual characteristics and combinations of various facial features
3) compare the facial features of the South African male population to those of other population groups
4) suggest the use of the created combinations in situations where the face of the suspect is masked and only regions of the face are visible for analysis

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

Through the years scientists attempted to classify humans into different groups, to create order. Somatotyping was one of the earliest techniques used. This system used the characteristics of the human body for the purpose of classification. Although these techniques are not used anymore, some aspects were incorporated into the identification techniques used today. As this field of science developed, different parts of the body, such as the face, were used for identification. For this reason, a brief overview of the history of somatotyping will be given. The development of facial identification, from the incorporation of measurements and morphology, to the wide use of computers for the purposes of identification, will also be discussed.

2.2 BIRTH OF SOMATOTYPING

In the early years, scientists classified people into different groups by looking at the shape of a person's body. Hippocrates was one of the earliest scientists to classify the body into two fundamental physical types: the phthisic habitus, which had a long, thin body and the apoplectic habitus, which had a short, thickset body (Brock 1972). Not only did Brock use physical appearances to identify a person, but also their personalities.

The next set of classifications in the bio-typological field came from a French scientist, Lèon Rostan in 1826. He identified four constitutional types using anatomical considerations:

> "One of the systems almost always appears to dominate the rest. In some cases the circulatory or respiratory systems dominate; in others, the digestive

system appears to draw on the entire strength of the organism. In a third group we may observe the outstanding development of the nervous system, while still others are characterised by the predominance of the muscular system." (Comas 1957:321)

Rostan believed that some systems in the human body were more dominant than others and this could be used to classify people into different groups (Figure 2.1). According to the above system, the four constitutional types were circulatory, respiratory, digestive, cerebral and muscular (Comas 1957:322).

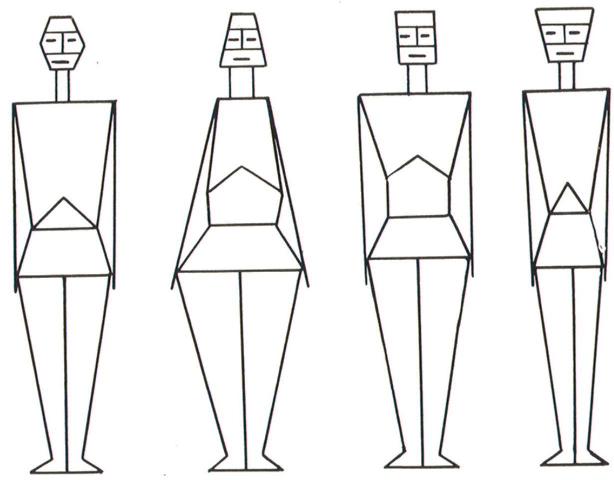


Figure 2.1: Schematic representations of the four constitutional types: Respiratory, digestive, muscular and cerebral (Comas 1957:327)

Much later, in 1923, French scientist MacAuliffe expanded Rostan's constitutional concept. According to MacAuliffe, the environment influences the different types greatly. Therefore he concluded that the respiratory type is mostly found among nomads, the digestive type among privileged social classes and regions where food was in abundance, the muscular type among physical workers and the cerebral type among mental workers. He also mentioned that these different types are not found in these clear groups, because of the different factors influencing the types, such as various hereditary factors. The definitions for each type are as follows

(Comas 1957:324):

a. The trunk has the predominant size in the upper half of the body in the **respiratory** type (Figure 2.2). The thorax is well developed in all directions. The face has a rhomboidal shape, because of the huge size of the respiratory zone.

b. In general the **digestive** type is 'all abdomen and jaw' (Figure 2.2). However, it still forms a body well in proportion. The neck is short and the shoulders narrow and sloping. The lower part of the trunk is larger, thus the bigger abdomen. The digestive zone of the face is the best developed of the three facial zones.

c. Strongly developed limbs and musculature is seen in the **muscular** type (Figure 2.2). The chest is well arched and the trunk is rectangular viewed from the front. The face of the person is square or rectangular with a longer vertical axis. MacAuliffe believed that the face could be studied by dividing it into three zones, by drawing a line through the eyebrows and a line through the base of the nose; the zones being cerebral, respiratory and digestive. In the muscular type all three these zones are well proportioned and equal. The hairline is rectangular, the eyebrows low and straight and may also be long and hairy. If present, the beard is thick and overall there is an abundance of body hair.

d. The cranial capacity is the main feature in the **cerebral** type, where it is bigger than the average sized face (Figure 2.2). The body of this physical type is shrunken. The cerebral zone of the face (region above the line drawn through the eyebrows) is the most prominent, and the face has a triangular shape. Viewed from the side, the forehead bulges. Facial hair is scarce and the digestive zone of the face (mouth and lips) is small. The overall appearance of this morphological type is short and thin.

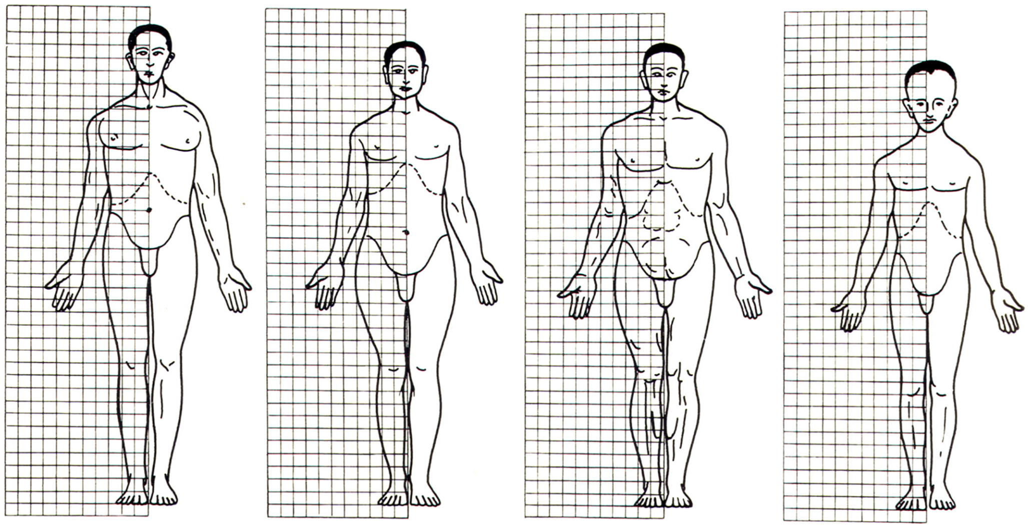


Figure 2.2: MacAuliffe's four constitutional types: Respiratory, digestive, muscular, and cerebral (Comas 1957:325)

Barbara (1934) based his work on trunk-limbs relationships. For the average human type the length of the trunk was equal to the length of the limbs. Barbara established five groups and also developed variations and intermediate groups, which enabled him to classify 100% of his subjects (Comas 1957:332).

Sheldon (1970) proposed his own set of constitutional types, based upon the development of the individual during the embryonic stages of life. According to him individuals could be classified into groups by looking at the differences between the degrees of development of the three embryonic layers. The three types are endomorphy (well developed derivatives from the endodermal layer), mesomorphy (mesodermal layer derivatives dominate the body) and ectomorphy (tissue derived from ectoderm dominates body).

Sheldon (1970) was the first to use photographs in his investigations. He standardised the photographing procedure, taking three pictures of each subject in three different positions, namely front, back and profile views of the whole body. The subject stood on a revolving pedestal with stops placed at 90º intervals. This enabled Sheldon to take photographs of the subject in three different positions, without the subject moving himself. Sheldon also had to make sure that the body would be free of photographic distortion, so as not to influence the measurements taken from the photographs. To do so he compared measurements from the photographs to measurements taken from the subject himself. The distance between the subject and the camera was accordingly adjusted to make both sets of measurements equal. Sheldon (1970) studied five different regions of the body and appointed a degree to the amount that each region contributed to the physique of the individual. Seven degrees were given to each region for the amount present. Number 1 was the least degree, 7 the maximum and 4 the midpoint. This method, using three numerical morphological components, is called the somatotyping of an individual. Sheldon used two systems for the investigation: visual evaluation (anthroposcopy) and measurements from the photographs (anthropometry). Comas stated that measurements taken from photographs, such as the diameter of the head, neck, trunk, arms and legs are more reliable than the same measurements taken on the person himself. Curved surfaces, on the other hand, cannot be measured accurately on a photograph. Of the 17 measurements Sheldon took, only two measurements were taken from the facial region. These included the facial breadth on the level of the junction between the ear pinna and the skin of the head as well as the facial breadth on the level just below the lobe of the ear.

Through the years some studies were done to investigate if a correlation exists between somatology and psychology and, if so, whether it can be used to classify individuals into various groups. Eppinger and Hess conducted studies in 1910 on the over-stimulation of different parts of the nervous system and the effects thereof on a person's health. In such cases pathological symptoms, presented due to the over-stimulation of the nervous system, were used for classification. Various groups could be identified from these symptoms, such as vagotonia (over-stimulation of the parasympathetic system) with slow breathing and digestive disorders (cited from Comas 1957).

Kretschmer (1921) was another scientist who studied psychosomatic classifications. He identified three main constitutions: the asthenic type (thin vertical body structure), the athletic type (tall and muscular) and the pyknic type (horizontal body structure).

During his studies Kretschmer used morphology to classify an individual. It became an important part of anthropology and the classification of humans. Between 1925 and 1927 different researchers e.g. Henckel, von Rohden and Weidenreich, used Kretschmer's constitutional types to classify the European Nordic, Dinaric and Alpine races. The three proposed constitutions were found in all the races. Later Kretschmer changed his three constitutions to only two, namely pyknic and asthenic (leptosomic) (Kretschmer 1925).

Pende (1928) also investigated the individuality of humans by describing his own four constitutional types: sthenic slender type (linear body with well-developed muscles), asthenic slender or hyposthenic-hypotonic type (linear body with narrow trunk), sthenic broad type (lateral structure with wide trunk) and asthenic broad or hyposthenic type (lateral body structure, high in weight).

2.3 DEVELOPMENT OF ANTHROPOMETRY

A. di Giovanni (1919) was the first scientist to use anthropometry for classification. He used standard characteristics and relationships to create different morphological combinations. The standard characteristics used were:

Stature (S) = Arm-span (As)

Chest circumference (Chc) = ½ S

Sternum height (Sh) = 1/5 Chc

Total abdominal height (Ah) = 2/5 Chc

Bi-iliac diameter (Bi) = 4/5 Ah

Various subjects were then classified using these characteristics in different combinations. Each subject had a different formula, according to the shape of his body. An example of such a formula for a specific morphological combination was:

"S < As; Chc < ½ S; Sh < 1/5 Chc; Ah = 2/5 Chc

Xiphiod-umbilical height > umbilical-pubic height; *Bi* < 4/5 *Ah*; small heart"

This combination is characterised by an underdeveloped thorax and abdomen, overdeveloped extremities and weak musculature. This is also characterised as the insufficient development of the respiratory system. Different combinations were used to create new formulae for other characteristics.

In 1931 Viola eliminated some of di Giovanni's (1919) measurements and created new ones. The first measurement to be eliminated was the arm-span. Instead he developed a group of measurements to describe and differentiate between the constitutional types, called the 'closed cycle' method. Ten basic measurements were taken from the whole body (Comas 1957:328):

1. Sternum length
2. Upper abdominal height
3. Lower abdominal height
4. Length of the arm
5. Length of the leg
6. Transverse thoracic diameter
7. Antero-posterior thoracic diameter
8. Transverse hypochondric diameter

9. Antero-posterior hypochondric diameter
10. Bi-iliac or transverse pelvic diameter

All the above-mentioned measurements can be divided into two groups: vertical (1-5) and horizontal (6-10) measurements (Figure 2.3). Using these basic measurements Viola formed three compound measurements (cited from Comas 1957):

1. **Stature**

   Taken from subject, measured with anthropometer
2. **Trunk height or suprasternal-pubic height**

   Sum of measurements 1, 2 and 3
3. **Total abdominal or pubic-xiphoid height**

   Sum of measurements 2 and 3

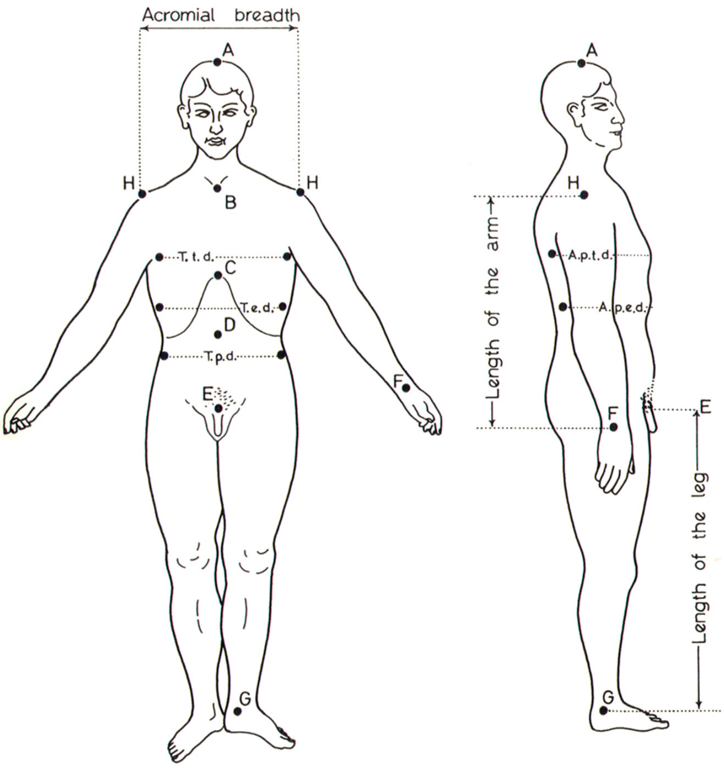


Figure 2.3: Points and measurements used to determine constitutional types according to Viola (Comas 1957:329)

Viola also calculated a number of indices (cited from Comas 1957):

1. Thoracic index = 1 x 6 x 7
2. Upper abdominal index = 2 x 8 x 9
3. Lower abdominal index = 3 x 9 x 10

4. Total abdominal index = sum of upper and lower abdominal indices
5. Trunk value = sum of the thoracic and total abdominal indices
6. Limbs value = 4 + 5

To determine the constitution of an individual, the relationship between the following pairs of measurements and indices must be determined (Comas 1957:330):

I	**II**
Trunk value	Limbs value
Trunk value	Suprasternal-pubic height
Antero-posterior diameters	Transverse diameters
Total abdominal index	Thoracic index

Three different constitutions can be identified i.e. normosplanchnic (where I = II), macrosplanchnic (brachymorphic), where the indices and measurements in column I are the greatest and microsplanchnic (dolichomorphic), where the indices and measurements in column II are the greatest.

2.4 <u>USING MORPHOLOGY OF THE FACE FOR CLASSIFICATION</u>

In the past, before the advent of DNA technology, morphological characteristics were extensively used in cases of disputed parenthood and also in the solving of crimes. The methodology used today relies heavily on the facial characteristics defined by these early researchers, although the application is, of course, different. One of these researchers is Spurzheim (1833), a phrenologist during the 16th century. The scientists of this century believed that the bumps, shallows and shape of the skull reflected the individual's thoughts, therefore putting the mental and moral standing of the individual under scrutiny. During studies conducted by the phrenologists, it was postulated that some bumps on the skull, which were said to control combativeness, destructiveness and acquisitiveness, were mostly found in thieves and evildoers. It was recorded that criminals had larger heads, heavy eye-ridges, receding foreheads, big jaws and muscles of mastication in constant motion.

Even as late as May 1924 these scientific theories were used in the case against Leopold and Loeb, who killed a 14-year old boy (Masters and Kennedy 2003). These theories were published together with the photos of the accused individuals (Figure 2.4). With this the scientists tried to explain the criminal characteristics found in the facial morphology of the two perpetrators. Ten characteristics were marked on the face of 18-year old Richard Loeb, which included:

1. Depth of brain – show above-average intellectual capacity
2. Length of forehead – show person to be reflective
3. Heavy eyebrows – person has jealous and passionate nature
4. Slightly bulging eyes – show unusually good memory
5. Outline and humps on nose – show executive ability
6. Long distance from tip of nose to base – inquisitiveness
7. Slight up curve at corners of straight mouth – individuals who always get their own way
8. Narrow mouths in relation to the width of the face – show pettiness of character
9. Depth of chin – show determinedness to succeed
10. Feminine jaw curve – show an individual that relies more on intuition than reason (Masters and Kennedy 2003)

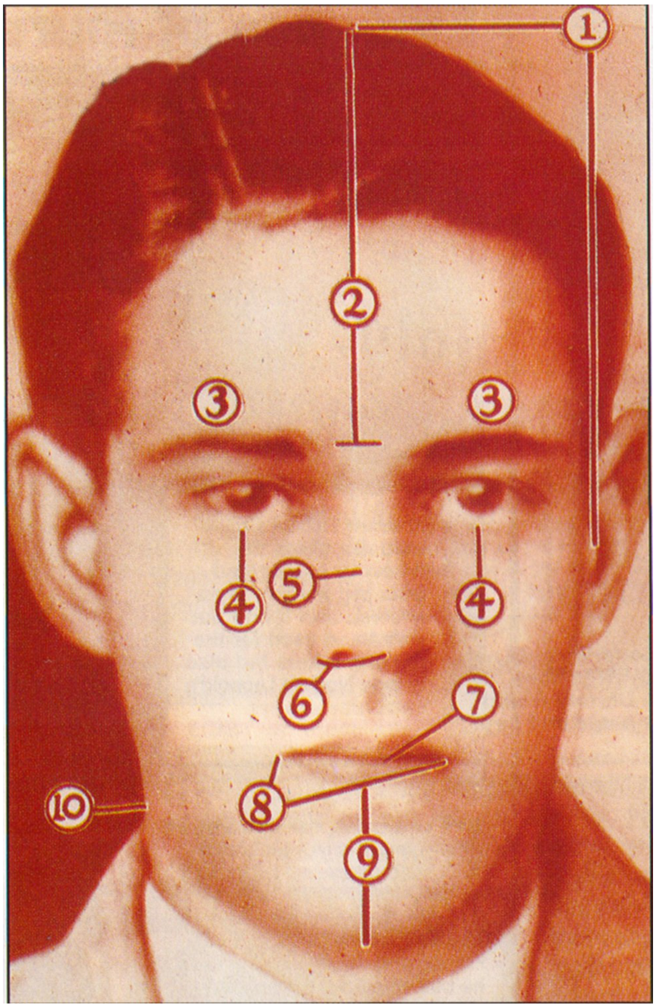


Figure 2.4: Facial markers used in the Leopold and Loeb-case in 1924 (Masters and Kennedy 2003)

Another scientist, Cesare Lombroso (1911), believed that some human beings are born as criminals. He concluded that criminals have a lack of morals and seeing that children don't understand morals, they must be criminals too. Not everyone accepted this way of thinking (Bonger 1943). Lomborso stated that the born criminal type had various anomalies, which could be identified. These include cranial and facial asymmetry, receding forehead, large ears, square projecting chin, broad cheekbones, left-handedness, etc. Lombroso (1911) noted that a person with 5 or more of these characteristics was definitely a criminal; a person with 3-5 characteristics was considered a partial criminal and a person with less than 3 characteristics normal. In 1911, Lombroso studied known criminals in jail and he concluded that 93% of the criminals studied showed more than three characteristics.

Two scientists, Goring (1913) and Hooton (1939), investigated Lombroso's findings. Goring found that the convicts in England's prisons were shorter in stature and lower in body weight than the normal citizens. Hooton described the morphology of the criminal, in relation to a civilian, as being smaller in overall size, lower in weight, having a smaller head with a broader, shorter face and straighter hair. The jaw was narrower and the ears small and broad.

In 1943, Lessa and De Greeff (Lessa 1943) contradicted the previous studies by measuring the stature, arm-span and weight during their study. They also investigated facial and cranial anomalies, shape of the ear, nose, mouth etc. They concluded that there is no such thing as "criminal morphology".

The theories discussed here are obviously no longer accepted today, but modern facial identification techniques still borrow from some of these early classifications in order to describe the morphology of an individual.

2.5 CLASSIFYING RACE: THE HISTORY

Previously scientists used the differences in morphology of faces to divide people into particular groups. According to Coon (1965) a general term for these groups was "races". Coon, Garn and Birdsell (Coon 1965) developed a classification system, which they called a "functional classification". This was based on the status of each race regarding evolution, body build and special surface features, such as skin colour, hair type etc. Coon (1950) and Garn (1955) later used a modified version of this classification. Much later, in 1968, Coon described races looking at the effect of aging on different morphological features. He identified 2 groups namely pedomorphic (keep infantile features through life) and gerontomorphic (mature features appear early in life).

Renato Biasutti (cited from Coon 1962) divided his racial system into 4 sub-species (Australoids, Negroid, Mongoloid, Europoid and derivative races), 16 primary and 52 secondary races.

Barnett (1970) divided the human species into three groups, mostly based on the structure of the hair. These groups were Negriforms, Europiforms and Mongoliforms. A smaller fourth group was also mentioned, namely the Australiforms. The Australiforms were proposed as a separate group because of the mixture of morphology visible in the group.

People from different population groups have different morphological characteristics, which can be used for identification. According to Barnett (1970) the greatest variety of racial morphology must be found in the face and hair.

All of the above-mentioned statements are solely based on external visible traits such as skin colour, facial features and the shape and size of the body. These statements were popular during the 19^{th} and 20^{th} century. We would like to distance ourselves from these statements and the controversial topic of race. At present, much controversy exists around the subject of race, its existence and if it can be successfully determined (Brace 1995; Williams *et al.* 2005). The statement by the AAPA (American Association of Physical Anthropologists) concerning race is widely accepted (AAPA 1996). This statement maintains that all humans living today belong to the same species, *Homo sapiens*, and share a common descent. The biological differences present between human beings are only due to hereditary factors, influenced by natural and social environments (AAPA 1996). Due to these factors, some physical differences can be seen between populations living in different geographic areas of the world. It is these differences that are currently used by anthropologists during forensic identification.

2.6 FACIAL STUDIES DONE ON PEOPLE OF AFRICAN ORIGIN

To date, two studies were done on facial morphology in Southern Africa. The first was a study done, using facemasks, to analyse the facial features of the Kuanyama Ovambo and Heikum Bushmen, both found in South West Africa (Eriksen 1954). The facial features were divided into primary (dominant) and secondary (less dominant) features and classified into a maximum of seven categories. These included Negro, Bush, Boskop, Mediterranean, Armenoid, Mongoloid and Nordic. The second study was done on the urban and rural Venda male population (de Villiers 1970). De Villiers investigated facial morphology for other applications than classification or identification. De Villiers' objective with this study was to determine if there are any differences between the facial morphology of rural Venda males and urban Venda males.

Herskovits (1970) studied the physical form of the "American Negro". During his study he also investigated the possibility that the subject might be from a mixed origin. This complicated the study, as mixture between populations would influence the physical form. Herskovits (1970) used different traits on living people for his investigations. He used measurements and morphology to classify the different traits all over the body, but this brief discussion will only focus on the traits used in the face and head region. These traits include nose width, lip thickness, width of the face and ear measurements – to name but a few. He did not consider using the shape of the hair as a trait, as more and more hair products were being used by all population groups.

Herskovits (1970) measured the length and width of the head using a spreading calliper. The length measurement was taken from the glabella, the most prominent point on the midline of the face between the eyebrows, to the opisthocranion, most posterior point of the head (point furthest away from the glabella). The width of the head was measured from euryon to euryon (two most widely separated points on the sides of the head). Using these measurements, he calculated a cephalic index. He compared the measurements of the American Negroid to the African Negroid and found that the American Negroid measured higher in both measurements. Comparing the cephalic index, the American Negroid was found to be less dolichocephalic than the West African groups. This means that the American Negroid's head is a little wider than the West African groups. Other measurements taken include the minimum forehead width (between the two lineae temporales), distance between the inner and outer corners of the eyes and interpupillary distance (between midpoints of pupils). Herskovits found the distance between the inner corners of the eyes to be characteristic to Negroid individuals (flat nose bridge with great distance between eyes). Measurements taken from the nose include the height (from nasion to subnasale), width (points on the alae farthest apart from each other) and depth (from subnasale to pronasale – tip of nose) of the nose. The height of the nose of the American Negroid was compared to that of the African Negroid, and it was found that the noses of the Americans were higher.

Three measurements were taken from the face: upper facial height (from nasion to prosthion), total facial height (from nasion to gnathion) and bizygomatic width (between two points furthest apart of each other on the cheeks). Compared to the "African Negroid", the "American Negroid" had larger dimensions in all the facial measurements, indicating that they were generally more robust than the African population. The width of the mouth was measured as the distance between the two corners of the mouth. The mouth was divided into a right and left side for the measurement of the thickness of the lips. Only the right side was measured. A measurement was also taken in the centre of the lips, between the labiale inferior and labiale superior. It was found that the Africans generally had thicker lips than the Americans. Herskovits (1970) also measured height and width of the ears. Compared to the "African Negroid", the "American Negroid" was smaller in both measurements. With his study, Herskovits wanted to investigate the origins of the "American Negroid" (a "racially crossed" group) and how these different origins affect various traits. After his study, Herskovits came to the conclusion that the traits investigated in the "American Negroid" population varied "according to the amount of racial mixture present in the subject". When the same traits were compared to the "African Negro", the Europeans (white) and Indian groups, the "American Negroid" mostly fell between the African Negroid groups and the White-Indian groups.

Similar to what is found in skeletal studies, it is thus clear that people from different continents and of different populations vary to a great degree. It is therefore necessary to have population specific standards when it comes to studies of identification (e.g., Todd and Lindala 1928; Cobb 1942; Giles and Elliot 1962; Curran 1990; Gill and Gilbert 1990; İşcan and Steyn 1999; İşcan *et al.* 2000).

2.7 FACIAL IDENTIFICATION

Facial photographs can be used to identify an individual. This method is commonly used today. Most of the documents used by a person contains a photograph of him/herself – licenses, gym cards, ID documents etc. Because it is so widely used, it can lead to criminal activity (falsification) of the various documents. This thus leads to the necessity of being able to identify a person from his/her facial photograph.

When comparing photographs, the facial morphology is analysed using different methods. The procedure of comparing two facial photographs, or alternatively a person with a photograph, is called face mapping (Clement and Ranson 1998). Four different identification methods currently exist when facial photographs are used namely superimposition, morphological characteristics, anthropometrical measurements and morphometrics (combination of morphology and measurements).

2.7.1 Superimposition

This method compares two known images with one another (Aulsebrook *et al.* 1995). Photographic superimposition involves tracings or overlays of two photographs, where the "face" of the individual is fitted over that of the suspect. For the most part, only the outlines of the face are used. A positive identification of the individual is more likely with more reference points used on the two images. Two photographs can also be faded into or wiped over each other when a mixer, a monitor and video cameras are used. Superimposition will not form part of this study, and will therefore not be pursued here.

2.7.2 Morphological characteristics

Morphology of the face can be analysed and compared between two facial photographs. Different features of the face are described morphologically and classified into relevant categories. The categories of two or more photographs are then compared to find a match.

The knowledge of facial shapes is important when using morphology to describe a face for identification purposes. The description of the face must be clear and concise. Penry (1971) divided the face into different morphological regions – each with different classes or categories. He investigated faces by looking at each one of the morphological characteristics and then classifying them into appropriate classes (category). Three general shapes were identified for the facial outlines, namely angular (▼), rounded (●) and mixed (▼ and ●). Two faces can have the same outlines, but the other facial features can be different, which changes the face entirely. To classify the rest of the facial features, the face was divided into sections using the guidelines described below. The lines of a face with normal proportions are as follows (Figure 2.5):

- The head is horizontally divided into four equal parts; top of head to normal hairline, hairline to medial inferior border of brows, brows to base of nose, base of nose to lower chin margin.
- The face is thus horizontally divided into three equal parts; normal hairline to brows, brows to base of nose, base of nose to lower chin margin.
- The distance between base of nose and lower chin margin is horizontally divided into three equal parts. The stomion (middle of the mouth) is then approximately one-third of the distance measured from the base of the nose.

These lines are used to classify the facial features. For example, the ears measure one-third of the facial length. If a face is then divided into three equal parts and the ears are more than one-third, the ears will be classified as big. In the same manner the distance between the eyes as well as the proportion of the forehead, mouth, nose etc. can be classified (Penry 1971).

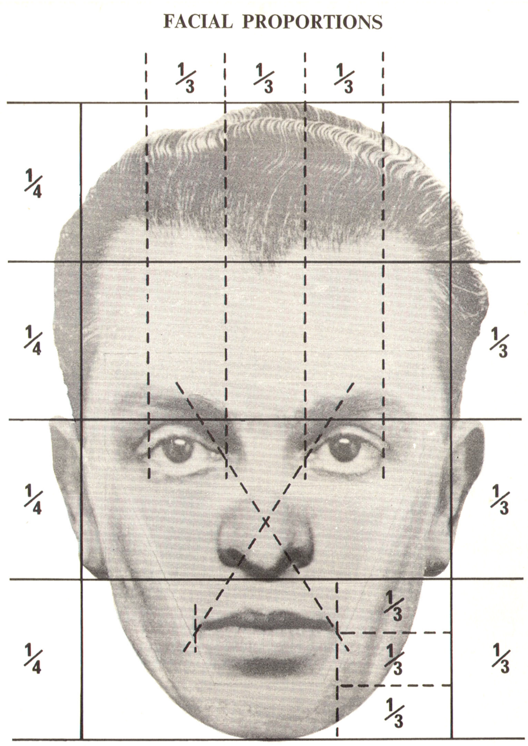


Figure 2.5: Penry's guidelines on the proportions of the face (Penry 1971)

Various other facial characteristics were classified, for example the eyes were divided into very large, large, medium, narrow, bulging, deep-set, slanting up, down-slanting, hooded etc (Figure 2.6).

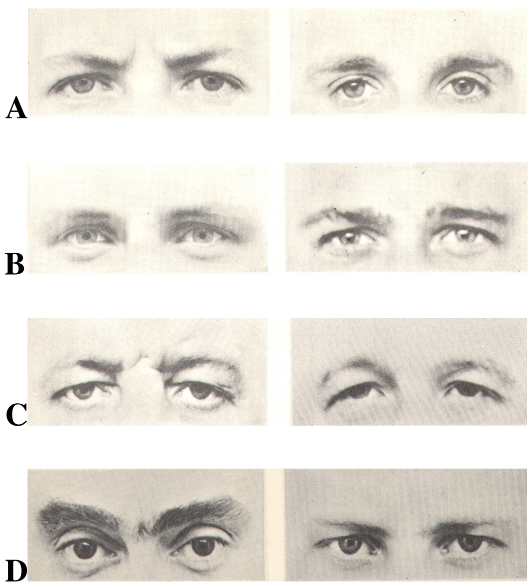


Figure 2.6: Some variations of the type of eyes according to Penry (1971): A-medium to large eyes, B-narrow, deep-set eyes, C-down-slanting eyes and D-eyes slanting upwards.

During his studies, Penry (1971) developed a system called PHOTO-FIT, which was used by the police and other security organisations in London. The system consisted of groups of photographs taken from the five sections of the face: Forehead/hair, eyes, nose, mouth and lower outline of the face (chin). A database was created from these photographs and people wanting to identify a face of an assailant, could then use these photographs as references to 'build' the face.

According to İşcan, it is preferable to use original photographs for comparisons. The distance between the camera and the subject must be taken into account when taking photographs for the purpose of comparison. This is important as a greater distance between the subject and the camera may cause the face to appear rounder than it actually is. The angle of the face is also very important as this too can affect morphological analysis of the face. İşcan produced a scoring sheet (Table 2.1 in appendix A) for people of European extraction, in which various morphological characteristics of the face can be analysed (İşcan 1993).

Features chosen for comparison must be clearly visible on the photographs and be consistent for the longest time throughout the aging process. According to İşcan and Loth, features that can easily be changed, such as length of hair and beards, should be avoided. Sites recommended for comparative use are the eyes (interpupillary distance), nasion or glabella, the tip of the nose, the base of the chin and ear shape (İşcan and Loth 2000). In a study conducted by these authors, 50 sets of photographs of Caucasian males were analysed using 39 facial features selected from Table 2.1. It was found that classifying height and width dimensions without fixed points, using only judgement from the observer, were the most unreliable. Facial shape was found to be more reliable and also repeatable (İşcan and Loth 2000).

Morphological analysis of the face can be used to classify various facial features according to the frequencies with which they occur in a population. Vanezis *et al.* developed a scoring sheet (Table 2.2 in appendix B) for Caucasian males in 1996, based on different facial features (Vanezis *et al.* 1996). The scoring sheet was adapted from original scoring sheets developed by Hammer (1978). Variable features, such as colour of hair and facial hair, were not considered for this sheet. Vanezis decided, after the analysis of the photographs, to exclude features that were difficult to classify by different observers. Such features included the classification of the length of the forehead without using any measurements.

2.7.3 Anthropometric measurements

The third method of facial identification involves various measurements taken between different facial landmarks. Indices are used to classify the features, not absolute size as enlarging the photographs can alter it. Most of the basic research in this field was done by craniofacial and maxillary surgeons, but can still be applied.

Hrdlička (1939) described measurements and indices for the whole body, but only those in the facial region will be discussed. According to Hrdlička, two measurements can be taken for the facial height, namely morphological height, from the lower margin of the chin to the nasion (menton-nasion) and physiognomical height, from the lower margin of the chin to the hairline (menton-crinion). Height of the forehead is the difference between the two previous measurements. Face breadth is the maximum measurement between the two zygomatic arches. The bigonial diameter is the measurement between the two bony landmarks on the lower margin of the mandible (Hrdlička 1939). Measurements of the nose and mouth include nose height (nasion-subnasion), nose breadth (maximum breadth between two alae without applying any pressure) and breadth of mouth (between angles of mouth where mucous membrane join skin) (Hrdlička 1939).

Using these measurements Hrdlička (1939) adapted indices, created by Martin and Saller in 1914, to calculate the proportion of different features of the face. Some of the indices included the cephalic index (cranial breadth / cranial length *100), total facial index (menton-nasion height / diameter bizygomatic maximum *100), ear index (ear breadth / ear length *100) etc. Hrdlička did his study on faces as well as skulls. For some of the indices, Hrdlička created standards. An example would be the nasal index. Three standard categories (leptorhinic, mesorhinic and platyrhinic) were used. The standard values for the head (face) were higher than those done on the skull, because of the presence of soft tissue. While Hrdlička's measurements were taken directly from a living subject, and not a photograph, the methodology can still be applied today.

Although his studies of facial morphology were not aimed strictly at facial identification, Farkas (1994) did a lot of work on the morphology as well as measurements from the face. He studied 2326 Caucasian subjects, 235 Mongoloid subjects and 132 Negroid (African-American) subjects, all with ages ranging between newborn and young adult. Studies were done on living subjects using morphology and measurements. Farkas created some of his own measurements and used standard measurements from a variety of landmarks on the face. Vertical, horizontal, perpendicular and angular measurements were used to analyse the face from different angles. The landmarks used include measurements of the:

Head (vertex, glabella, frontotemporale, etc.)

Face (zygion, gonion, gnathion, etc.)

Orbits (endocanthion, orbitale, palpebrale superius, etc.)

Nose (nasion, alare, subnasale, etc.)

Lips and mouth (labiale superius, stomion, cheilion etc.)

Ears (superaurale, porion, tragion, etc.)

During the 70's Farkas *et al.* (1980) conducted a study comparing the reliability of measurements taken from photographs to those taken directly from a face. The measurements included linear distances, inclinations and angles. Out of 104 direct anthropometric facial measurements, 62 measurements were possible from the photographs (frontal and lateral views). From these measurements, only 21 measurements were reliable, as three measurements were consistently longer, 22 were consistently shorter and 16 measurements were mixed in length. A measurement was considered reliable if the average difference between the direct and indirect measurement was less than 1 mm or 2 degrees. Considering the reliable measurements, most were found to be in the area around the lips and mouth. Of all the different measurements, inclinations proved to be the most reliable. No accurate measurements of the ears were registered. Farkas attributed the low accuracy rate to photographic distortion and its effect on the measurements taken (Farkas 1980). From these results it seem as though it is problematical to directly compare measurements taken from photographs, to those taken from living subjects.

Another study was done by Hajniš *et al.* using direct anthropometry (Hajniš 1994). A variety of measurements were taken from each subject. The subjects represented three different races, namely the North American Caucasians, the Chinese and the African-Americans. During the study, the three different races were compared to one another using some of the measurements taken from the craniofacial complex. The morphology of the different races was documented, in order to assist those involved with restoration of the craniofacial complex. These are shown in Table 2.3.

Table 2.3: Facial comparison between races using measurements (Hajniš 1994)

	North American Caucasians (n = 103)	**Chinese (n = 60)**	**African-American (n = 100)**
Cephalic index	Mesocephalic (medium wide-long)	Hyper-brachycephalic (short-wide)	Dolichocephalic (long-narrow)
Facial index	Mesoprosop (balanced facial frame)	Mesoprosop (balanced facial frame)	Leptoprosop (longer than wide)
Intercanthal index	Small	Large	Small
Nasal index	Narrow	Narrow	Chamaerrhin (wide-short)
Nasal tip protrusion	Largest	Smallest	Medium
Mouth index	Medium	Smallest	Largest
Lower and upper vermillion line	Upper smaller than lower	Upper larger than lower	Well-balanced
Ear width	Medium	Narrowest	Widest
Ear index	Large (narrow-long)	Medium	Small (wide-short)
Ear length-facial index	Long ear in relation to face	Medium	Short ear in relation to face

2.7.4 Morphometrical methods

Morphology of the face can also be combined with measurements into one analytic procedure to create a more reliable method of facial identification. Porter and Doran (2000) conducted a study on identification from photographs using forensic photography and anatomy. Enlargements from original identification document photographs were analysed and compared to photographs of known criminals, suspecting to be the same individual. The original smaller size photograph proved to be more difficult to measure and compare accurately. The use of a magnified photograph can be critical to the validity of the anatomical comparisons, as more detail can be seen on the enlarged photographs. Porter and Doran (2000) found that, to ensure the accuracy of the measurements, the distance between the two pupils on the photograph should preferably be 6 cm or more. According to the authors, this allows greater accuracy and measurement resolution.

These authors analysed four different components on each photograph:

1. Individual facial characteristics (moles, scars etc.)
2. Morphology of facial features (size and shape of nose, mouth, etc.)
3. Facial symmetry
4. Anthropometric measurements

Tracings were made from the outline of the face and some features in the face (nose, mouth, eyebrows etc.) of each photograph. The different features were then compared individually and in relation to the face (Porter and Doran 2000).

Porter and Doran also used anthropometric measurements for comparison, similar to what was done in previous studies (Clement and Ranson 1998; Porter and Doran 2000; İşcan and Loth 2000). For this component, standard anthropometric orientation lines were drawn over the photograph (Porter and Doran 2000).

The six lines are:

*Horizontally through the pupils

*Vertically at right angles at the midpoint of the previous line

*Horizontally through the oral fissure (where the lips meet)

*Horizontally through the midpoint of the ears

*Vertically at the widest points of the alae (wings of nostrils)

*Vertically at the widest point of the mouth on the oral fissure line (Figure 2.7)

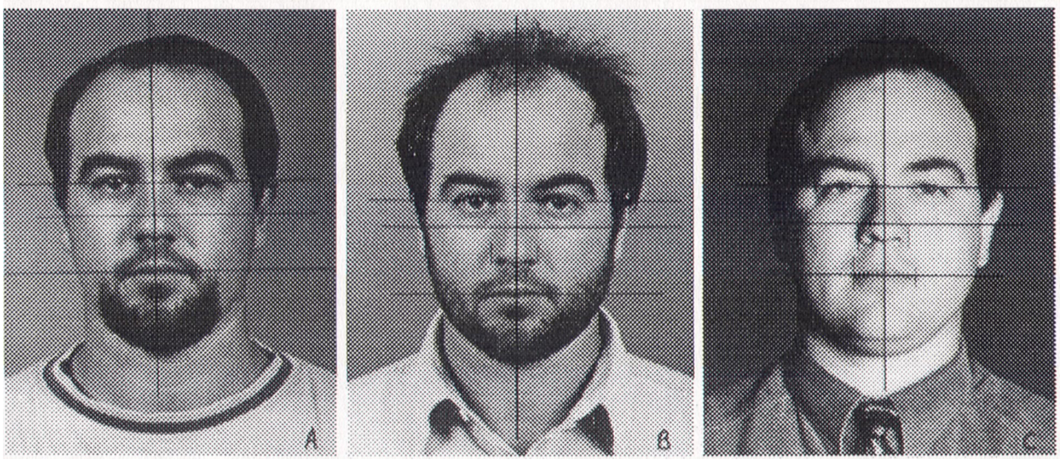


Figure 2.7: Anthropometric orientation lines on the face (Porter and Doran 2000)

During this study the measurements were taken between different landmarks; only on the horizontal lines, with a digital calliper to the nearest 0.05 mm. According to the authors measurements taken from the vertical axis should be avoided, due to the distortion found on this axis. The above-mentioned method has proven valuable for several law enforcement agencies in Australia (Porter and Doran 2000).

İşcan (1993) also used measurements in his research to classify the features of the face into different morphological classes. The use of measurements increases the repeatability of the procedure and decreases subjectivity. The use of measurements on photographs is called photoanthropometry (İşcan 1993; İşcan and Loth 2000). Different landmarks on the face are used to create measurements, which will later be used in indices. The proportions of the face are then analysed instead of absolute size. The different landmarks used must be visible on both photographs and marked on both photographs. Usually standard landmarks are used, but other landmarks may be used if they are repeatable and well defined. Different measurements can be taken between different landmarks, for example width and height of the mouth. From these measurements, indices are created as follows:

Smaller dimension/larger dimension*100

Indices are used instead of the actual measurements to calculate the proportions of the face (Porter and Doran 2000; İşcan and Loth 2000). Different morphological classes are then created from the indices, to describe the proportions of the face.

2.8 FACIAL IDENTIFICATION AND ITS FORENSIC APPLICATION

Facial identification plays an integral part in forensics, especially when combined with information technology (IT). From the late 90's to the present day, technology developed in such a way that scientists incorporated the use of surveillance cameras and computers for the purpose of facial identification. Rösing (2000) stated that for facial identification from a surveillance camera, one should make comparative pictures with the same camera, and compare the photographs, not the living person to the photograph. This ensures that both the images are two-dimensional and that the same landmarks and facial areas will be visible on both photographs (Rösing 2000).

The use of computers, to some extent, solved the problem of faces being at different angles on the photographs and the difficulty of calculating indices from these photographs. Researchers in Japan developed a face-to-face video superimposition system using 3D measurement apparatus (Yoshino *et al.* 2000). The system consists of a computerised superimposition unit and a 3D-range finder, which measures the facial surface on the left and right hand side with two CCD (closed circuit digital) cameras. Together the two CCD cameras can record 220 degrees around the face. With this wide recording, the ear shape and other data measured on the ear can also be included in the comparison. Morphological comparison and anthropometrical analysis of facial images in different angles are possible with this system. When trying to identify an individual, the 3D image of the person is stored in the computer and the photograph of the "suspect" is scanned into the computer where it is converted to a 3D image. The distance between the surveillance camera and the "suspect's" face is taken into account to keep the distortion on the 3D image to a minimum. The 3D facial image is adjusted to the same position and size as the 2D facial image by comparing seven anatomical and/or anthropometrical points on both images, which include both the pupils, nasion, pronasale, stomion and the left and right subaurale on the ear.

After the adjustments, the images are superimposed by wiping and fading mode. During this comparison, fifteen anthropometrical points are marked on both images and compared to one another. Depending on the orientation of the faces, up to eighteen points can be chosen for comparison. The distance between two different points and the angles between three or more points are measured on each image. The images are then superimposed to compare the distances and angles. This system is very objective in the sense that it uses anthropometrical data as well as superimposition for the comparison of a face to a photograph.

Until recently this system was only successfully tested on Japanese subjects, but in 2003 Fraser *et al.* used the system in a study analysing Japanese as well as Caucasian faces. The Caucasian subjects were all males from Australia. Each subject was paired with a subject with the same ethnicity and age. This was done using information from a questionnaire. For example, if Caucasian subject A was 22-years old and had parents with an Irish background, then he was paired with subject B of the same age and also an Irish background. All the Japanese subjects were randomly paired as all of them were of the same age and ethnic group. A 2D-image (photograph) was taken of each subject in frontal and oblique left views. The 2D-image of subject A was then compared to the 3D-image of subject B using 14 different anthropological landmarks on the face. The images were superimposed using the subnasale as the standard point. The results showed that this system could be used to identify Japanese subjects from any angle. The Caucasian subjects were best identified from the oblique images, where identification was done with 100% confidence. A large amount of overlapping occurred when comparing the frontal photographs of the Caucasian subjects with this system (Fraser *et al.* 2003).

A variable to consider when comparing two facial photographs, is the difference in conditions when each photograph was taken. Faces can change either by natural aging or artificial disguise, such as wigs, hats etc. A system developed in India called SPAN (symmetry perceiving adaptive neuronet) works with facial images changed either by artificial disguise or natural aging (Sinha 1998). SPAN works with the symmetry of the face to analyse unclear facial features. The user can choose the features or area that should be analysed on both the source image (suspect) and target image (individual compared). SPAN then processes the source image so that it can be superimposed onto the target image. The system must be 'trained' before each comparison. Features are chosen from both photographs and stored before the comparison can start. The points marking the features can be moved, if it is not anatomically correct. The different features selected for comparison of photographs in artificial disguise are, for example, the four corners of the eyes, mid-nasal point, sub-nasal point etc. The suspect (source image) was identified positively with the first test run of the system.

Using different facial expressions, the corners of the eyes matched in each comparison. Individuals were also positively identified, when comparing photographs of an individual taken over a period of time (natural ageing). Although the facial features changed, the ratios of the features stayed the same throughout the years. Other facial features easily identified by SPAN include the hairline boundary, forehead, eyebrows, eyelids, mouth, lips, chin and a great deal of wrinkles. SPAN can be successfully used in cases of missing persons as well as on personal identification documents. The photographs used must have a nearly frontal view to be successfully identified (Sinha 1998).

In the U.K., the Home Office implemented a program called F.A.C.E.S (Facial Analysis Comparison and Elimination System). This program takes facial photographs of individuals in a crowd. These facial photographs are then compared to a database of known criminals, using pattern recognition techniques, to either recapture or locate a known criminal. SPAN can be used in these cases to compare the two faces with each other (Sinha 1998).

Asymmetry can also be used for facial identification. Individuals in the general population display a wide range of variation in the amount of facial asymmetry. *Intrinsic facial asymmetry* in individuals is affected by multiple factors including growth, injury and age-related change. Viewing orientation, illuminations, shadows, and highlights cause *extrinsic facial asymmetry*. Liu *et al.* (2003) used two different facial databases to prove that intrinsic facial asymmetry could be used for identification. The first database used was the FERET face database, which consists of only frontal views of faces, with slight variation in expression. According to these authors, this database proved that intrinsic facial asymmetry could be used for automatic human identification across different databases.

The second database used by these authors was the Cohn–Kanade AU-Coded Facial Expression Database (video sequences of subjects of different races and sexes with different facial expression), which proved automatic human identification under variation of expression using facial asymmertry (Liu *et al.* 2003). The location and movement of the facial muscles play an important role during expression changes. Not much difference can be seen on the face when looking at anger and disgust expressions. This is due to the location of the muscles involved in these expressions. The muscles are located close to the midline of the face and therefore only create small changes to the face. On the other hand, muscles for expressions of joy are located to the side of the face, where more movement and change to the face can be observed. From this it can be deducted that expressions of joy increase asymmetry on the face, more than expressions of anger or disgust. To analyse the faces, three points were chosen to represent the midline of the face (midpoint between the two inner canthi and the philtrum). These three points were then monitored through different facial expressions, using the Lucas–Kanade algorithm. The comparison is then completed using other mathematical models (Liu *et al.* 2003).

Identix, a computer company situated in the USA, recently launched a web-based facial recognition-matching platform (2003). The ABIS (Automated Biometric Identification System) is designed primarily for passport agencies, interior ministries and motor vehicle agencies that face the task of sifting through millions of images to find duplicates before issuing an ID, as well as law enforcement agencies that rely on facial searches for investigations. The Department of State, Consular Systems Division in the United States of America, is currently using the product in a pilot study to process passport and visa applications in order to eliminate duplicates.

The outlines of a face can also be used for identification. For this method a Hausdorff distance measure is used (Guo *et al.* 2003). A Hausdorff distance measure is the *minimum-maximum* measurement of an object. It measures the extent to which two images (faces) are similar or different to one another based on their edge maps. Because the face has different regions and some are more important than others in identification, a Hausdorff distance was especially designed for the human face. Results show that the recognition rate with this method is very successful.

Hancock *et al.* (1998) did a comparative study to analyse the differences between two facial identification systems and the perception of humans. The two systems used different techniques for facial identification. The first was a system designed by Pentland *et al.* (1994) that is based on principal components analysis (PCA) of the pixels found in the image. The second system is based on graph-matching of Gabor wavelets and was designed by Wiskott *et al.* (1995). The effect of hair on the identification process was tested with both the systems. This feature has great variation from different styles to being completely absent, which can influence the identification process (Herskovits 1970; Vanezis 1996). Differences in hair affected the identification with the PCA system, as the hair was also included in the calculation of the pixels. The graph-matching system wasn't affected by a change in hair at all, since the grid was only placed over the face and did not include the hair. The changes in hair also affected the human perception of the face (Hancock *et al.* 1998).

In South Africa, unfortunately, none of these sophisticated and expensive systems are available, and facial identification is done on an individual case-by-case basis (pair matching) of two photographs (pers comm. Inspector JE Naudé).

2.9 FACIAL IDENTIFICATION CASE STUDIES

Not many case studies could be found in the relevant literature. The case studies that were found are briefly discussed.

Comparison of facial photographs for the purpose of identification was used in a court case as early as 1871. In 1854 Lady Tichborne's son, Sir Roger Tichborne, disappeared while on an overseas vacation. The mother never believed that her son was dead. Eleven years later a man in Australia, known only as the "Claimant", claimed that he was the missing son. Facial photographs of the "Claimant" and a much younger Sir Roger Tichborne were compared during the court proceedings. In 1874 the jury found the "Claimant" not to be Sir Roger Tichborne and found him guilty of perjury (Coleman and Simmons 1994).

In 1987 İşcan was called to Israel as an expert witness in a trial of an accused Nazi concentration camp guard, Ivan Demjanjuk (İşcan 1987). The difficulty with this investigation was that only an old I.D. photograph of the now aged soldier was available to compare to a retired autoworker, which resembled Demjanjuk. Therefore facial photographs of Demjanjuk, at different ages, had to be compared with the old ID photograph of the soldier. The size and shape of the ears were used during this case. It was found that the retired autoworker was not Demjanjuk (İşcan 1987). İşcan was also involved in other cases involving facial identification from photographs, in Toronto, Canada in 1990 and Florida, USA in 1992.

Facial identification was also used in the case concerning Donald Stellwag in Desember of 1991 (Boell and Haerpfer 2001). A German facial identification expert, F Rösing, formed part of the team working on this case. Donald Stellwag was wrongly arrested for a bank robbery. Comparing his facial photograph to the face on the surveillance camera proved his innocence.

Since 1994, 253 cases, consisting of a minimum of 628 comparisons, were done in South Africa alone (pers comm. Inspector JE Naudé). Of these 253 cases, only 35 cases have gone to court. About 80% of these cases were done on people of

African origin. Only 1-2% of the cases could not be done due to poor quality of the evidence.

One of the most important facial comparisons done in South Africa has to be the facial comparison of ex-president Mr. Nelson Mandela. In 1986, Scope magazine published a photograph in an advertisement. The eyes of the person were blocked with a black strip, but it was thought to be the photograph of Nelson Mandela, a political prisoner at the time. It was illegal to publish photographs of political prisoners. Captain Curlewis compared the published photograph (Figure 2.8A) with a facial photograph of Nelson Mandela (Figure 2.8B). Using the indicated landmarks and morphological features on both photographs, it was proved that the published photograph was indeed that of Nelson Mandela and the magazine was fined. This was the first facial comparison in the history of South Africa (pers comm. Inspector JE Naudé).

Figure 2.8: Facial comparison done on Nelson Mandela: A-published photograph, B-photograph used for comparison (photographs courtesy of Inspector JE Naudé, SAPS)

CHAPTER 3
MATERIALS AND METHODS

3.1 MATERIALS

This study is descriptive in nature. Facial photographs were taken of a group of African males in order to analyse their facial features. Subjects that qualified as participants were African males between the ages of 20 – 40 years. Subjects younger than 20 years were excluded, as growth is not completed at that age. Subjects older than 40 years were also excluded as changes due to old age are already present in these subjects. Individuals with facial deformities were excluded as this can influence the measurements taken from the photographs.

The Student Ethics Committee of the University of Pretoria granted permission for this study to be performed, with the provisions that only non-recognisable parts or partial sketches of the subject's faces are published and the photographs stay the property of the author alone. Informed consent was obtained from all subjects for their participation in the study, before any data was collected. Each participant received a number to connect him anonymously with his age and home language. The participants could choose the applicable home language from all 11 official languages of South Africa. These parameters may be useful in future studies. All information obtained during the course of this study was held strictly confidential. Participants had the choice of participating in the study and not have any part of their photograph published. All volunteers gave permission to publish parts of their photographs.

Two hundred volunteers from the Pretoria Police College took part in the study. Two photographs were taken of each of the 200 participants, one from the front (norma frontalis), and one from the side (norma lateralis). For this purpose, the faces of the participants were orientated to be in the Frankfurt plane. The Frankfurt plane is achieved when the lower margin of preferably the left orbit of the eye and the external auditory meatus form a straight, horizontal line (Martin and Saller 1957). With this positioning, a standard was created where the optimal length of the face was visible. An upward or downward tilt will affect the actual length of the face. Measurements taken over the width of the face will not be affected if the face is tilted up or down, but will be greatly affected if the face is turned laterally (İşcan and Loth 2000). This makes this technique widely applicable as most ID photographs are taken in the same position, with only slight differences in the orientation of the face. For this study only the frontal photographs (norma frontalis) were used. The lateral views will be kept in case of follow-up studies.

3.2 PHOTOGRAPHY

The photographs were taken at the Pretoria Police College under the supervision of the investigator and with the help of photography experts of the Department of Anatomy, University of Pretoria. Two cameras were used to take the photographs used in this study. The first camera was a SONY digital still camera; model DSC-P52, with a focal length of 6.30 mm. The second camera was an OLYMPUS OPTICAL CO., LTD; model C2500L with a 9.20 mm focal length. Both the cameras were positioned on tripods and placed at a distance of 1 m from the backboard. The position of the tripod on the floor was marked and fixed. The cameras were thus placed as close as possible to the backboard, allowing only enough space for the subject on a chair, as the face may appear rounder at a greater distance between camera and subject (İşcan and Loth 2000).

On the backboard, a radial and square grid was placed, allowing for positioning of the subject in the middle of the frame (Figure 3.1). The subject was seated on a fixed chair with their head against the backboard. The head of the subject was positioned on the centre line of the grid. Height of the cameras was adjusted in each case to align with the approximate centre of the face of the subject (nasal area) and a photo taken. Distance between the subject and the focal length of the camera was not adjusted between photographs.

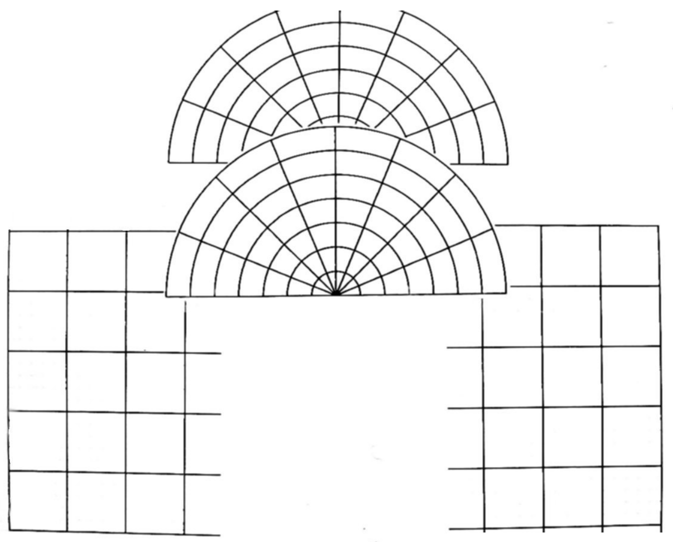


Figure 3.1: Radial and square grid on the backboard

Facial features on the photographs were analysed combining two different techniques, namely measurements and morphology.

3.3 <u>METRICAL ANALYSIS</u>

All the photographs were investigated to determine which of the standard biometric landmarks found on the face were visible on most of the photographs. These landmarks were then used as fixed points for the measurements (Martin and Saller 1957, Knussmann 1988, İşcan 1993, Clement and Ranson 1998, İşcan and Loth 2000). The following standard landmarks were used for the taking of the facial measurements (Figure 3.2)

1. Vertex
2. Trichion
3. Glabella
4. Nasion
5. Endocanthion
6. Exocanthion
7. Alare
8. Subnasale
9. Labiale superius
10. Stomion
11. Labiale inferius
12. Gnathion
13. Cheilion
14. Zygion

The landmarks used in this study were chosen because of good visibility on most of the photographs and that will give minimal error when measured. All the landmarks used in this study are standard facial landmarks, previously defined by Martin and Saller (1957). A description of each landmark, from authors such as Farkas (1981, 1994), adapted from Martin and Saller, is as follows:

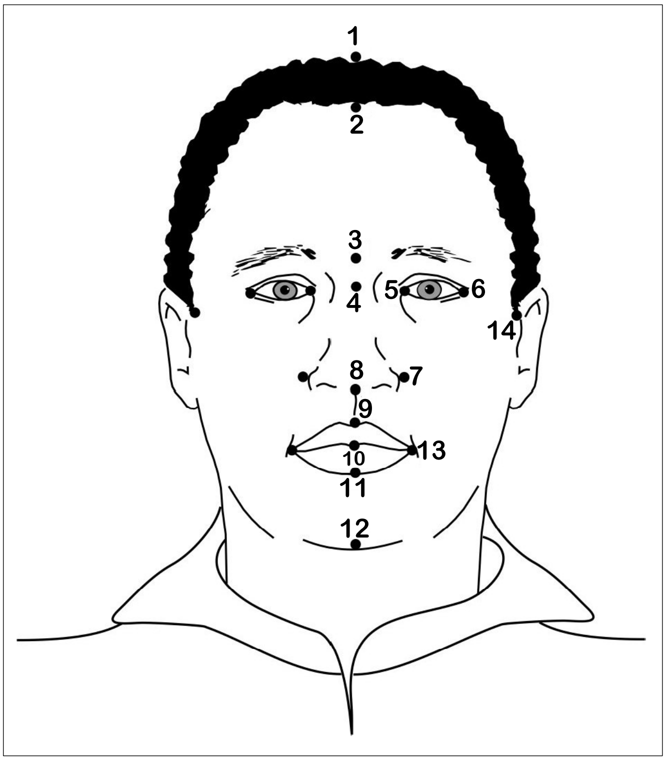


Figure 3.2: Biometric landmarks of the face used in this study (1 = vertex, 2 = trichion, 3 = glabella, 4 = nasion, 5 = endocanthion, 6 = exocanthion, 7 = alare, 8 = subnasale, 9 = labiale superius, 10 = stomion, 11 = labiale inferius, 12 = gnathion, 13 = cheilion, 14 = zygion)

3.3.1 Landmarks

3.3.1.1 Vertex (v)

This is the highest point of the head when it is placed in the standard Frankfurt Horizontal plane (Farkas 1981). The vertex is not visible if a considerable amount of hair is present.

3.3.1.2 Trichion (tr)

This is the point on the hairline, in the middle of the forehead (Farkas 1981). The landmark cannot be identified on a bald head or a head where all the hair has been shaved off. In this study the landmark was not used if the subject was bald or had a shaven head.

3.3.1.3 Glabella (g)

The glabella is the most prominent point on the midline of the face, between the eyebrows (Farkas 1981). If the glabella is not clearly visible and the subject has thin eyebrows, the top border of eyebrows can be used as reference to the position of the glabella. If the glabella is not visible and the subject has thick eyebrows, the middle of eyebrows can be used (Farkas 1994).

3.3.1.4 Nasion (n)

This landmark is found on the midpoint of the nasal root. The landmark is always above the level of a horizontal line connecting the two endocanthions (Hrdlička 1943). This was also true for this study population, although the distance from the horizontal line varied.

3.3.1.5 Endocanthion (en)

Point at the inner commissure of the eye fissure, where the upper and lower eyelids meet medially. This landmark is just lateral of the bony landmark (Farkas 1981).

3.3.1.6 Exocanthion (ex)

Point at outer commissure of eye fissure, where the upper and lower eyelids meet laterally. This landmark is slightly medial to the bony exocanthion (Farkas 1981).

3.3.1.7 Alare (al)

Most lateral point on the alar contour of the nose (Farkas 1981). This landmark is the most lateral point on the lateral borders on each of the two nostril wings of the nose.

3.3.1.8 Subnasale (sn)

This landmark is found where the lower border of the nasal septum meets the surface of the upper lip (Howells 1937).

3.3.1.9 Labiale superius (ls)

Midpoint of upper vermilion line of upper lip (Farkas 1981). This landmark is found on the midpoint of the upper lip, where the mucous membrane of the upper lip joins the skin.

3.3.1.10 Stomion (sto)

The point where a vertical line through the middle of the face crosses a horizontal line through the cheilions of the mouth (Farkas 1981).

3.3.1.11 Labiale inferius (li)

Midpoint of lower vermilion line of the lower lip (Farkas 1981). This landmark is at the midpoint of the lower lip, where the mucous membrane of the lip joins the skin.

3.3.1.12 Gnathion (gn)

Lowest median landmark on the lower border of the mandible (Farkas 1981).

3.3.1.13 Cheilion (ch)

Point at each labial commisure, where the outer borders of the upper and lower lips meet when the mouth is in standard position (mouth lightly closed, molar teeth in occlusion, no smiling) (Farkas 1981; Knussmann 1988).

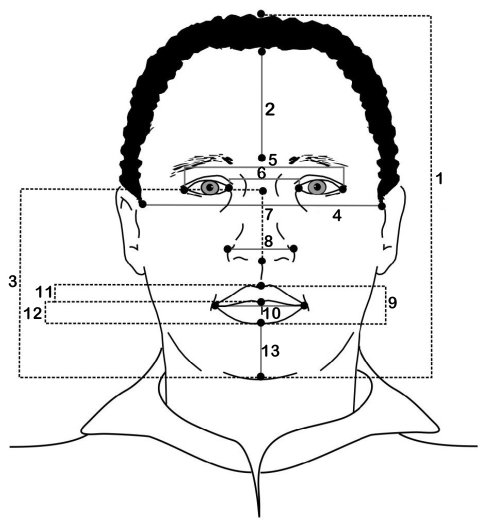
3.3.1.14 Zygion (zy)

Most lateral point on each zygomatic arch, widest part of the face below the level of the eyes. This landmark is found by trial measurement. Measurements are taken from the photograph on different levels below the eyes. The landmark is found with the widest measurement (Gosman 1950).

To keep the procedure as objective as possible, only landmarks that was clearly visible and had the potential for good repeatability, were used. Landmarks found on the ears and some landmarks of the eyes were excluded. The landmarks on the ears were excluded because of poor visibility on the anterior-posterior photographs. Because of the great variability seen in the sample, landmarks on the superior and inferior eyelids (used to calculate the size of the eyes) were excluded. Light and the reaction to the photograph taken, caused some of the subjects to close or partially close their eyes during the taking of the photograph. This made the use of some of the landmarks on the eyes impossible. Some of the landmarks used are situated on a round surface, such as the alare of the nose and others may be covered by a skin fold, such as the endocanthions and exocanthions of the eyes. These may affect the precise location of the landmarks (Farkas et. al. 1980). But Farkas (1980) pointed out that only small errors are made when using the landmarks on the nose and eyes. These landmarks were therefore included in this study.

3.3.2 <u>Measurements</u>

Various measurements were taken from the photographs and used to calculate indices. These measurements were taken directly from the photographs. They were measured to the nearest 0.5 mm, using a sliding digital calliper. Thirteen measurements were taken from each photograph between the predetermined facial landmarks (Figure 3.3).



1	gn - v
2	g - tr
3	gn - n
4	zy - zy
5	ex - ex
6	en - en
7	n - sn
8	al - al
9	ls - li
10	ch - ch
11	ls - sto
12	li - sto
13	li - gn

Figure 3.3: Measurements taken from each photograph

A brief description of each measurement follows:

3.3.2.1 Gnathion to vertex (gn – v)

This is a vertical measurement, combining the height of the head and the face (Farkas 1981).

3.3.2.2 Glabella to trichion (g – tr)

This is a measurement from the glabella to the trichion (Farkas 1981). This measurement was not possible if the subject had any form of hair loss. The measurement was used to assess the height of the forehead.

3.3.2.3 Gnathion to nasion (gn – n)

This measurement is used to determine the morphological height of the face. It is measured from the lower border of the chin to just above the level of the eyes (Martin and Saller 1957, Farkas 1981, Knussmann 1988).

3.3.2.4 Zygion to zygion (zy – zy)

This measurement assesses the breadth of the face, below the level of the eyes. The landmarks used for this measurement is found by trial, taking the points at the widest part of the face, after a number of measurements were taken at the level below the eyes (Martin and Saller 1957, Farkas 1981, Knussmann 1988).

3.3.2.5 Exocanthion to exocanthion (ex – ex)

The biocular diameter is measured, also known as the distance between the lateral borders of the eyes (Martin and Saller 1957, Farkas 1981, Knussmann 1988).

3.3.2.6 Endocanthion to endocanthion (en – en)

This measurement assesses the interocular diameter, which is the distance between the medial borders of the eyes (endocanthions) (Martin and Saller 1957, Farkas 1981, Knussmann 1988).

3.3.2.7 Nasion to subnasale (n – sn)

With this measurement the length of the nose is assessed from the middle of the nasal root to the inferior border of the nose, where it joins the surface of the upper lip (Matrin and Saller 1957, Farkas 1981).

3.3.2.8 Alare to alare (al – al)

This dimension measures the breadth of the nose from alare to alare (Martin and Saller 1957, Farkas 1981, Knussmann 1988). The measurement is taken between the most lateral points on the lateral borders of the nostrils.

3.3.2.9 Labiale superius to labiale inferius (ls – li)

The height of the mucous lips in standard position is measured when using this measurement. It is also called the bilabial height measurement (Martin and Saller 1957, Knussmann 1988).

3.3.2.10 Cheilion to cheilion (ch – ch)

This measurement determines the breadth of the mouth, from one corner to the other, with the mouth in standard position (Matrin and Saller 1957, Farkas 1981, Knussmann 1988).

3.3.2.11 Labiale superius to stomion (ls – sto)

This measurement is used to assess the medial vermilion height of the upper lip, which is the thickness of the upper lip (Martin and Saller 1957, Farkas 1981, Knussmann 1988). The measurement is taken between the labiale superius and the stomion.

3.3.2.12 Labiale inferius to stomion (li – sto)

With this measurement the medial vermilion height of the lower lip is measured, which is the thickness of the lower lip (Martin and Saller 1957, Farkas 1981, Knussmann 1988). It is taken from the labiale inferius tot the stomion.

3.3.2.13 Labiale inferius to gnathion (li – gn)

This measurement assesses the vertical height of the chin, from the midpoint of the lower vermilion line of the lower lip to the lowest median landmark on the lower border of the mandible. Both the landmarks were defined by Martin and Saller (1957) and Farkas (1981), but this has not been used as a measurement before.

3.3.3 Basic statistics and indices for each individual

The measurements described above were used to calculate a total of 12 indices. All the indices were calculated by dividing the smaller measurement with the larger measurement, multiplied by 100. The indices were used in order to nullify the effect of absolute size. This means that any difference in size of the face on the photographs had no effect on the outcome of the results. Using this method, small photographs can potentially be enlarged to an optimal size for accurate measurements. The indices describe the relationship between different features of the face. The mean, standard deviation and ranges were calculated for each index.

The ranges of each index were then used to classify the features into different morphological categories. Two different methods were used to calculate the ranges for each of the various indices. In **Method A**, the original indices and ranges designed by Farkas (1981, 1994) and Knussmann (1988) were used, where applicable. The author created index categories for the newly designed indices, by dividing the index values into equal thirds, from the smallest to the largest. For example, referring to the index for the thickness of the upper lip, the minimum and maximum values for this index were 20.0 and 54.62 respectively (Table 4.2). The difference between these two values was divided into equal thirds. Using these values, three ranges were created, with the smallest being less than and equal to 31.9 (thus covering the range between 20.0 and 31.9), the middle category between 32 and 44 and the third category greater than and equal to 44.1 (thus covering the range between 44.1 and 54.62). Less than and equal to 31.9 constitutes a thin upper lip, between 32 and 44 average thickness and greater than and equal to 44.1 a thick upper lip, in relation to the total height of the mouth.

In **Method B**, index categories were created for all the indices. The distributional properties of the data were investigated using box-whisker plots. Outliers were defined as values further removed than 1.5 inter-quartile range above the 75th centile and below the 25th centile. Using this method, outliers were identified in three of the indices used during this study. After removal of the outliers, the distributions were symmetric and hence the range from two standard deviations below up to two standard deviations above the mean was recalculated and employed, i.e. 94% of the study population, to define the cut points (categories) for the indices. The categories were calculated by dividing the range in equal thirds. For example, referring again to the index for the thickness of the upper lip, the mean value was 38.9

and the standard deviation 6.07 (Table 4.3). The total range for this index, excluding values beyond two standard deviations from the mean, was thus between 26.8 and 51.0. The difference between these two values was divided into equal thirds. Using these values, three ranges were created, with the smallest being less than and equal to 34.7 (thus covering the range between 26.8 and 34.7), the middle category between 34.8 and 43.0 and the third category greater than and equal to 43.1 (thus covering the range between 43.1 and 51.0). Less than and equal to 34.7 constitutes a thin upper lip, between 34.8 and 43.0 average thickness and greater than and equal to 43.1 a thick upper lip, in relation to the total height of the mouth.

Each of the features described by the indices were divided in a similar fashion, using **Method A** as well as **Method B**. By using these calculation techniques, the study population was never divided into equal groups. Rather, the values of the indices were divided into equal ranges and the population classified using these ranges. The use of indices ensured that the procedure was objective.

For purposes of statistical analysis the numbers 1, 2 and 3 were assigned to the different ranges: small = 1, intermediate = 2 and large = 3.

3.3.4 Intra- and inter-observer reliability

To investigate intra-observer reliability, a total of 30 randomly chosen photographs were measured again. To investigate inter-observer reliability, the same 30 randomly chosen photographs were measured by another individual/researcher, trained in the field of facial identification. Inspector JE Naudé from the SAPS was chosen to measure the photographs, as she works with facial identification on a daily basis. In both cases the data was compared to the initial values and the reliability calculated. Intra- and inter-observer reliability was only tested on the metrical analysis as only continuous data can be used for this purpose.

3.4 MORPHOLOGY

Morphological characteristics were also used to classify the different facial features. Different features on the face were selected for morphological analysis. Each feature was subdivided into different morphological categories. For example, the nose bridge of each individual was classified into flat, having a ridge or being intermediate and the philtrum under the nose as deep, shallow or absent. Where possible, known standards for each of the morphological characteristics were used to keep the procedure as objective as possible. Characteristics of the ears and eyes were excluded, because of the variation seen in these features. The size of the eyes was excluded from the study, as some of the subjects closed their eyes or forced it open during the taking of the photograph. Therefore, the true size of the eyes could not be evaluated. The ears were excluded from the study as only anterior-posterior photographs were used. The parts of the ear visible from these photographs were not significant enough for classification. Only features that could be grouped into definite categories, with no overlapping of characteristics, were used in this study. This ensures a better chance of repeatability. The features classified by morphology include:

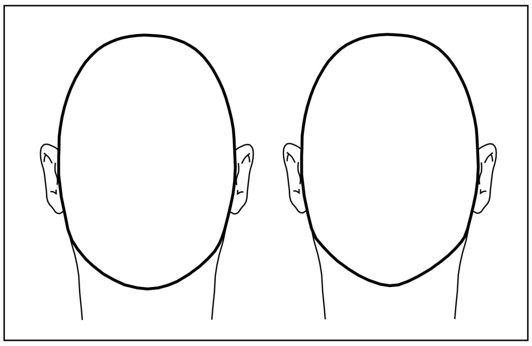
3.4.1 Facial shape

In order to study the facial shapes of the subjects, six different categories were used. İşcan (1993) assembled a table with ten categories and Vanezis (1996) used seven categories to classify the facial shape. The six categories chosen for this study is a combination of categories suggested by Martin and Saller (1957), Penry (1971), Hammer (1978), İşcan (1993) and Vanezis (1996). Only six categories were used in this study, because it was found that some of the categories overlapped in previous studies and that these six categories were more suitable for the faces studied during this study. To classify the facial shape, the shape of the head and the jaw line is investigated. The categories for facial shape are:

3.4.1.1 Oval

When looking at the length and width of the head, the vertical axis (length) is longer than the horizontal axis (width). This makes the head longer than it is wide. The head is dome-shaped and the chin is round or pointed. The lateral sides of the face (area in front of the ears) form a convex line, from the head to the chin (Figure 3.4).

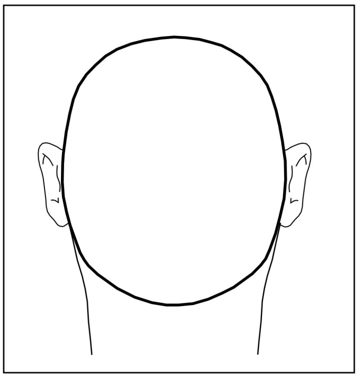
Figure 3.4: Oval facial shape



3.4.1.2 Round

When looking at the head, the width and length of the head is nearly equal, giving it a round appearance. The head is dome-shaped and the chin round. The lateral side of the face protrude laterally, forming a convex curve (Figure 3.5).

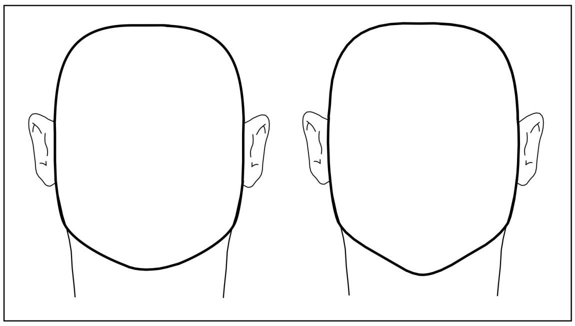
Figure 3.5: Round facial shape



3.4.1.3 Square

For a square facial shape, the length and width of the head is nearly equal. The head is broad in shape and the area around the gonia is also wide. The lateral sides of the face form a straight line from the head to the gonia. This gives the face a square shape. The chin may be broad or pointed (Figure 3.6).

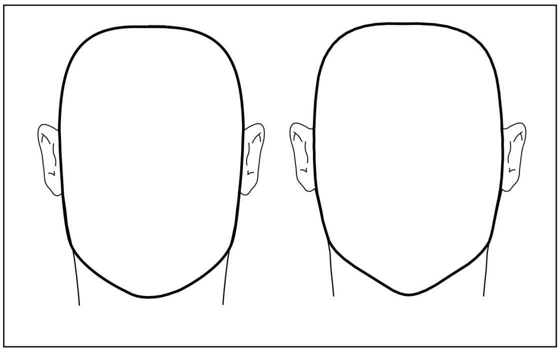
Figure 3.6: Square facial shape



3.4.1.4 Rectangular

For the rectangular facial shape, the head is longer than it is wide. This gives a rectangular shape to the face. The head, as well as the areas around the gonia, are broad in shape. The lateral sides of the face form a straight line from the head to the gonions. Again the chin can be broad or pointed (Figure 3.7).

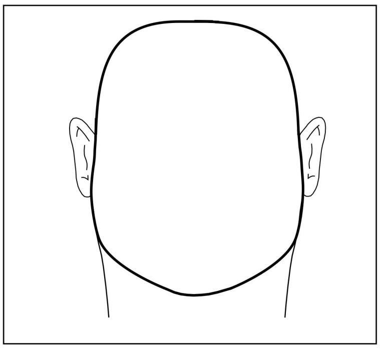
Figure 3.7: Rectangular facial shape



3.4.1.5 Trapezoid

This facial shape looks like a trapezoid. The head is narrower than the jaw, which makes the lateral sides of the face appear to curve inward, from the wide jaw to the narrow forehead (Figure 3.8).

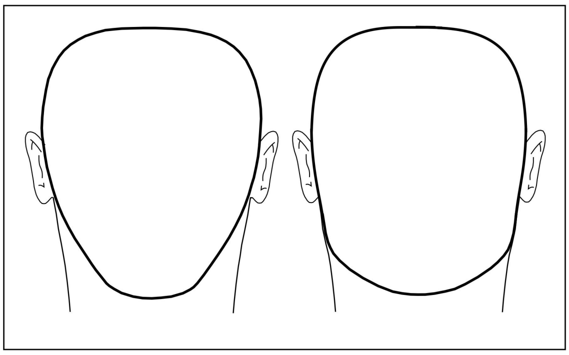
Figure 3.8: Trapezoid facial shape



3.4.1.6 Inverted trapezoid

This facial shape is the opposite of the previously discussed facial shape. For this shape, the head is wider than the jaw. The lateral sides of the face now seem to expand from the narrow jaw and chin to the wide forehead. For this facial shape the chin may be narrow or pointed (Figure 3.9).

Figure 3.9: Inverted trapezoid facial shape



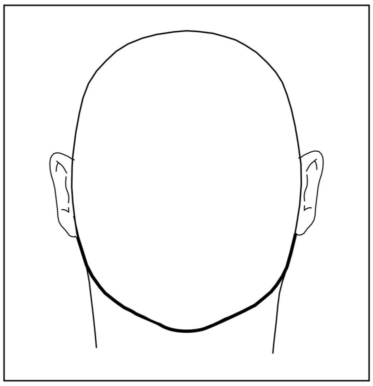
3.4.2 Jaw line

To classify the jaw line separate from the face, two areas should be investigated. Firstly, the shape of the chin is investigated and classified into a category. Secondly the area around the gonial angles is investigated and also classified. The categories used to classify the jaw line were adapted from categories used by Penry (1971) and Vanezis (1996). Only four categories were used, to keep the overlapping of characteristics to the minimum.

3.4.2.1 Round pointed

For this category the chin is pointed (narrow) at the gnathion, giving the chin a prominent shape. When a considerable amount of subcutaneous fat is present around the gonia, the jaw line has a round shape (Penry 1971) (Figure 3.10).

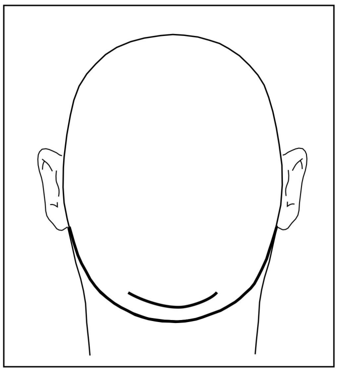
Figure 3.10: Round pointed jaw line



3.4.2.2 Round globular

For this shape of jaw line the chin is insignificant and round. No definite definition of shape can be seen at the gnathion (Penry 1971). The area around the gonions is again covered in subcutaneous fat, giving the round appearance to the jaw line (Figure 3.11).

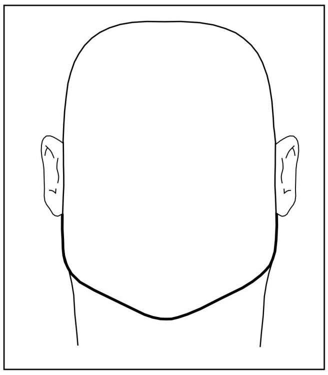
Figure 3.11: Round globular jaw line



3.4.2.3 Angular narrow

For this category the chin is tapered compared to the gonions. This makes the chin narrow and pointed in shape (Penry 1971). Not a lot of subcutaneous fat is present in the area around the gonions, which makes the gonions appear more prominent than in the previous categories (Figure 3.12).

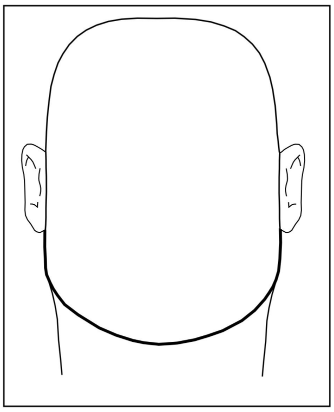
Figure 3.12: Angular narrow jaw line



3.4.2.4 Angular broad

The chin is very wide at the gnathion in this category. Again there is not much subcutaneous fat present around the areas of the gonions (Penry, 1971). This gives a prominent shape to the gonions (Figure 3.13).

Figure 3.13: Angular broad jaw line



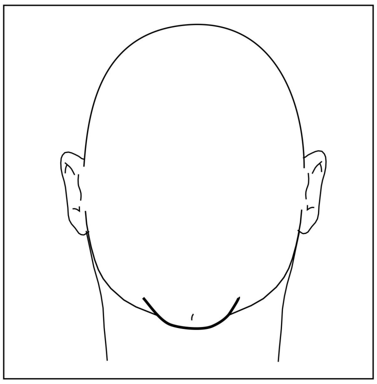
3.4.3 Chin shape

Chin shape is the feature that classifies the morphology of the chin. İşcan used three categories to classify this feature (İşcan 1993). Vanezis (1996) described five categories for this feature. A combination of both these studies was used during this study. This feature could not be classified in all the subjects, due to the presence of facial hair.

3.4.3.1 Dimpled

In this category a vertical depression is present in the middle of the chin (Figure 3.14).

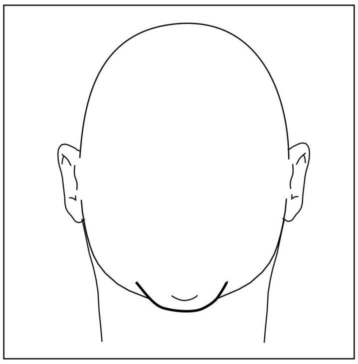
Figure 3.14: Dimpled chin



3.4.3.2 Concave mental sulcus

A mental sulcus is a semicircular depression found on the chin. A concave shaped mental sulcus is a semicircular sulcus with the rounded side of the sulcus towards the side of the chin (Figure 3.15).

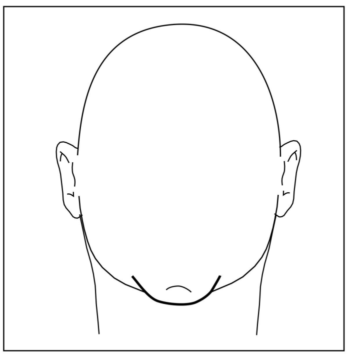
Figure 3.15: Concave mental sulcus



3.4.3.3 Convex mental sulcus

In this category the mental sulcus is convex in shape. In order to be classified as convex, the rounded side of the semicircular sulcus must be towards the side of the mouth (Figure 3.16).

Figure 3.16: Convex mental sulcus



3.4.3.4 None of the above

Subjects classified in this category do not have any of the above morphological characteristics present in the chin area. The chin is smooth and no depressions or sulci are visible.

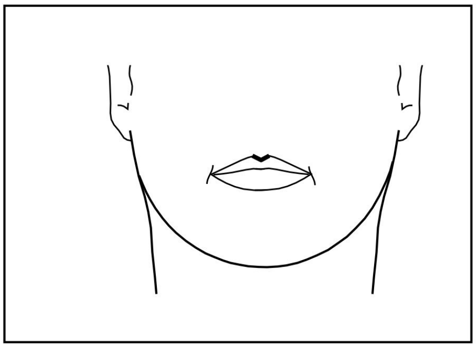
3.4.4 Cupid's bow

Cupid's bow is the midpoint of the upper lip on the junction where the mucous membrane of the upper lip joins the skin (upper vermilion line). In this category the shape of the mucous membrane is classified. Martin and Saller (1957) used 4 categories to classify the cupid's bow. Both İşcan (1993) and Vanezis (1996) described this category as the upper lip notch. These authors described three and four categories respectively. Three categories were used during this study.

3.4.4.1 V-shaped

The upper vermilion line is V-shaped at the midpoint of the upper lip (Figure 3.17).

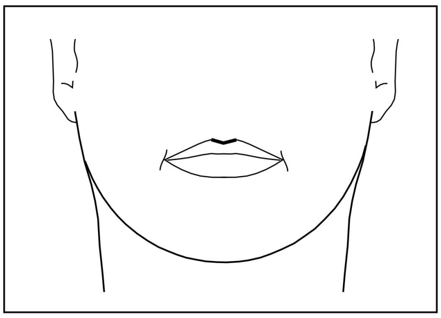
Figure 3.17: V-shaped cupid's bow



3.4.4.2 Flat V

The upper vermilion line is shaped as a wide V, but the notch is not entirely absent (Figure 3.18).

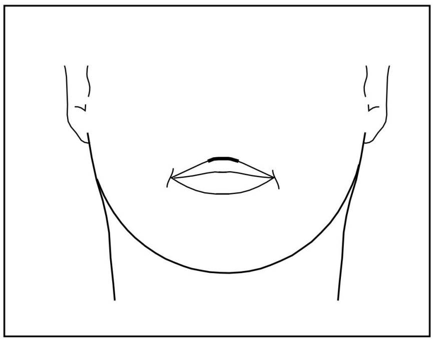
Figure 3.18: Flat V-shaped cupid's bow



3.4.4.3 Absent

The upper vermilion line is flat, with no incline or decline visible at any point on the mucous membrane (Figure 3.19).

Figure 3.19: Absent cupid's bow



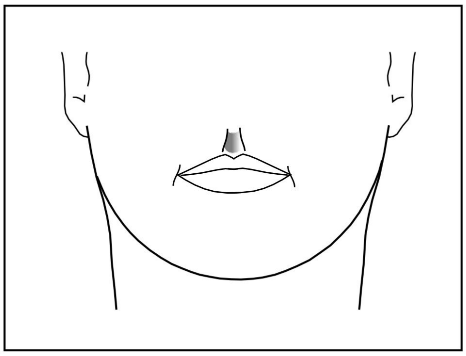
3.4.5 Philtrum

The philtrum is the landmark visible between the inferior border of the nose and the vermilion line of the upper lip. The philtrum is a depression formed by two upraised borders, the cristae philtri. Martin and Saller (1957) described the philtrum with 4 categories. İşcan described two different morphological characteristics for the philtrum, namely size and shape (İşcan 1993). The classifications used by Vanezis, describing the depth of the philtrum, were used during this study (Vanezis 1996). The level of the cristae philtri is investigated for this classification. This feature could not be successfully classified in subjects with moustaches.

3.4.5.1 Deep

In order for the philtrum to be deep, the crista philtri must be high enough to form a visible indentation in between them (Figure 3.20).

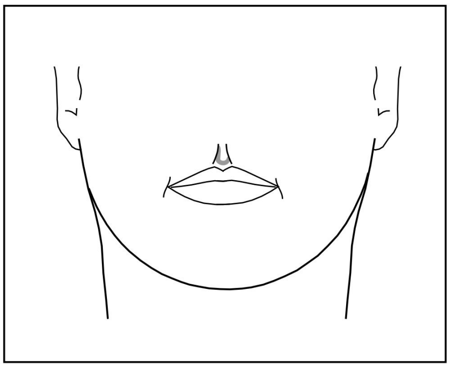
Figure 3.20: Deep philtrum



3.4.5.2 Shallow

The philtrum is shallow when the crista philtri are visible, but not as high as the previous category. The indentation in between is only slightly visible (Figure 3.21).

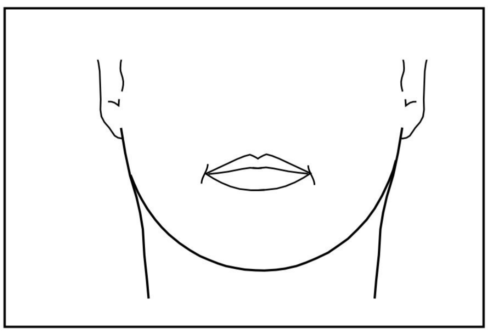
Figure 3.21: Shallow philtrum



3.4.5.3 Absent

The philtrum is absent when the crista philtri are entirely flat, thus not forming an indentation in between at all. The area between the nose and the upper lip is flat (Figure 3.22).

Figure 3.22: Absent philtrum



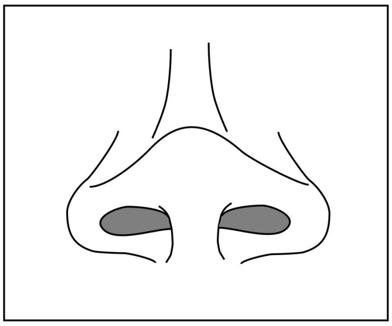
3.4.6 Septum tilt

The septum is the structure dividing the nose into two nostrils. The orientation of the septum has an effect on the orientation of the tip of the nose, which in turn could have an effect on the visibility of the nostrils. Martin and Saller (1957) described this feature with 4 categories. Both İşcan (1993) and Vanezis (1996) described this feature with five categories, ranging from upward to downward and horizontal as the intermediate category. The categories chosen for this study is a combination of these two studies.

3.4.6.1 Upturned

The septum is classified as upturned when the whole septum is visible on the photograph, while the face is in the standard Frankfurt plane. Both the nostrils are also visible and the tip of the nose is turned upward, making the tip of the nose higher than the lateral borders of the nose (Figure 3.23).

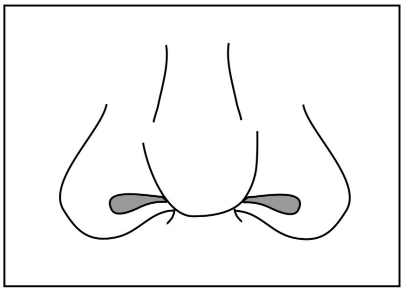
Figure 3.23: Upturned septum



3.4.6.2 Intermediate

Intermediate is the same category as horizontal, used in previous studies (İşcan 1993, Vanezis 1996). In this category the septum is in a horizontal position. This causes the tip of the nose to neither cover the nostrils nor be turned upward. Only part of the nostrils is visible in this category (Figure 3.24).

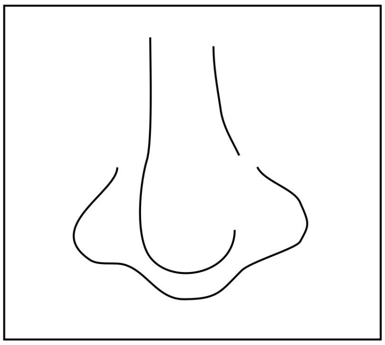
Figure 3.24: Intermediate septum



3.4.6.3 Down-turned

In this category the septum is not visible as the tip of the nose is turned downwards, covering the septum. In order for the tip of the nose to be turned downwards, the septum must also be tilted downwards. The tip of the nose may cover both the nostrils and is longer than the base of the nose (Figure 3.25).

Figure 3.25: Down-turned septum



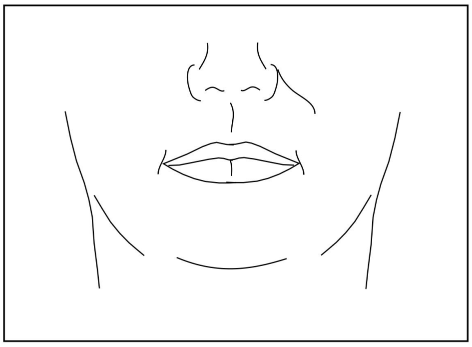
3.4.7 <u>Nasolabial fold</u>

The nasolabial fold is a skin fold found between the nose and the mouth. The variation in length of this feature can be used for the purpose of identification. The length of the folds may vary between the left and right sides. Due to this occurrence, only the left side of the face is scored for this feature. Three different categories were used for classifying this feature (Hammer 1978).

3.4.7.1 Short

For this category the nasiolabial fold extends from the nose, but proceeds only halfway to the mouth (Figure 3.26).

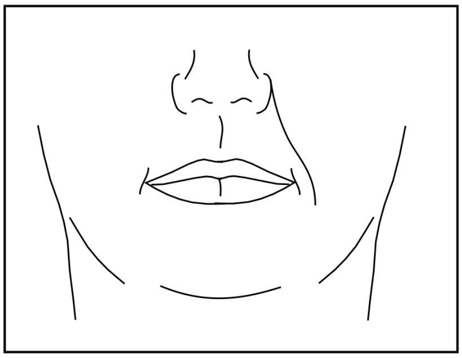
Figure 3.26: Short nasolabial fold



3.4.7.2 Long

A long nasolabial fold extends from the nose to the corner of the mouth, at the level of the cheilions, or past the corner of the mouth (Figure 3.27).

Figure 3.27: Long nasolabial fold



3.4.7.3 Absent

The nasolabial fold is classified as absent when there is no fold present on the left side of the face, even if there is a fold present on the right side of the face.

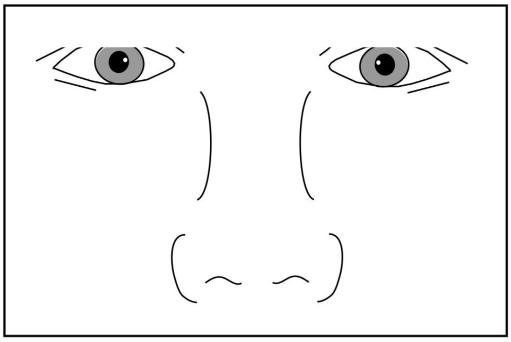
3.4.8 Nose bridge height

With nose bridge height the level of elevation of the nose bridge is investigated. The nose bridge can be found just below the level of the endocanthions of the eyes, where the upper and lower eyelids join medially. During their study, Martin and Saller (1957) described the height and breadth of the nose bridge. İşcan described the feature as bridge height and used three categories for classification: small, medium and high (İşcan 1993). Three categories were also used during this study.

3.4.8.1 Flat

The nose bridge is considered as flat when no crest is visible on the level below the endocanthions. The area is level with the rest of the face (Figure 3.28).

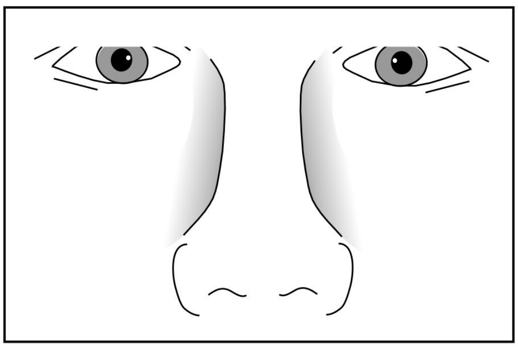
Figure 3.28: Flat nose bridge



3.4.8.2 Intermediate

When a small crest is visible on the level just below the endocanthions, the nose bridge is classified as being intermediate (Figure 3.29).

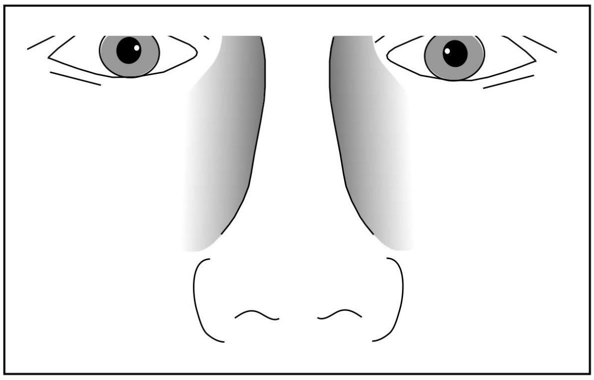
Figure 3.29: Intermediate nose bridge



3.4.8.3 Ridge

The bridge of the nose is classified into this category when a high crest is visible just below the level of the endocanthions (Figure 3.30).

Figure 3.30: Ridge nose bridge



For statistical purposes the numbers 1, 2, 3, etc. were assigned to the different categories of each morphological feature that was analysed.

A scoring sheet containing measurements, indices and morphological analysis, was completed for each facial photograph (appendix C).

3.5 STATISTICAL ANALYSIS

The frequencies of appearance of individual characteristics in the population were documented, for both the metrical (method A and method B) and morphological data. For example, the occurrence of thick lips was determined in the population, to conclude whether this is a **common** or a **rare** characteristic. This will show if the characteristic is worth using in a case of contested identity. If the characteristics used are common, there is a greater chance of having a positive match (not the same person), but if a rare characteristic is used then a match will be more significant.

The occurrence of certain combinations of characteristics in the population was also investigated. Three different regions of the face were investigated namely the upper region of the face (forehead and nose), the middle region of the face (nose and mouth) and the lower region of the face (mouth and chin). The whole face was also analysed. The three regions were chosen to ensure that every feature of the face would be analysed. It was advantageous to divide the face into regions, emphasising smaller areas, to keep the statistics as meaningful as possible. Two of the regions overlap at the nose and mouth respectively. This ensures that the whole face is analysed even if the regions are analysed separately. This technique is also usable when the whole face is not visible, e.g. if a suspect is wearing a mask.

Three combinations were used for each region: metrical data only, morphological data only and a combination using both metrical and morphological data. Only results from **Method A** were used in combinations where metrical data is concerned. For example, the metrical combination for the upper part of the face consisted of the forehead size index, intercanthal index, nasofacial index and nose-face width index, all calculated by using **Method A**. Both Methods (A and B) are valid for the facial classification of the study population. However, only **Method A** was used in the calculation of the various combinations, as this method either includes the outliers in the study population, or in some cases use the published values for index categories. The different combinations are shown in Table 3.1. Frequency distributions of feature combinations were determined for each of the four regions.

The intra-observer reliability, for each of the observers, was determined as the intra class correlation (ICC), which is bounded by 1, i.e. the closer to 1, the higher the reliability (Lachin 2004). The inter-observer reliability was done by analysing the inter-rater agreement (Bland and Altman 1986). All statistical analyses were done together with Prof P Becker, statistician at the MRC (Medical Research Council).

Table 3.1: Combinations of characteristics for each region of the face

Metrical combinations	
Complete face	Facial index Chin size index Lip index Nasal index
Upper region of the face (Forehead and nose)	Forehead size index Intercanthal index Nasofacial index Nose-face width index
Middle region of the face (Nose and mouth)	Nasal index Lip index Upper lip thickness index Lower lip thickness index
Lower region of the face (Mouth and chin)	Chin size index Lip index Vertical mouth height index Mouth width index
Morphological combinations	
Complete face	Facial shape Cupid's bow Septum tilt Jaw line
Upper region of the face (Forehead and nose)	Philtrum Septum tilt Nose bridge height
Middle region of the face (Nose and mouth)	Philtrum Cupid's bow Septum tilt
Lower region of the face (Mouth and chin)	Philtrum Cupid's bow Chin shape
Metrical and morphological combinations	
Complete face	Facial index Nose bridge height Lip index Jaw line
Upper region of the face (Forehead and nose)	Forehead size index Nose bridge height Nasal index Nasofacial index Septum tilt
Middle region of the face (Nose and mouth)	Nose-face width index Philtrum Cupid's bow Mouth width index
Lower region of the face (Mouth and chin)	Upper lip thickness Lower lip thickness Chin shape Chin size index Jaw line

CHAPTER 4

RESULTS

4.1 INTRODUCTION

In this study, both metrical and morphological analyses were attempted. This data was then used to classify the faces of the study population. The raw data can be seen in Appendix C.

4.2 METRICAL ANALYSIS

The metrical analysis consisted of measurements, taken between predetermined landmarks directly from the photograph, to the nearest 0.5 mm. The measurements are therefore not direct measurements from the individual's face, but taken as described in Chapter 3 (3.2.2 Measurements). Basic descriptive statistics for the measurements can be seen in Table 4.1.

Table 4.1: Basic descriptive statistics for the measurements (gn = gnathion, v = vertex, g = glabella, tr = trichion, n = nasion, zy = zygion, ex = exocanthion, en = endocanthion, sn = subnasale, al = alare, ls = labiale superius, li = labiale inferius, ch = cheilion, sto = stomion)

Measurement	n	Mean (in mm)	Standard deviation	Min	Max
gn – v	200	110.58	9.90	70.00	135.30
g – tr	161	29.25	4.73	18.10	41.50
gn – n	200	56.86	5.19	38.20	71.60
zy – zy	200	65.57	5.75	46.20	81.50
ex – ex	200	47.14	4.85	29.00	60.50
en – en	200	17.12	2.19	11.10	23.60
n – sn	200	24.20	3.01	18.00	33.30
al – al	200	22.43	2.63	13.70	28.30
ls – li	200	11.48	2.08	5.00	17.70
ch – ch	200	25.95	2.89	16.10	34.60
ls – sto	200	4.49	1.18	2.00	7.50
li – sto	200	6.66	1.22	3.10	10.00
li – gn	200	12.78	2.94	6.10	24.30

All the measurements were taken on every subject, except the measurement between the trichion and the glabella. This measurement could only be taken on 161 photographs, because of an absent observable hairline in some of the subjects. The measurements were used to calculate various indices. The indices were used to nullify the effect of absolute size and described parts of the face using proportional relationships. The basic descriptive statistics for the indices, calculated by using **Method A**, are shown in Table 4.2. These indices are described in Chapter 3 (3.3.3 Basic statistics and indices for each individual).

Table 4.2: Basic descriptive statistics for the indices (Method A)

Index	n	Mean (in mm)	Standard deviation	Min	Max
Forehead size index	161	26.52	3.52	16.59	35.22
Facial index	200	86.86	5.43	70.46	103.10
Intercanthal index	200	36.36	3.18	28.72	55.17
Nasal index	200	93.29	10.32	69.84	123.65
Nasofacial index	200	42.60	3.91	30.83	53.79
Nose-face width index	200	34.18	2.40	28.13	39.86
Lip index	200	44.40	7.35	20.66	64.47
Vertical mouth height index	200	20.19	3.13	10.75	27.22
Upper lip thickness index	200	38.90	6.07	20.00	54.62
Lower lip thickness index	200	58.25	5.65	42.75	72.12
Mouth width index	200	55.16	4.28	44.58	77.59
Chin size index	200	22.43	4.41	11.71	36.54

The forehead size of only 161 of the subjects could be calculated, as the measurement from the trichion to the glabella formed part of this index. From Table 4.2, it can be seen that the nasal and lip index deviate the most from the standard. This shows that there is a considerable amount of variation in the population for these characteristics. The least variation was seen in the nose-face width index (Table 4.2).

Basic descriptive statistics were also calculated for each index using **Method B**. Outliers were identified in three of the indices using box and whisker plots. These outliers (two for each of the three indices) were excluded from the calculations. Thus only 198 subjects were used to recalculate the mean and standard deviations for the intercanthal, mouth width and chin size indices (Table 4.3). All 200 subjects were still classified for these three indices. For the remainder of the indices, all 200 individuals were used in the calculations. The original mean and standard deviation values were used to calculate the categories for these indices. The categories were calculated by dividing the range from two standard deviations below up to two standard deviations above the mean into equal thirds.

Table 4.3: Basic descriptive statistics for the indices (Method B)

Index	n	Mean (in mm)	Standard deviation	Min	Max
Forehead size index	161	26.52	3.52	16.59	35.22
Facial index	200	86.86	5.43	70.46	103.10
Intercanthal index	198	36.19	2.73	28.72	42.14
Nasal index	200	93.29	10.32	69.84	123.65
Nasofacial index	200	42.60	3.91	30.83	53.79
Nose-face width index	200	34.18	2.40	28.13	39.86
Lip index	200	44.40	7.35	20.66	64.47
Vertical mouth height index	200	20.19	3.13	10.75	27.22
Upper lip thickness index	200	38.90	6.07	20.00	54.62
Lower lip thickness index	200	58.25	5.65	42.75	72.12
Mouth width index	198	54.94	3.70	44.58	64.74
Chin size index	198	22.29	4.22	11.71	32.68

Each of the indices (using Method A and Method B) was divided into three ranges, classifying characteristics into, for example small, intermediate and large. The frequency of occurrence for each of the three ranges (1-3) for all the indices (Method A and Method B) was calculated in the population (Tables 4.4 – 4.27). These are shown graphically in Figures 4.1-4.24.

4.2.1 <u>Forehead size index</u> *100 * g-tr/gn-v*

This index is used to calculate the relationship between the length of the forehead (g-tr) and the height of the head and face (gn-v). Farkas (1981) used both measurements during his study, but not in this specific calculation. The index categories calculated from this study, using **Method A**, are ≤21.9 low, 22-28 intermediate, ≥28.1 high. The index categories, using **Method B**, are ≤24.1 low, 24.2-28.8 intermediate, ≥28.9 high.

Figure 4.1 shows the distribution of the study population for the forehead size index. The vertical black lines show two standard deviations from the mean for the index. Two Methods (A and B) were used to calculate the index categories. For Method A, the distance between the minimum and maximum values were divided into equal thirds. To calculate the index categories with Method B, the distance between the two standard deviations from the mean were divided into equal thirds. This distance constitutes 94% of the population.

Figure 4.1: Distribution of forehead size index (vertical black line indicates two standard deviations from the mean)

4.2.1a <u>Forehead size index (Method A)</u>

This index could only be calculated in 161 subjects, as the hairline was not clearly visible on all the photographs. Most of the subjects (58.4%) were classified in the intermediate category (Table 4.4). Only 9.3% of the population was classified as having a low forehead. The rest of the population (32.3%) was classified as having a high forehead (Figure 4.2).

Table 4.4: Forehead size index (Method A)

Forehead size	n	%
1. ≤21.9 low	15	9.3
2. 22-28 intermediate	94	58.4
3. ≥28.1 high.	52	32.3
Total	161	100.0

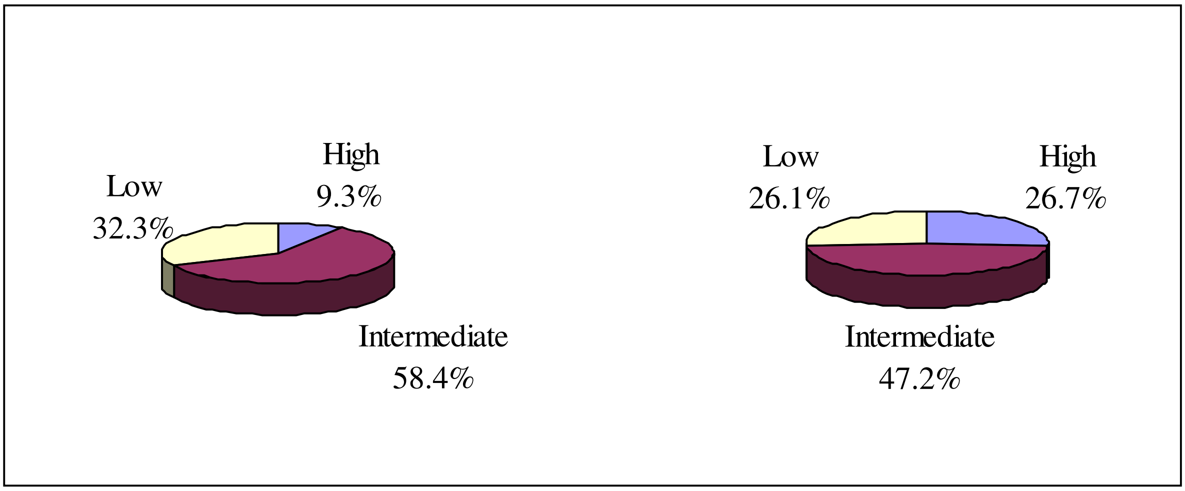
4.2.1b **<u>Forehead size index (Method B)</u>**

From Table 4.5 it can be seen the most of the subjects (47.2%) were classified in the intermediate category. The rest of the population was almost equally distributed between a low (26.1%) and high (26.7%) forehead (Figure 4.2).

Table 4.5: Forehead size index (Method B)

Forehead size	n	%
1. ≤24.1 low	42	26.1
2. 24.2-28.8 intermediate	76	47.2
3. ≥28.9 high.	43	26.7
Total	161	100.0

Figure 4.2: Comparison for the distribution of the forehead size index (Method A: left and Method B: right)



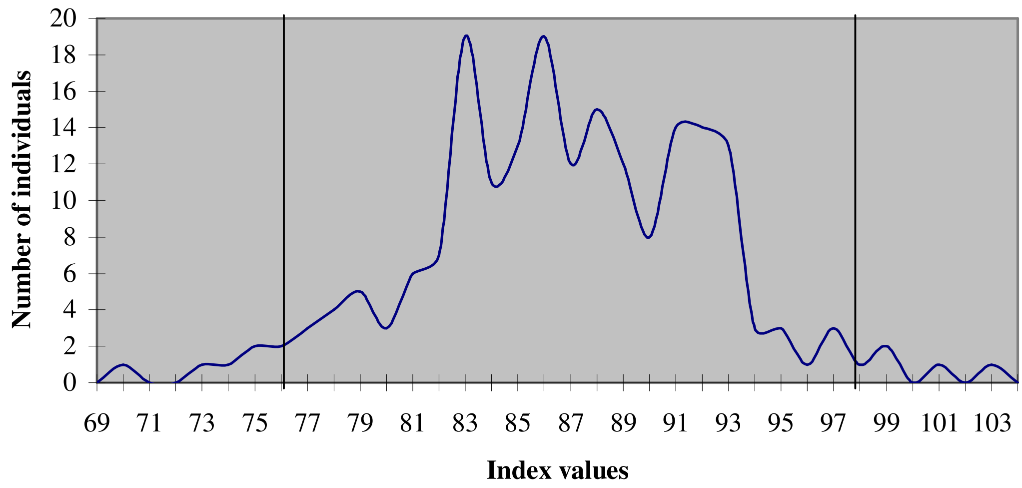
From Figure 4.2 it can be seen that the number of individuals in the "high forehead" category increased from 9.3% to 26.7%, when using Method B. Both the low and intermediate categories decreased in size.

4.2.2 Facial index *100 * gn-n/zy-zy*

The relationship between the morphological height of the face and the breadth of the face is calculated when using this index. The morphological height of the face (gn-n) is divided by the breadth of the face (zy-zy) and shown as a percentage. The existing index categories (**Method A**) for this index are ≤78.9 euryproscopic (short, wide), 79-92.9 mesoproscopic (intermediate), ≥93 leptoproscopic (long, narrow) (Martin and Saller 1957). Using **Method B**, the index categories are ≤83.2 euryproscopic (short, wide), 83.3-90.5 mesoproscopic (intermediate), ≥90.6 leptoproscopic (long, narrow).

The distribution in the study population for the facial index is shown in Figure 4.3. The vertical black line indicates two standard deviations from the mean.

Figure 4.3: Distribution of facial index



4.2.2a Facial index (Method A)

Considering the facial index, most of the population (80%) was classified in the mesoproscopic (intermediate) category. Only 9% and 11% of the population were classified as having euryproscopic (short, wide) and leptoproscopic (long, narrow) faces respectively (Table 4.6 and Figure 4.4).

Table 4.6: Facial index (Method A)

Facial index	n	%
1. ≤78.9 euryproscopic (short, wide)	18	9.0
2. 79-92.9 mesoproscopic (intermediate)	160	80.0
3. ≥93 leptoproscopic (long, narrow)	22	11.0
Total	200	100.0

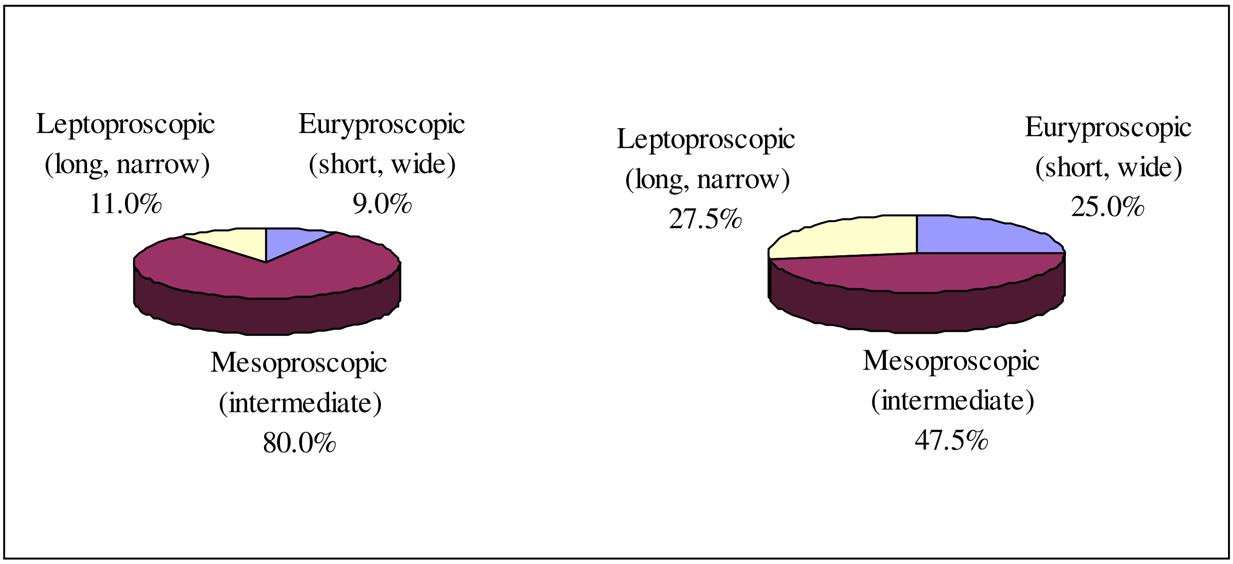
4.2.2b Facial index (Method B)

A large group of the population (47.5%) was classified in the mesoproscopic (intermediate) category for the facial index. The remainder of the population, 25.0% and 27.5%, were classified as having euryproscopic (short, wide) and leptoproscopic (long, narrow) faces respectively (Table 4.7 and Figure 4.4).

Table 4.7: Facial index (Method B)

Facial index	n	%
1. ≤83.2 euryproscopic (short, wide)	50	25.0
2. 83.3-90.5 mesoproscopic (intermediate)	95	47.5
3. ≥90.6 leptoproscopic (long, narrow)	55	27.5
Total	200	100.0

Figure 4.4: Comparison for the distribution of the facial index (Method A: left and Method B: right)



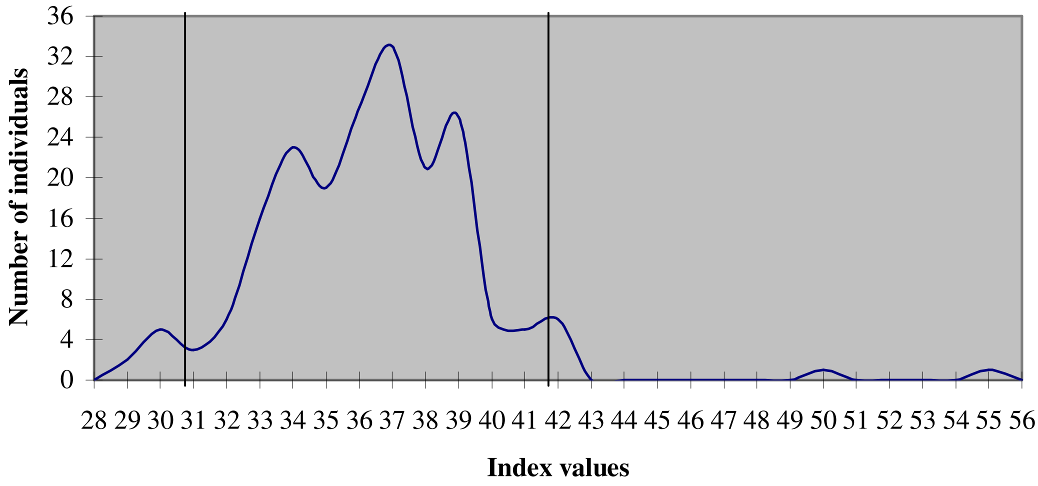
Both the leptoproscopic (long, narrow) and euryproscopic (short, wide) categories increased considerably when using Method B for the calculations (Figure 4.4). Because of the increase in these two categories, the mesoproscopic (intermediate) category decreased from 80% of the study population to only 47.5%.

4.2.3 Intercanthal index *100 * en-en/ex-ex*

This index is used to calculate the relationship between the interocular diameter (en-en) and the biocular diameter (ex-ex) of the eyes. The size of the eyes can be determined with this index. This index was first used by Martin and Saller (1957) and later used during a study on children between the ages of 6 and 18 years old (Farkas and Munro 1986). The ranges calculated from that study are not applicable for the present study. The index categories for this index, calculated from the data collected during this study using **Method A**, are ≤36.9 close, 37-46 intermediate, ≥46.1 far apart. The index categories for this index, calculated by using **Method B**, are ≤34.3 close, 34.4-38.0 intermediate, ≥38.1 far apart.

Figure 4.5 shows the distribution of the intercanthal index in the study population and clearly indicates that two individuals fell far outside the otherwise fairly normally distributed sample. As previously mentioned, in Table 4.3 it can be seen that only 198 subjects were used in the calculations for Method B. The two maximum outliers were not included in the calculations for Method B, as it significantly affected the index categories.

Figure 4.5: Distribution of intercanthal index



4.2.3a <u>Intercanthal index (Method A)</u>

The intercanthal index was used to assess the distance between the eyes. Most of the population (58%) were classified in the category where the eyes are situated close to each other, followed by 41% who were classified in the intermediate category (Table 4.8). Only 1% of the population was classified in the category where the eyes are far apart from each other (Figure 4.6).

Table 4.8: Intercanthal index (Method A)

Intercanthal index	n	%
1. ≤36.9 close	116	58.0
2. 37-46 intermediate	82	41.0
3. ≥46.1 far apart	2	1.0
Total	200	100.00

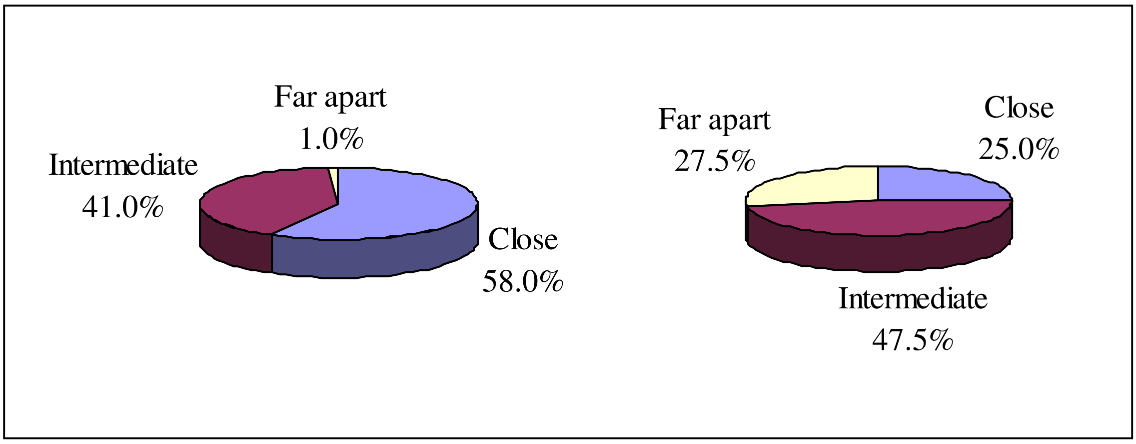
4.2.3b <u>Intercanthal index (Method B)</u>

Using Method B, a large group of the population (47.5%) were classified in the category where the eyes are situated at an intermediate distance from each other (Table 4.9). The rest of the population (Figure 4.6) were almost equally distributed between the eyes being close together (25.0%) and the eyes situated far apart from each other (27.5%).

Table 4.9: Intercanthal index (Method B)

Intercanthal index	n	%
1. ≤34.3 close	50	25.0
2. 34.4-38.0 intermediate	95	47.5
3. ≥38.1 far apart	55	27.5
Total	200	100.00

Figure 4.6: Comparison for the distribution of the intercanthal index (Method A: left and Method B: right)



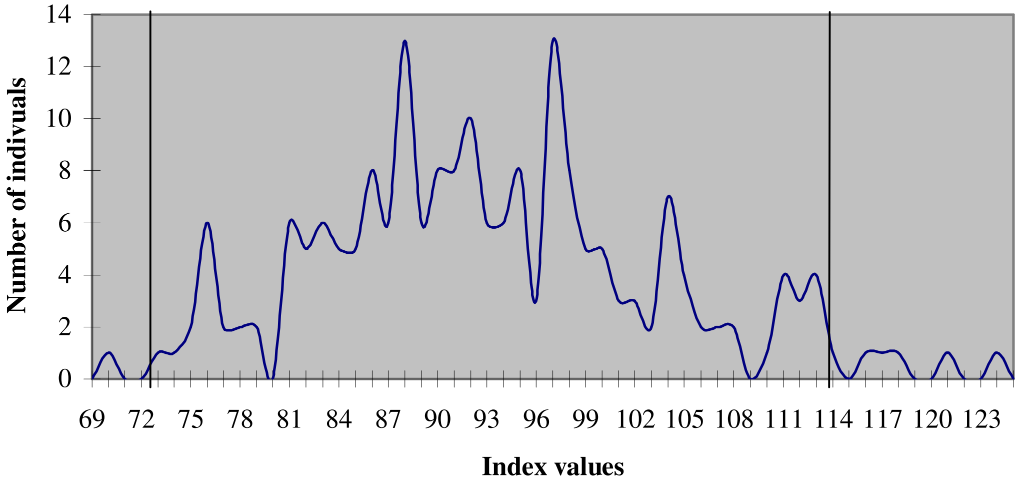
Referring to Figure 4.6, it can be seen that there is a significant difference between the distributions when using Methods A and B. Only 1% of the study population was classified with eyes situated far apart when using Method A. This distribution changed to 25.5% with Method B. A dramatic decrease can be seen in the close category (58% to 25%), because of the increase in the "far apart" category.

4.2.4 <u>Nasal index</u> *100 * al-al/n-sn*

The relationship between the nasal width and the nasal length is calculated with this index. The breadth of the nose (al-al) is divided by the length of the nose (n-sn). The ranges for the nasal index, using **Method A**, are: ≤54.9 leptorrhin (narrow), 55-99.9 mesorrhin (intermediate), ≥100 chamaerrhin (wide). In this case the published index categories of Martin and Saller (1957) were used. The index categories for this index, calculated using **Method B**, are: ≤86.3 leptorrhin (narrow), 86.4-100.2 mesorrhin (intermediate), ≥100.3 chamaerrhin (wide).

The distribution of the nasal index in the study population and two standard deviations from the mean are shown in Figure 4.7. It is clear that there is a high degree of variation in the study population for the nasal index (Table 4.2). This is also visible in Figure 4.7.

Figure 4.7: Distribution of nasal index



4.2.4a Nasal index (Method A)

The shape of the nose was assessed by using the nasal index. As can be seen in Table 4.10, most of the population (76%) were classified in the mesorrhin (intermediate) category. No subjects were classified in the leptorrhin (narrow) category. The rest of the population (24%) was classified in the chamaerrhin (wide) category (Figure 4.8).

Table 4.10: Nasal index (Method A)

Nasal index	n	%
1. ≤54.9 leptorrhin (narrow)	0	0
2. 55-99.9 mesorrhin (intermediate)	152	76.0
3. ≥100 chamaerrhin (wide)	48	24.0
Total	200	100.0

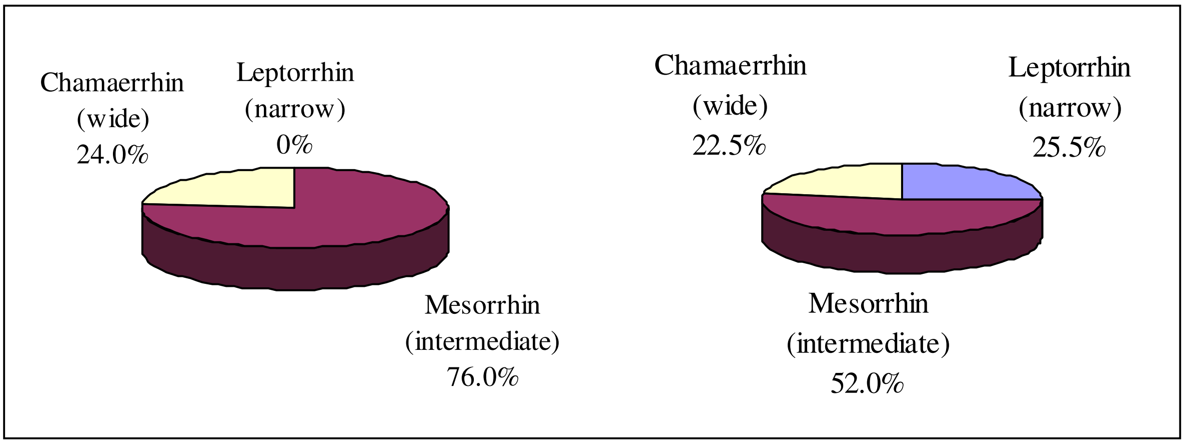
4.2.4b Nasal index (Method B)

From Table 4.11 it can be seen that most of the population (52.0%) were again classified in the mesorrhin (intermediate) category. However, the leptorrhin (narrow) category (25.5%) and chamaerrhin (wide) category (22.5%) were almost equally distributed in the population (Figure 4.8).

Table 4.11: Nasal index (Method B)

Nasal index	n	%
1. ≤86.3 leptorrhin (narrow)	51	25.5
2. 86.4-100.2 mesorrhin (intermediate)	104	52.0
3. ≥100.3 chamaerrhin (wide)	45	22.5
Total	200	100.0

Figure 4.8: Comparison for the distribution of the nasal index (Method A: left and Method B: right)



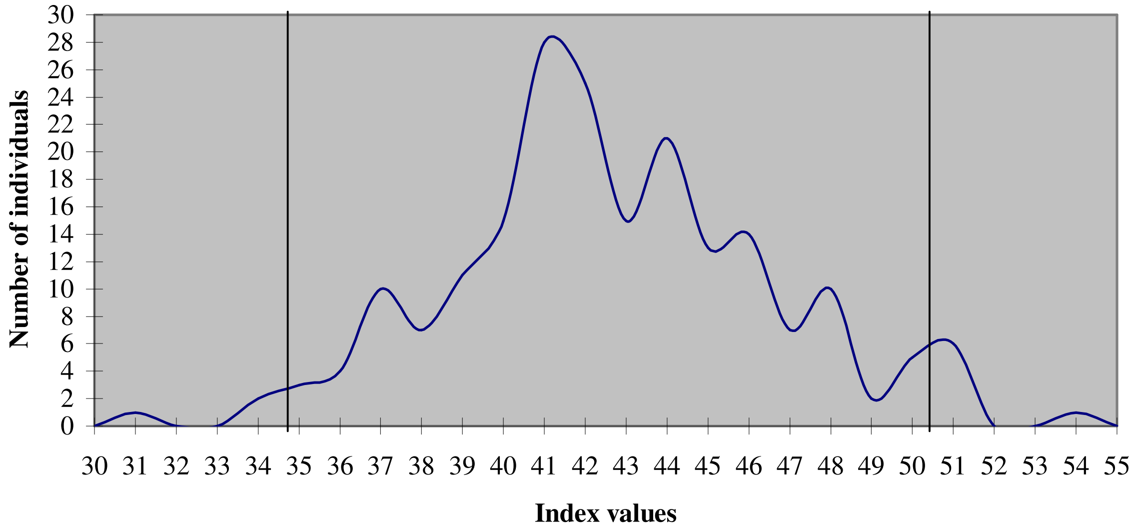
A considerable difference is seen in the distributions, when using Method B during the calculations (Figure 4.8). With Method A, there were no leptorrhin (narrow) noses found in the study population. When using Method B, 25.5% of the study population were classified with leptorrhin (narrow) noses. The mesorrhin (intermediate) category decreased significantly from 76% to 52%.

4.2.5 Nasofacial index *100 * n-sn/gn-n*

With this index the relationship between the length of the nose (n-sn) and the morphological height of the face (gn-n) is calculated and shown as a percentage. The index was created by Martin and Saller (1957) and used during a study of children between the ages 6 years and 18 years old (Farkas and Munro 1986). Therefore the only available categories for this index are not applicable to this study. The ranges for this index, using Method A, are: ≤37.9 short, 38-46 intermediate, ≥46.1 long. The ranges, calculated with Method B, are: ≤39.9 short, 40.0-45.2 intermediate, ≥45.3 long.

Figure 4.9 indicates the distribution for the nasofacial index in the study population. The vertical black line indicates two standard deviations from the mean. Most of the study population is concentrated around the mean of the index (Figure 4.9).

Figure 4.9: Distribution of nasofacial index



4.2.5a Nasofacial index (Method A)

The relationship between the length of the nose and the morphological height of the face was calculated using the nasofacial index. As seen from Table 4.12, most of the population (69.5%) was classified as being intermediate. The rest of the population is almost equally distributed between having a long nose in relation to the face (18.5%) and having a short nose in relation to the face (12%). Figure 4.10 illustrates these results.

Table 4.12: Nasofacial index (Method A)

Nasofacial index	n	%
1. ≤37.9 short	24	12.0
2. 38-46 intermediate	139	69.5
3. ≥46.1 long	37	18.5
Total	200	100.0

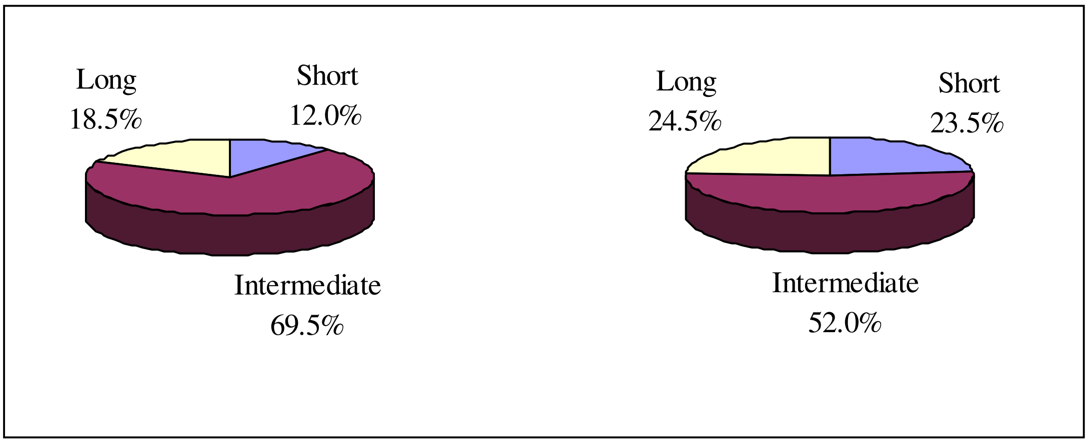
4.2.5b Nasofacial index (Method B)

Using Method B, just over half of the population (52.0%) was classified as being intermediate (Table 4.13). The rest of the population is almost equally distributed between having a long nose in relation to the face (24.5%) and having a short nose in relation to the face (23.5%). Figure 4.10 illustrates these results.

Table 4.13: Nasofacial index (Method B)

Nasofacial index	n	%
1. ≤39.9 short	47	23.5
2. 40-45.2 intermediate	104	52.0
3. ≥45.3 long	49	24.5
Total	200	100.0

Figure 4.10: Comparison for the distribution of the nasofacial index (Method A: left and Method B: right)



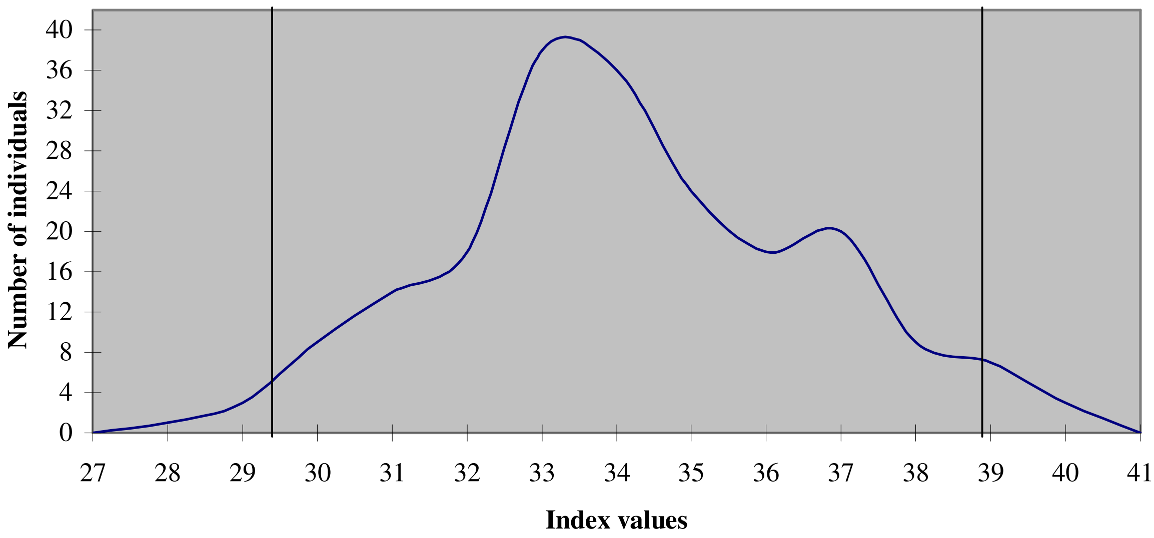
The percentage of short noses in relation to the face increased from 12% to 23.5% in the study population, when using Method B. Long noses in relation to the face also increased with Method B (Figure 4.10). Because of these increases, the intermediate category decreased.

4.2.6 <u>Nose-face width index</u> ***100 * al-al/zy-zy***

This index is used when calculating the relationship between the nasal width (al-al) and the facial width (zy-zy). This index was created by Martin and Saller (1957) and used in the study done on children between the ages 6 years and 18 years old (Farkas and Munro 1986). The index categories from this study are not applicable to the present study and were therefore not used. The index categories for this index, calculated with **Method A**, are: ≤31.9 narrow, 32-36 intermediate, ≥36.1 wide. Using **Method B**, the index catergories are: ≤32.5 narrow, 32.6-35.8 intermediate, ≥35.9 wide.

Figure 4.11 indicates the distribution of the nose-face width index for the study population and two standard deviations from the mean.

Figure 4.11: Distribution of nose-face width index



4.2.6a **<u>Nose-face width index (Method A)</u>**

This index was used to assess the relationship between the width of the nose and the width of the face. The majority of the population (57.5%) was classified in the intermediate category (Table 4.14). The rest of the population was almost equally distributed amongst the categories for a narrow nose in relation to the width of the face (17.5%) and a wide nose in relation to the width of the face (25%). Figure 4.12 illustrates these results.

Table 4.14: Nose-face width index (Method A)

Nose-face width index	**n**	**%**
1. ≤31.9 narrow	35	17.5
2. 32-36 intermediate	115	57.5
3. ≥36.1 wide	50	25.0
Total	200	100.0

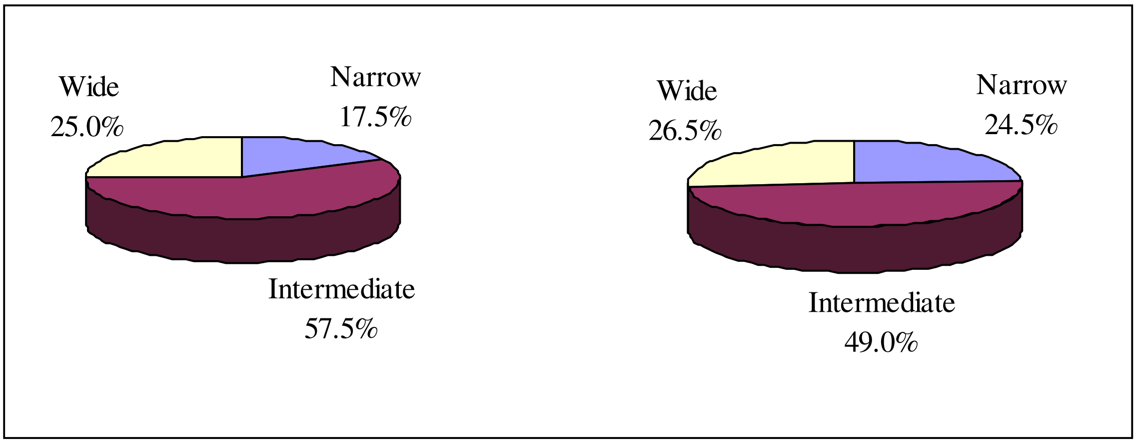
4.2.6b **<u>Nose-face width index (Method B)</u>**

A large group in the population (49.0%) fell in the intermediate category (Table 4.15). The rest of the population was almost equally distributed amongst the categories for a narrow nose in relation to the width of the face (24.5%) and a wide nose in relation to the width of the face (26.5%). Figure 4.12 illustrates these results.

Table 4.15: Nose-face width index (Method B)

Nose-face width index	**n**	**%**
1. ≤32.5 narrow	49	24.5
2. 32.6-35.8 intermediate	98	49.0
3. ≥35.9 wide	53	26.5
Total	200	100.0

Figure 4.12: Comparison for the distribution of the nose-face width index (Method A and Method B)



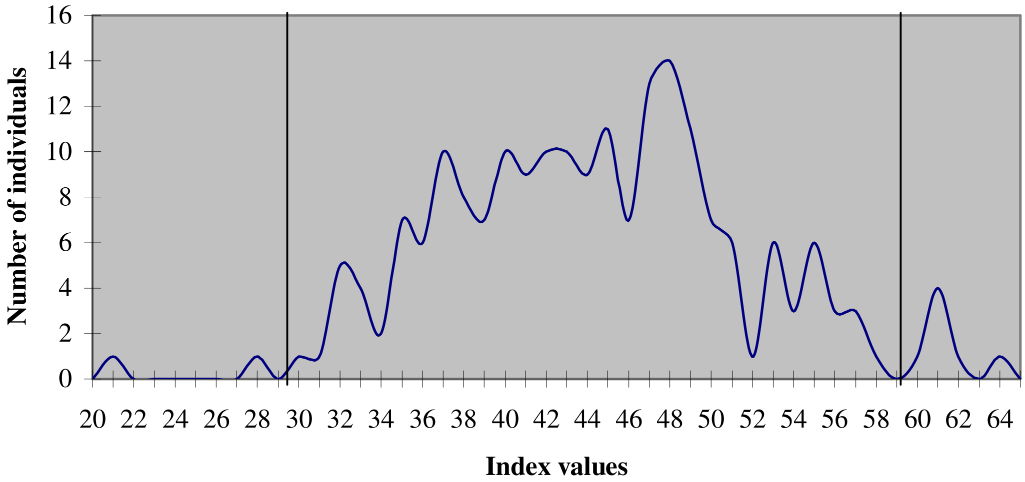
Only a small change can be seen in the distribution of the nose-face width index between Method A and Method B (Figure 4.12). The narrow category increased with 7% and the intermediate category decreased with 8.5% of the study population.

4.2.7 <u>Lip index</u> *100 * ls-li/ch-ch*

This index is used to calculate the relationship between the height (thickness) of the lips and the breadth of the mouth. The height of the lips (ls-li) is divided by the breadth of the mouth (ch-ch) and shown as a percentage. The index categories for this index, using **Method A**, are: ≤34.9 thin, 35-44.9 intermediate, ≥45 thick. In this case the published index categories of Olivier (1969) were used. The index categories for this index, using **Method B**, are: ≤39.4 thin, 39.5-49.3 intermediate, ≥49.4 thick.

Figure 4.13 shows the distribution of the lip index in the study population. The vertical black line indicates two standard deviations from the mean. It is clear that there is a high degree of variation in the study population for the lip index (Table 4.2). Two outliers (minimum and maximum) can be seen in Figure 4.13.

Figure 4.13: Distribution of lip index



4.2.7a <u>Lip index (Method A)</u>

The relationship between the height and the breadth of the mouth was calculated using the lip index. As seen in Table 4.16, most of the population was classified in the intermediate category (66%). Only 10% of the population was classified as having a thin mouth. Figure 4.14 illustrates these results.

Table 4.16: Lip index (Method A)

Lip index	n	%
1. ≤34.9 thin	20	10.0
2. 35-44.9 intermediate	132	66.0
3. ≥45 thick	48	24.0
Total	200	100.0

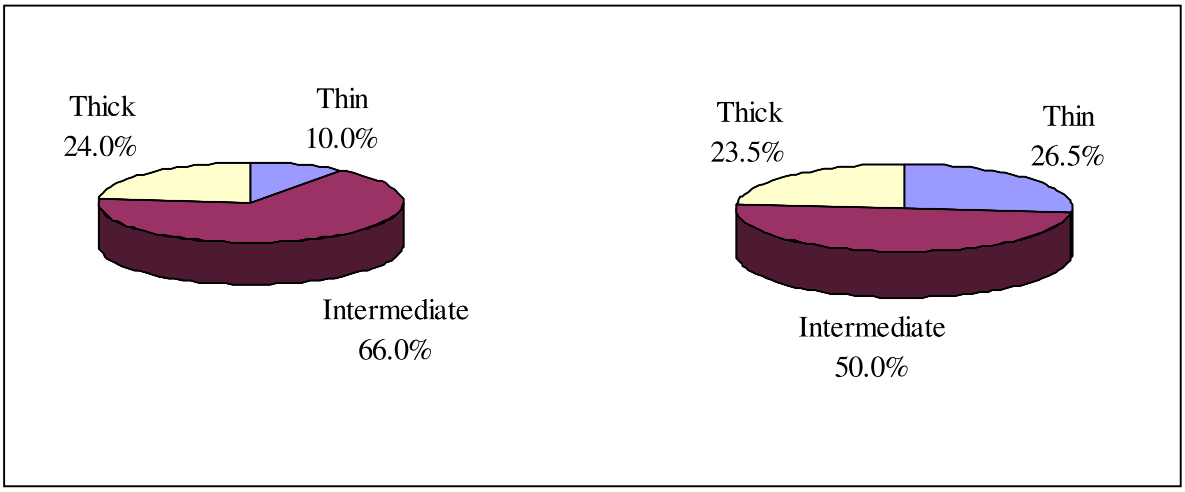
4.2.7b <u>Lip index (Method B)</u>

From Table 4.17 it can be seen that half of the population was classified in the intermediate category (50.0%). The rest of the population were equally distributed between having thin (26.5%) and thick (23.5%) lips. Figure 4.14 illustrates these results.

Table 4.17: Lip index (Method B)

Lip index	**n**	**%**
1. ≤39.4 thin	53	26.5
2. 39.5-49.3 intermediate	100	50.0
3. ≥49.4 thick	47	23.5
Total	200	100.0

Figure 4.14: Comparison for the distribution of the lip index (Method A: left and Method B: right)



A considerable difference can be seen in the thin category for the lip index (Figure 4.14). This category increased from only 10% to 26.5%, when using Method B for the calculations. The intermediate category decreased from 66% to 50%.

4.2.8 <u>Vertical mouth height index</u> *100 * ls-li/gn-n*

The relationship between the height of both the lips (ls-li) and the morphological height of the face (gn-n) is calculated with this index. The lips must be in the standard position. Both these measurements were used by Martin and Saller (1957) and Knussmann (1988), but not as an index. The index categories for this index, calculated by using **Method A**, are: ≤15.9 low (thin), 16-22 intermediate, ≥22.1 high (thick). The index categories for this index, calculated by using **Method B**, are: ≤18.0 low (thin), 18.1-22.3 intermediate, ≥22.4 high (thick).

The distribution for the vertical mouth height index and two standard deviations from the mean are shown in Figure 4.15. It can be seen that most of the study population centres around the mean value (20.19) for this index (Table 4.2).

Figure 4.15: Distribution of vertical mouth height index

4.2.8a <u>Vertical mouth height index (Method A)</u>

The vertical mouth height index was used to calculate the relationship between the height of the mouth (thickness of both the lips) and the morphological height of the face. From Table 4.18 it can be seen that, 60% of the population studied were classified as having a mouth of intermediate height in relation to the height of the face. Sixty subjects (30%) were classified as having a high (thick) mouth in relation to the height of the face (Figure 4.16).

Table 4.18: Vertical mouth height index (Method A)

Vertical mouth height	n	%
1. ≤15.9 low (thin)	20	10.0
2. 16-22 intermediate	120	60.0
3. ≥22.1 high (thick)	60	30.0
Total	200	100.0

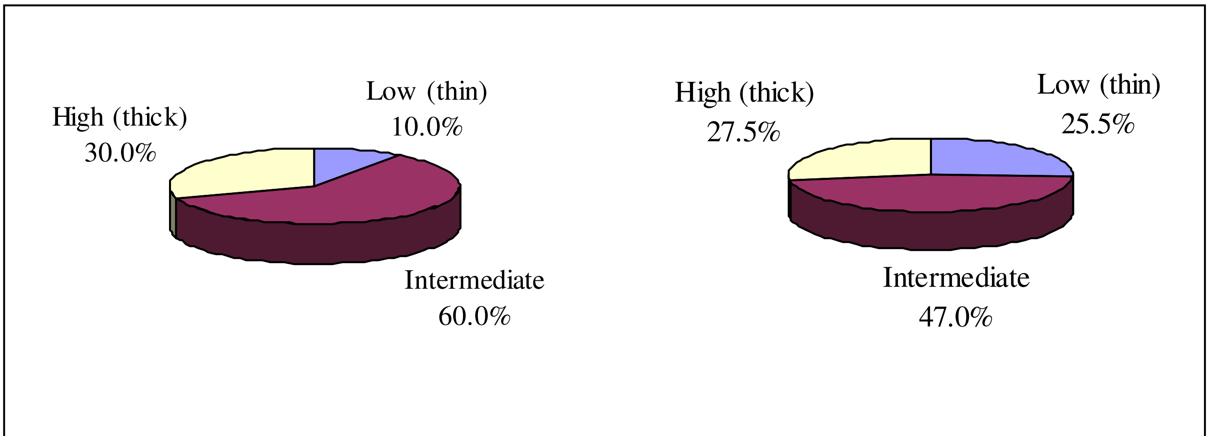
4.2.8b Vertical mouth height index (Method B)

From Table 4.19 it can be seen that, 47.0% of the population studied were classified as having a mouth of intermediate height in relation to the height of the face. Fifty-five subjects (27.5%) were classified as having a high (thick) mouth in relation to the height of the face (Figure 4.16).

Table 4.19: Vertical mouth height index (Method B)

Vertical mouth height	n	%
1. ≤18.0 low (thin)	51	25.5
2. 18.1-22.3 intermediate	94	47.0
3. ≥22.4 high (thick)	55	27.5
Total	200	100.0

Figure 4.16: Comparison for the distribution of the vertical mouth height index (Method A: left and Method B: right)



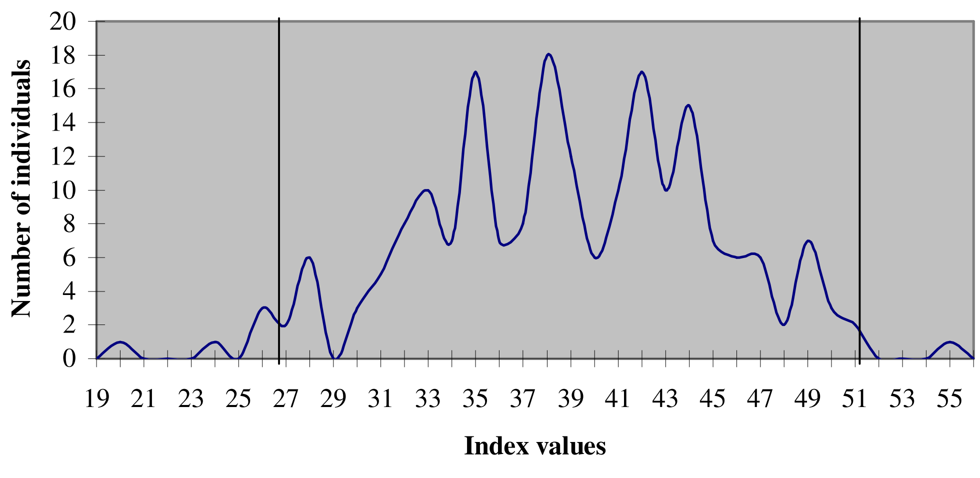
The percentage of individuals classified with a low (thin) mouth in relation to the face increased with 15.5%, when using Method B for the calculations (Figure 4.16). Because of this increase, the intermediate category decreased. When using Method B, the effect on the high (thick) category was minimal (-2.5%).

4.2.9 Upper lip thickness index *100 * ls-sto/ls-li*

This index is used to calculate the relationship of the thickness of the upper lip (ls-sto) to the height (thickness) of both lips (ls-li). The index shows, in the form of a percentage, how much the upper lip contributes to the height of the whole mouth. Martin and Saller (1957), Farkas (1981) and Knussmann (1988) all used these measurements in their respective studies, but not in this specific calculation. The index categories for this index, calculated by using **Method A**, are ≤31.9% thin, 32-44 intermediate, ≥44.1 thick. The index categories, calculated by using **Method B**, are ≤34.7% thin, 34.8-43.0 intermediate, ≥43.1 thick.

Figure 4.17 shows the distribution of the upper lip thickness in the study population. The vertical black line indicates two standard deviations from the mean. Some variation can be seen in the study population for this index.

Figure 4.17: Distribution of upper lip thickness index



4.2.9a Upper lip thickness index (Method A)

The thickness of the upper lip in relation to the height of the mouth was studied using this index. As seen from Table 4.20, most of the population studied was classified as having an average (intermediate) size upper lip (70%). Only 9.5% of the population had thin upper lips in relation to the total height of the mouth (Figure 4.18).

Table 4.20: Upper lip thickness index (Method A)

Upper lip thickness	**n**	**%**
1. ≤31.9 thin	19	9.5
2. 32-44 intermediate	140	70.0
3. ≥44.1 thick	41	20.5
Total	200	100.0

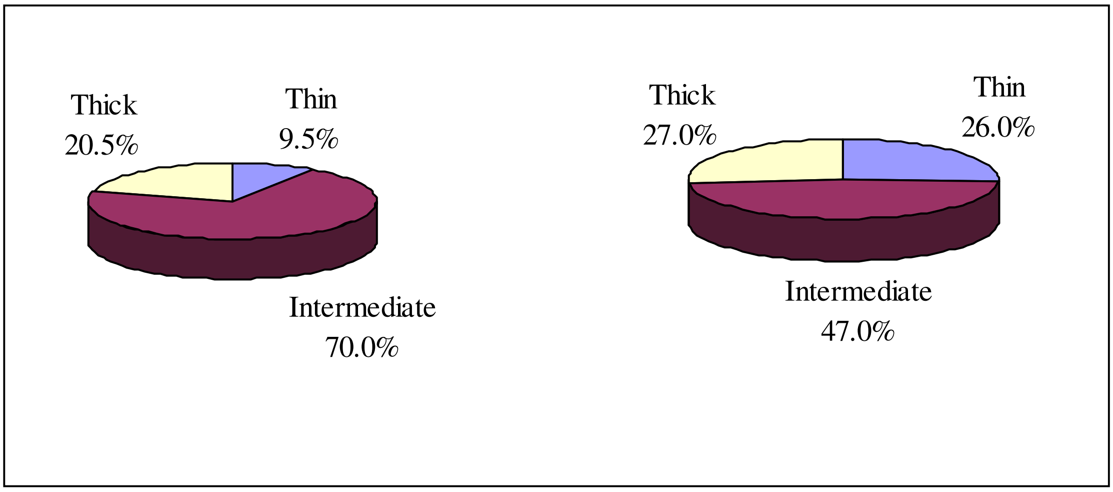
4.2.9b Upper lip thickness index (Method B)

Using Method B, a large group of the population (47.0%) was classified as having an average (intermediate) size upper lip (Table 4.21). The rest of the population were almost equally distributed between having thin (26.0%) and thick (27%) upper lips (Figure 4.18).

Table 4.21: Upper lip thickness index (Method B)

Upper lip thickness	**n**	**%**
1. ≤34.7 thin	52	26.0
2. 34.8-43.0 intermediate	94	47.0
3. ≥43.1 thick	54	27.0
Total	200	100.0

Figure 4.18: Comparison for the distribution of the upper lip thickness index (Method A: left and Method B: right)



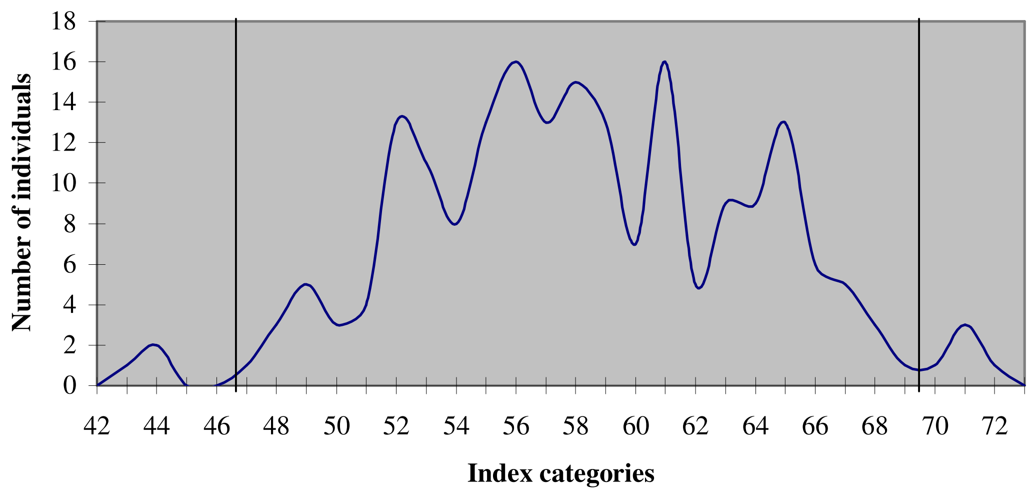
Using Method A, only 9.5% of the study population was classified with thin upper lips (Figure 4.18). With Method B, this category increased considerably to 26%. The intermediate category decreased considerably from 70% to 47% of the study population.

4.2.10 Lower lip thickness index *100 * li-sto/ls-li*

This index is used to calculate the relationship between the thickness of the lower lip (li-sto) and the height of both lips (ls-li). The index shows how much the lower lip contributes to the height of the whole mouth. Martin and Saller (1957), Farkas (1981) and Knussmann (1988) used both these measurements in their respective studies, but not as an index. The index categories for this index, calculated by using **Method A**, are: ≤51.9 thin, 52-62 intermediate, ≥62.1 thick. When using **Method B**, the index categories for this index are ≤54.5 thin, 54.6-62.0 intermediate, ≥62.1 thick.

The distribution of the lower lip thickness in the study population and two standard deviations from the mean (vertical black line) are shown in Figure 4.19.

Figure 4.19: Distribution of lower lip thickness index



4.2.10a Lower lip thickness index (Method A)

The portion that the lower lip contributes to the height (thickness) of the mouth was calculated using this index. As seen from Table 4.22, the majority of the population was classified in the intermediate category (63%). Only 11.5% was classified as having thin lower lips and 25.5% of the population was classified as having thick lower lips (Figure 4.20).

Table 4.22: Lower lip thickness index (Method A)

Lower lip thickness	n	%
1. ≤51.9 thin	23	11.5
2. 52-62 intermediate	126	63.0
3. ≥62.1 thick	51	25.5
Total	200	100.0

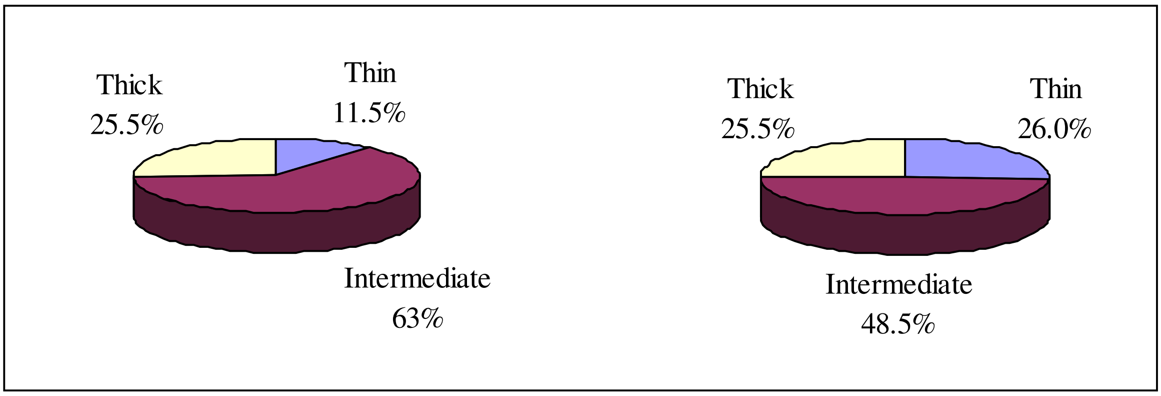
4.2.10b Lower lip thickness index (Method B)

As seen from Table 4.23, 48.5% of the population was classified in the intermediate category. The remainder of the population were almost equally distributed between having thin (26%) and thick (25.5%) lower lips (Figure 4.20).

Table 4.23: Lower lip thickness index (Method B)

Lower lip thickness	n	%
1. ≤54.5 thin	52	26.0
2. 54.6-62.0 intermediate	97	48.5
3. ≥62.1 thick	51	25.5
Total	200	100.0

Figure 4.20: Comparison for the distribution of the lower lip thickness index (Method A: left and Method B: right)



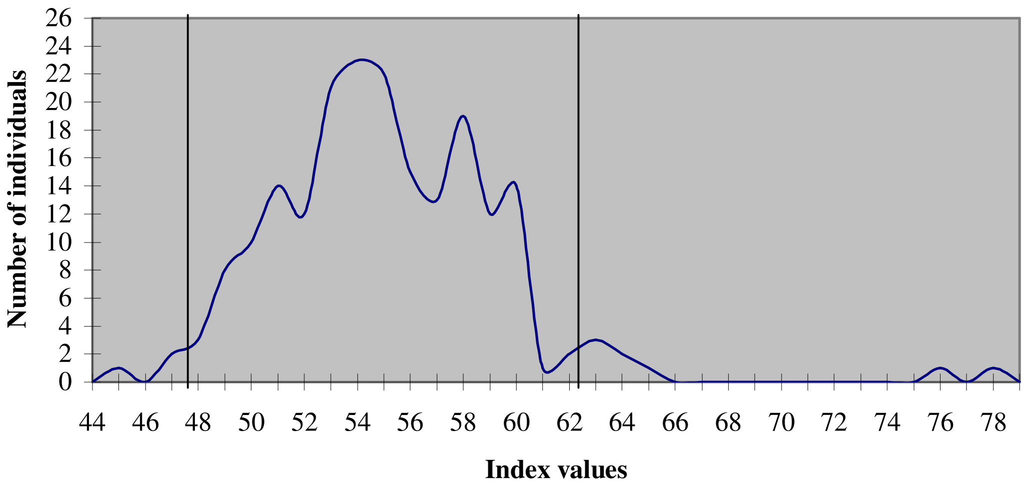
The thin category increased considerably from 11.5% (Method A) to 26% (Method B) for the lower lip thickness index. Because of this increase, the intermediate category decreased from 63% to 48.5% (Figure 4.20). The thick category (25.5%) was not influenced.

4.2.11 Mouth width index *100 * ch-ch/ex-ex*

This index is used to calculate the relationship between the width of the mouth (ch-ch) and the biocular diameter of the eyes (ex-ex). Martin and Saller (1957), Farkas (1981) and Knussmann (1988) described this index as the biocular breadth, but no known categories were found. The index categories for this index, using **Method A**, are ≤54.9 narrow, 55-66 intermediate, ≥66.1 wide. Using **Method B**, the index categories are ≤52.3 narrow, 52.4-57.4 intermediate, ≥57.5 wide.

Figure 4.21 indicates the distribution for the mouth width index in the study population. The vertical black line indicates two standard deviations from the mean. Two outliers can be seen from an otherwise normally distributed sample. These two maximum two outliers were not included in the calculations of Method B for this index. Therefore, only 198 subjects were used in these calculations (Table 4.3). The exclusion of these two outliers, affected the mean, standard deviation and maximum values.

Figure 4.21: Distribution of mouth width index



4.2.11a Mouth width index (Method A)

With the mouth width index, the relationship between the width of the mouth and the width of the eyes (taken between the lateral borders of the eyes) was calculated. Two main groups were identified (Table 4.24). Most of the population was classified as having a narrow mouth in relation to the width of the eyes (52.5%), followed closely by the intermediate category (46.5%). In only 1% of the population the mouth was almost as wide as the lateral borders of the eyes (Figure 4.22).

Table 4.24: Mouth width index (Method A)

Mouth width index	n	%
1. ≤54.9 narrow	105	52.5
2. 55-66 intermediate	93	46.5
3. ≥66.1 wide	2	1.0
Total	200	100.0

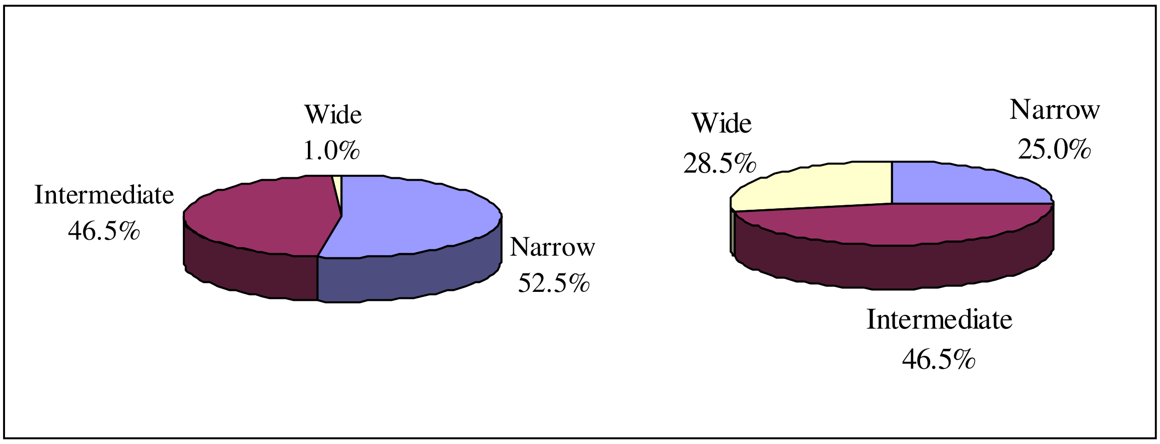
4.2.11b Mouth width index (Method B)

A large group in the population (46.5%) was classified as having a mouth of intermediate width in relation to the width of the eyes (Table 4.25). In a quarter of the population (25%), the mouth was almost as wide as the lateral borders of the eyes (Figure 4.22).

Table 4.25: Mouth width index (Method B)

Mouth width index	n	%
1. ≤52.3 narrow	50	25.0
2. 52.4-57.4 intermediate	93	46.5
3. ≥57.5 wide	57	28.5
Total	200	100.0

Figure 4.22: Comparison for the distribution of the mouth width index (Method A: left and Method B: right)



When using Method B for the calculations, both the wide and narrow categories changed considerably. With Method A, only 1% of the study population was classified as having a wide mouth in relation to the lateral borders of the eyes (Figure 4.22). With Method B 28.5% of the study population were classified with wide mouths. Because of this increase in the wide category, the narrow category decreased considerably from 52.5% to only 25% of the study population. The intermediate category was not influenced.

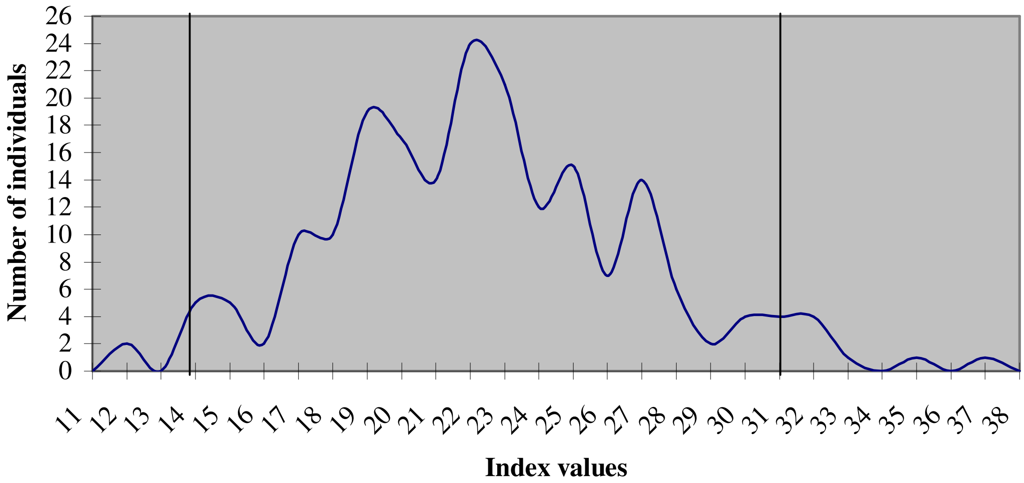
4.2.12 <u>Chin size index</u> ***100 * li-gn/gn-n***

This index is used to calculate the relationship between the height of the chin (li-gn) and the morphological height of the face (gn-n). The contribution of the chin to the height of the face is shown as a percentage. Martin and Saller (1957), Farkas (1981) and Knussmann (1988) all used the measurement for the morphological height of the face in their respective studies, but not the measurement for the height of the chin. Therefore this index is relatively new and the index categories for this index, calculated from this study using **Method A**, are ≤19.9 short, 20-29 intermediate,

≥29.1 long. Using **Method B**, the index categories for this index are ≤19.4 short, 19.5-25.1 intermediate, ≥25.2 long.

Figure 4.23 indicates the distribution of the chin size index, as well as two standard deviations from the mean (vertical black line). Two outliers can be seen from an otherwise normally distributed sample. These two maximum outliers were excluded from calculations when using Method B, as these significantly influenced the results. Therefore only 198 subjects were used in the calculations of Method B (Table 4.3).

Figure 4.23: Distribution of chin size index



4.2.12a Chin size index (Method A)

This index was used to calculate the size of the chin in relation to the morphological height of the face. The greater part of the population was classified as having an intermediate (average) size chin (64%). Only 7.5% of the population was classified as having a long chin and the rest of the population (28.5%) was classified as having a short chin (Table 4.26). Figure 4.24 shows these results graphically.

Table 4.26: Chin size index (Method A)

Chin size index	n	%
1. ≤19.9 short	57	28.5
2. 20-29 intermediate	128	64.0
3. ≥29.1 long	15	7.5
Total	200	100.0

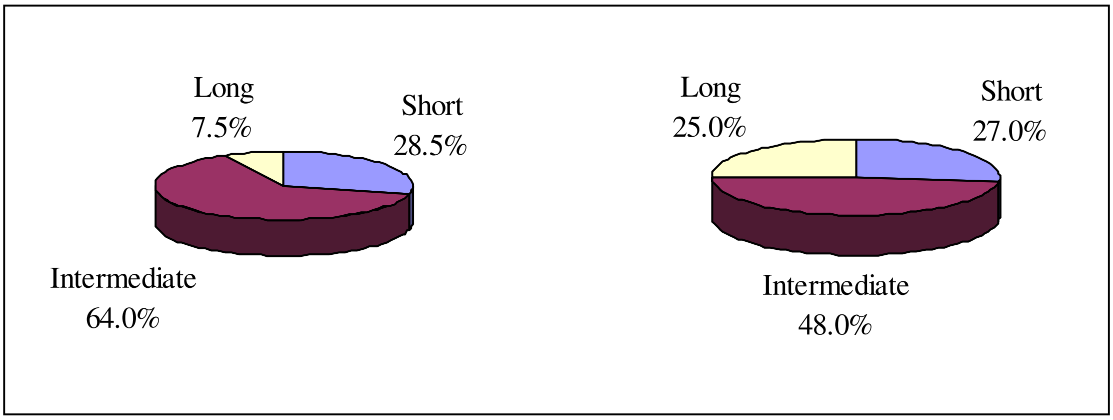
4.2.12b Chin size index (Method B)

Using Method B, almost half of the population was classified as having an intermediate (average) size chin (48.0%). The rest of the population was almost equally classified as having a long (25.0%) or short (27.0%) chin (Table 4.27).

Table 4.27: Chin size index (Method B)

Chin size index	n	%
1. ≤19.4 short	54	27.0
2. 19.5-25.1 intermediate	96	48.0
3. ≥25.2 long	50	25.0
Total	200	100.0

Figure 4.24: Comparison for the distribution of the chin size index (Method A: left and Method B: right)



For the chin size index, the long and intermediate categories changed considerably when using Method B. The long category increased from only 7.5% to 25% of the study population (Figure 4.24). Because of this increase, the intermediate category decreased from 64% to 48% of the study population.

4.3 MORPHOLOGICAL ANALYSIS

Various morphological characteristics were analysed by classifying each feature into different categories. Descriptions of these categories can be found in Chapter 3 (3.4 Morphology). The frequency of occurrence of each of these categories was calculated for the study population (Tables 4.28-4.35). Figures 4.25-4.32 illustrate the results from the tables.

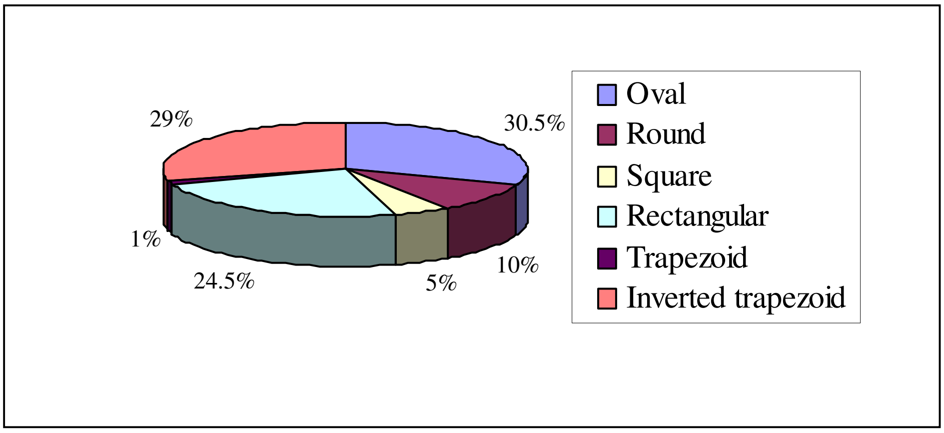
4.3.1 Facial shape

Six different facial shapes were chosen, which included oval, round, square, rectangular, trapezoid and inverted trapezoid. As seen from Table 4.28, the two most common facial shapes were oval (30.5%) and inverted trapezoid (29%). The two facial shapes least common for the population were square (5%) and trapezoid (1%). Figure 4.25 illustrates the results from the table.

Table 4.28: Facial shape

Facial shape	n	%
1. Oval	61	30.5
2. Round	20	10.0
3. Square	10	5.0
4. Rectangular	49	24.5
5. Trapezoid	2	1.0
6. Inverted trapezoid	58	29.0
Total	200	100.0

Figure 4.25: Distribution of facial shape



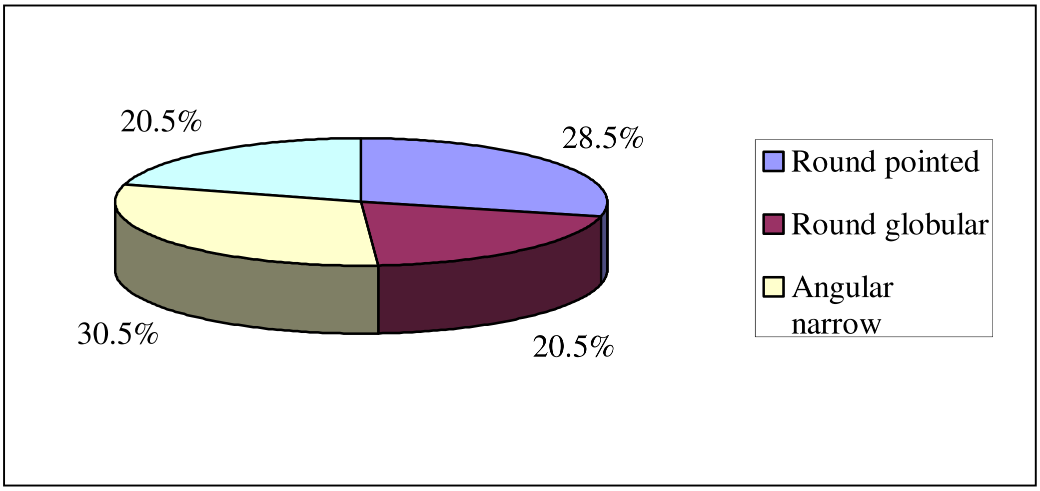
4.3.2 Jaw line

The chin and the area around the gonial angles were investigated to classify the jaw line. Four different categories were chosen for this feature, which included round pointed, round globular, angular narrow and angular broad. As can be seen from Table 4.29, an almost even distribution between the various categories was found. Figure 4.26 illustrates these results.

Table 4.29: Jaw line

Jaw line	**n**	**%**
1. Round pointed	57	28.5
2. Round globular	41	20.5
3. Angular narrow	61	30.5
4. Angular broad	41	20.5
Total	200	100.0

Figure 4.26: Distribution of jaw line



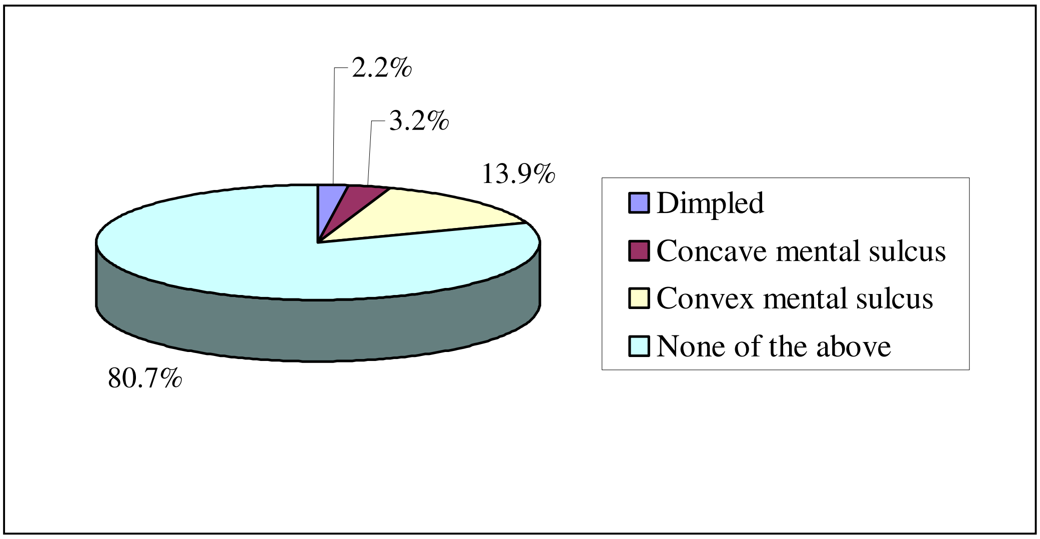
4.3.3 Chin shape

The chin was classified into four different categories depending on the morphology present. The possibilities were dimpled, concave mental sulcus, convex mental sulcus and none of the above (Table 4.30). Most of the population was classified as having no distinctive morphology present on the chin (80.7%). Only 2.2% and 3.2% had a dimpled chin and concave mental sulcus respectively (Figure 4.27).

Table 4.30: Chin shape

Chin shape	n	%
1. Dimpled	4	2.2
2. Concave mental sulcus	6	3.2
3. Convex mental sulcus	26	13.9
4. None of the above	150	80.7
Total	186	100.0

Figure 4.27: Distribution of the morphology of the chin shape



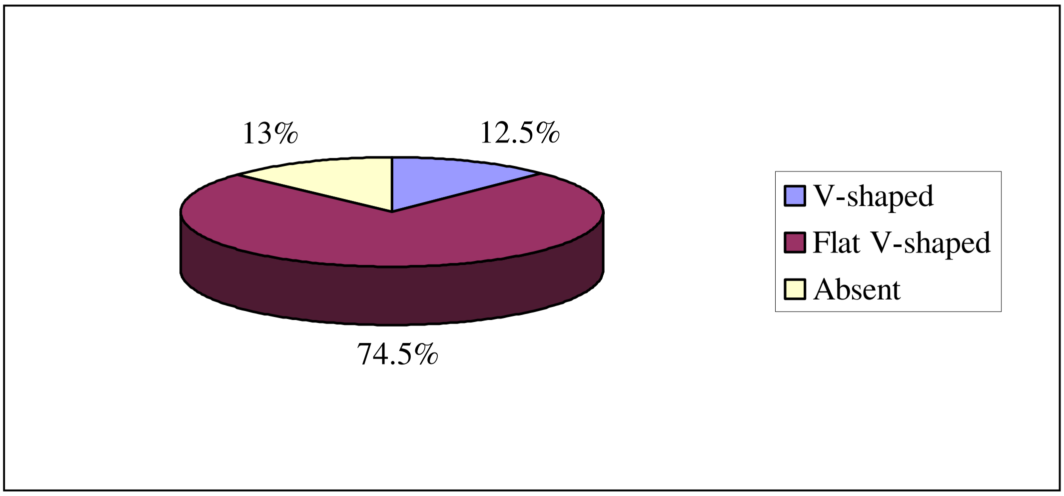
4.3.4 Cupid's bow

Three different categories were chosen to classify the cupid's bow. These included V-shaped, flat V and absent. The majority of the population were classified as having a flat V cupid's bow (74.5%). The remainder of the population was evenly distributed between not having a cupid's bow at all (13%), and having a V-shaped cupid's bow (12.5%). Figure 4.28 illustrates these results.

Table 4.31: Cupid's bow

Cupid's bow	n	%
1. V-shaped	25	12.5
2. Flat V-shaped	149	74.5
3. Absent	26	13.0
Total	200	100.0

Figure 4.28: Distribution of the Cupid's bow



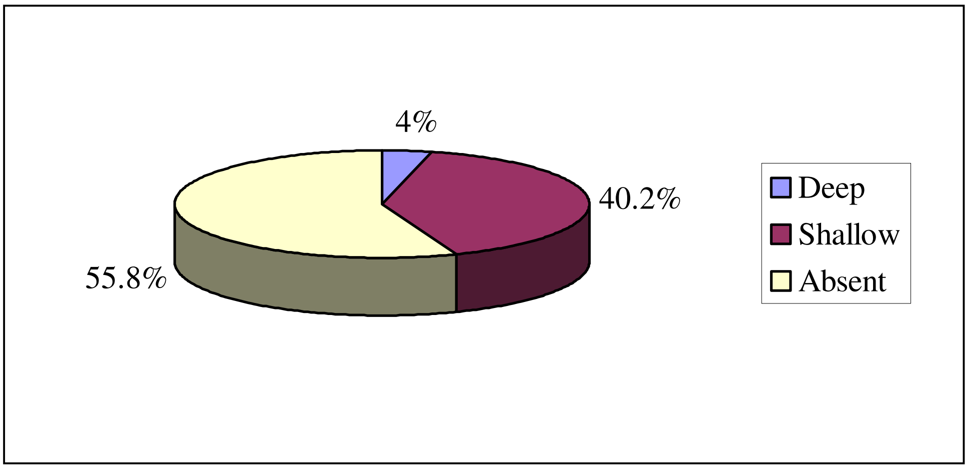
4.3.5 Philtrum

The philtrum was classified using three different categories. These included deep, shallow and absent (Table 4.32). The majority of the population did not have a visible philtrum (55.8%). Only 4.0% of the population were classified as having a deep philtrum. The rest of the population was classified as having a shallow philtrum (40.2%). Figure 4.29 illustrates these results.

Table 4.32: Philtrum

Philtrum	n	%
1. Deep	8	4.0
2. Shallow	80	40.2
3. Absent	111	55.8
Total	199	100.0

Figure 4.29: Distribution of the philtrum



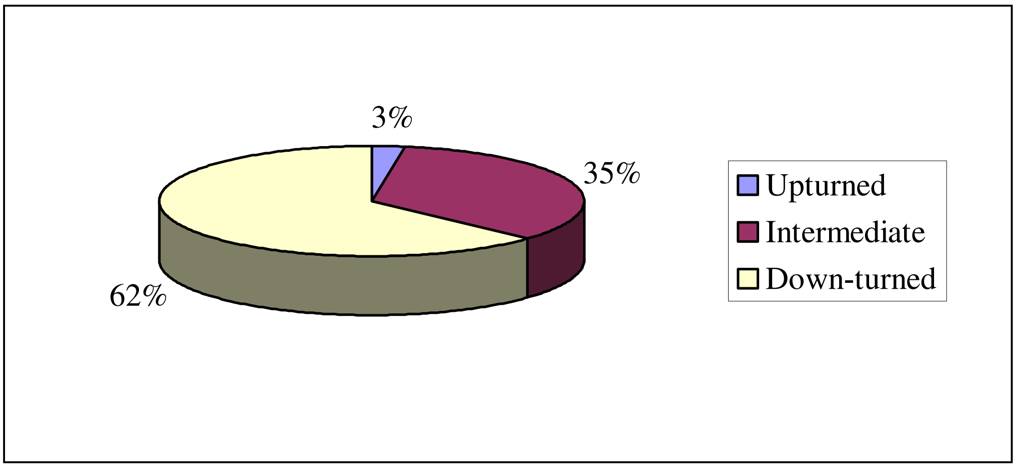
4.3.6 Septum tilt

The position of the septum and the tip of the nose were classified into three categories, which included upturned, intermediate and down-turned (Table 4.33). The greater part of the population was classified as having a down-turned septum (63%). Only 2.5% of the population was classified as having an upturned septum (Figure 4.30).

Table 4.33: Septum tilt

Septum tilt	**n**	**%**
1. Upturned	5	2.5
2. Intermediate	69	34.5
3. Down-turned	126	63.0
Total	200	100.0

Figure 4.30: Distribution of the septum tilt



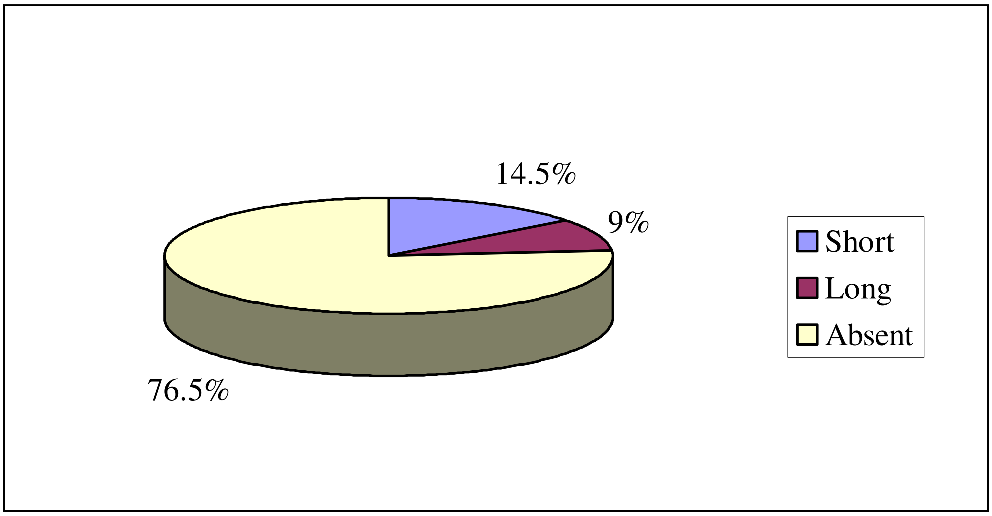
4.3.7 Nasolabial fold

Only the left side of the face was analysed when classifying the nasolabial fold. Three categories were chosen to describe the morphology concerning the nasolabial fold, namely short, long and absent (Table 4.34). In most of the study population a nasolabial fold was absent (76.50%). Only 9% of the population had a long nasolabial fold and 14.50% had a short nasolabial fold (Figure 4.31).

Table 4.34: Nasolabial fold

Nasolabial fold	n	%
1. Short	29	14.5
2. Long	18	9.0
3. Absent	153	76.5
Total	200	100.0

Figure 4.31: Distribution of the nasolabial fold



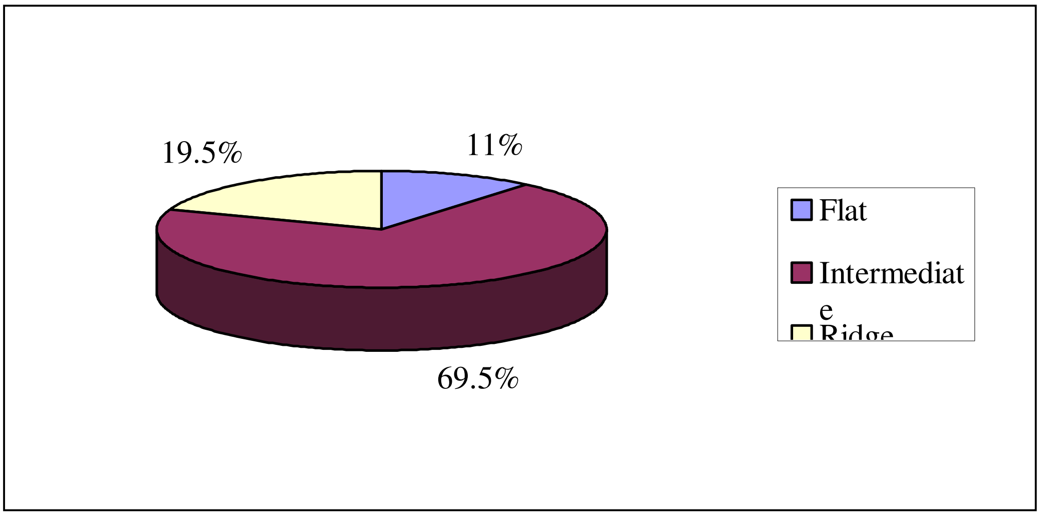
4.3.8 Nose bridge height

The nose bridge height concerns the prominence of the nose at the root, just below the level of the endocanthions of the eyes. The three different categories chosen for this feature included flat, intermediate and ridge (Table 4.35). The majority of the population was classified as having an intermediate nose bridge (69.5%). Only 11% of the population had a flat nose bridge (Figure 4.32).

Table 4.35: Nose bridge height

Nose bridge height	n	%
1. Flat	22	11.0
2. Intermediate	139	69.5
3. Ridge	39	19.5
Total	200	100.0

Figure 4.32: Distribution of the nose bridge height



4.4 ANALYSIS OF THE OCCURRENCE OF COMBINATIONS OF CHARACTERISTICS

Different combinations were created using the metrical and morphological analysis for various parts or regions of the face. The face was divided into three regions namely the upper region of the face (forehead and nose), the middle region of the face (nose and mouth) and the lower region of the face (mouth and chin). The whole face was also analysed. These regions were chosen to facilitate the statistical analysis of each face. The bigger the area of analysis, the more features are present and more categories for each feature. For each of these regions combinations were chosen using metrical data, morphological data and a mixture of both metrical and morphological data. All the features analysed were used at least once in a combination. Only metrical data (indices) calculated using **Method A** was used in the combinations, as this included the outliers in the study population. It is important to include the outliers, as they represent the complete facial variation found in the study population. As this study focussed on individual facial identification, these unique and rare features are important. As previously described in Chapter 3 (3.3.3 Basic statistics and indices for each individual and 3.4 Morphology), only clearly visible landmarks and discernable morphological features were used during the analysis. The frequency of occurrence of each of these combinations was calculated for the study population (Tables 4.36-4.47).

4.4.1 Complete face

4.4.1.1 Metrical analysis of the complete face

For this combination four indices were chosen to represent the whole face. These indices are from left to right, in Table 4.36, left column, the facial index, chin size index, lip index and nasal index. The first number in column one thus represents the index category for the facial index. The second number the index category for the chin size index, etc. All variations with frequencies of the combinations can be seen in Table 4.36. The number (1) represents the lower/smallest index category, (2) the intermediate category and (3) the highest/largest index category. For example, if an individual had a long, narrow face (3), long chin (3), thin lips (1) and an intermediate nose (2), the combination would be 3312. Only one out of the 200 individuals had this combination of characteristics. This is thus a rare combination. However, 20 individuals were classified as having an intermediate face (2), intermediate size chin (2), thick lips (3) and an intermediate nose (2). The combination for these individuals is 2232. This is thus a more common combination of characteristics. The most common combination was 2222 (24.5%). This means that all the indices used were classified in the 2nd or intermediate category, indicating that the face was mesoproscopic, the chin size intermediate, the lips intermediate and the nose of medium width. The second largest group was classified as having a 2122 combination (13.5%). Only the chin size differs between the two combinations, changing from intermediate length to short. The combinations that were not present in the population are not shown in Table 4.36, and comprises of a total of 38 combinations. For example the combination 2131, where the individual would be classified as having an intermediate proportioned face (2), a short chin (1), thick lips (3) and a narrow nose (1) did not occur at all. It can thus be argued that these combinations are very rare in the study population.

Table 4.36: Metrical combinations for the complete face

Facial index Chin size index Lip index Nasal index	**n**	**%**
1122	7	3.50
1123	1	0.50
1212	1	0.50
1222	4	2.00
1223	5	2.50
2112	2	1.00
2122	27	13.50
2123	4	2.00
2132	10	5.00
2133	2	1.00
2212	10	5.00
2213	1	0.50
2222	49	24.50
2223	17	8.50
2232	20	10.00
2233	6	3.00
2312	2	1.00
2313	2	1.00
2322	2	1.00
2323	5	2.50
2333	1	0.50
3122	1	0.50
3132	3	1.50
3212	1	0.50
3222	6	3.00
3223	3	1.50
3232	4	2.00
3233	1	0.50
3312	1	0.50
3322	1	0.50
3332	1	0.50
Total	200	100.00

4.4.1.2 Morphological analysis of the complete face

Combinations were also chosen from only the morphological data. The combinations classifying the whole face morphologically can be seen in Table 4.37. Features chosen to represent the whole face include the facial shape, cupid's bow, septum tilt and jaw line. The most common combination for the population was 1231 (9.50%). This means that many individuals in the population were classified as having an oval face with a flat V-shaped cupid's bow, a down-turned septum tilt and a round pointed jaw line (Table 4.37). The second biggest combination is 6233. This combination classifies 7.50% of the population as having an inverted trapezoid facial shape, a flat V-shaped cupid's bow, a down-turned septum tilt and a angular narrow jaw line. Not all the possible variations are shown in Table 4.37, as a total of 158 possible combinations were absent in the study population. These can then be seen as rare combinations.

Table 4.37: Morphological combinations for the complete face

Facial shape Cupid's bow Septum tilt Jaw line	n	%
1121	2	1.00
1132	1	0.50
1211	1	0.50
1212	1	0.50
1221	6	3.00
1222	5	2.50
1223	1	0.50
1224	1	0.50
1231	19	9.50
1232	12	6.00
1233	5	2.50
1321	1	0.50
1323	1	0.50
1331	4	2.00
1332	1	0.50
2122	1	0.50
2132	1	0.50
2212	1	0.50
2222	8	4.00
2231	1	0.50
2232	5	2.50
2321	1	0.50
2322	2	1.00
3134	1	0.50
3224	1	0.50
3233	2	1.00
3234	3	1.50
3334	3	1.50
4123	1	0.50
4124	2	1.00
4133	2	1.00
4134	2	1.00
4223	4	2.00
4224	9	4.50
4233	8	4.00
4234	13	6.50
4323	1	0.50
4324	2	1.00
4333	2	1.00
4334	3	1.50
5122	1	0.50

Table 4.37: Continued

Facial shape Cupid's bow Septum tilt Jaw line	**n**	**%**
5334	1	0.50
6121	1	0.50
6123	4	2.00
6131	3	1.50
6133	3	1.50
6211	1	0.50
6213	1	0.50
6221	2	1.00
6222	1	0.50
6223	9	4.50
6231	14	7.00
6233	15	7.50
6321	1	0.50
6323	1	0.50
6332	1	0.50
6333	1	0.50
Total	200	100.00

4.4.1.3 Combination analysis of the complete face

For the next set of combinations, metrical as well as morphological data were used. For classifying the whole face, two indices were chosen and two morphological features. These include in order, from left to right in the table, left column, the facial index, nose bridge height, lip index and jaw line (Table 4.38). As seen in Table 4.38, a large group of the population was classified as having a 2223 combination (13%). Thereafter, 9% was classified as having a 2221 combination, which was thus the second most frequent combination. The only difference between these two combinations is the jaw line. For the 2223 combination it is classified as angular narrow and for the 2221 combination the jaw line is classified as round pointed. In both combinations the facial index was mesoproscopic (intermediate) and the nose bridge and lip index both intermediate. Not all the possible variations of the combination are shown in Table 4.38. A total of 53 combinations were not present in the study population. These can be seen as rare combinations.

Table 4.38: Morphometrical combinations for the complete face

Facial index Nose bridge height Lip index Jaw line	n	%
1123	2	1.00
1211	1	0.50
1221	2	1.00
1222	2	1.00
1223	2	1.00
1224	5	2.50
1322	1	0.50
1323	2	1.00
1324	1	0.50
2111	1	0.50
2112	1	0.50
2121	3	1.50
2122	4	2.00
2123	2	1.00
2124	3	1.50
2131	1	0.50
2211	4	2.00
2213	3	1.50
2214	2	1.00
2221	18	9.00
2222	16	8.00
2223	26	13.00
2224	17	8.50
2231	13	6.50
2232	7	3.50
2233	5	2.50
2234	4	2.00
2311	1	0.50
2312	3	1.50
2313	1	0.50
2314	1	0.50
2321	4	2.00
2322	4	2.00
2323	6	3.00
2324	1	0.50
2331	3	1.50
2332	1	0.50
2333	3	1.50
2334	2	1.00
3111	1	0.50
3123	1	0.50
3124	2	1.00
3134	1	0.50
3221	1	0.50
3222	1	0.50
3223	3	1.50
3224	1	0.50
3231	3	1.50
3233	3	1.50
3314	1	0.50
3321	1	0.50
3323	1	0.50
3332	1	0.50
3333	1	0.50
Total	200	100.00

4.4.2 Upper region of the face

4.4.2.1 Metrical analysis of the upper region of the face

These combinations were used to metrically assess the upper region of the face (Table 4.39). Four indices were chosen to represent this region of the face. The indices are forehead size, intercanthal index, nasofacial index and nose-face width index. Only 161 subjects could be used in these combinations as only 161 were measured for the size of the forehead. The remaining 39 individuals were not taken into account. The majority of the population was classified as having a 2122 combination (11.18%). This means that the forehead was often of intermediate size, the eyes were close together and both the length and width of the nose were intermediate in relation to the face. Not all the variations are shown in Table 4.39. A total of 24 combinations were not present in the study population. These can thus be seen as rare combinations.

Table 4.39: Metrical combinations for the upper region of the face

Forehead size index Intercanthal index Nasofacial index Nose-face width index	n	%
1111	1	0.62
1112	1	0.62
1122	4	2.48
1132	3	1.86
1212	2	1.24
1221	1	0.62
1222	2	1.24
1223	1	0.62
2111	2	1.24
2112	4	2.48
2113	3	1.86
2121	3	1.86
2122	18	11.18
2123	7	4.35
2131	1	0.62
2132	6	3.73
2133	5	3.11
2212	4	2.48
2221	7	4.35
2222	14	8.70
2223	7	4.35
2231	2	1.24

Table 4.39: Continued

Forehead size index **Intercanthal index** **Nasofacial index** **Nose-face width index**	**n**	**%**
2232	6	3.73
2233	3	1.86
2322	1	0.62
2332	1	0.62
3111	1	0.62
3112	1	0.62
3121	7	4.35
3122	15	9.32
3123	6	3.73
3131	1	0.62
3132	3	1.86
3211	1	0.62
3213	1	0.62
3221	2	1.24
3222	10	6.21
3223	3	1.86
3232	1	0.62
Total	161	100.00

4.4.2.2 Morphological analysis of the upper region of the face

For this combination, representing the upper part of the face (forehead and nose), the philtrum, septum tilt and nose bridge were chosen (Table 4.40). Only 199 subjects could be classified with this combination, as the one subject's philtrum could not be classified due to the presence of a moustache. The two most common combinations were 332 (25.63%) and 232 (16.08%). The first combination means that the individuals were classified as not having a visible philtrum with a down-turned septum tilt, and intermediate nose bridge. The second group differs from the first with only the philtrum being present and shallow. Only 7 combinations were not present in the study population.

Table 4.40: Morphological combinations for the upper region of the face

Philtrum Septum tilt Nose bridge	**n**	**%**
122	1	0.50
123	1	0.50
132	3	1.51
133	3	1.51
211	1	0.50
212	2	1.01
213	1	0.50
221	2	1.01
222	19	9.55
223	5	2.51
231	7	3.52
232	32	16.08
233	11	5.53
312	1	0.50
321	5	2.51
322	29	14.57
323	7	3.52
331	7	3.52
332	51	25.63
333	11	5.53
Total	199	100.00

4.4.2.3 Combination analysis of the upper region of the face

Three indices and two morphological features were chosen to assess the upper region of the face (Table 4.41). These include the size of the forehead, nose bridge, nasal index, nasofacial index and the septum tilt. Only 161 subjects could be classified with this combination, as the size of the forehead was included. As seen from Table 4.41, a large group of the population was classified with a 22223 combination (14.91%). This means that all the features were classified as intermediate except the septum tilt, which was classified as down-turned. The second most common group was classified with a 22222 combination (8.07%). The only change from the previous combination is the septum tilt, which is classified as being average. Closely following this group was a 32223 combination (7.45%). This combination classifies the population as having a low forehead, down-turned septum and the rest as intermediate. Not all the possible variations of the combination are shown in Table 4.41. A total of 185 variations were not present in the study population. These can be seen as rare combinations.

Table 4.41: Morphometrical combinations for the upper region of the face

Forehead size index Nose bridge height Nasal index Nasofacial index Septum tilt	n	%
11212	1	0.62
12212	1	0.62
12222	3	1.86
12223	3	1.86
12233	1	0.62
12312	1	0.62
12313	1	0.62
12323	1	0.62
13222	1	0.62
13232	1	0.62
13233	1	0.62
21213	1	0.62
21222	1	0.62
21223	4	2.48
21232	1	0.62
21233	1	0.62
21313	2	1.24
21322	1	0.62
21323	1	0.62
22221	1	0.62
22222	13	8.07
22223	24	14.91
22231	1	0.62
22232	3	1.86
22233	12	7.45
22312	3	1.86
22313	4	2.48
22322	2	1.24
22323	3	1.86
23213	1	0.62
23222	1	0.62
23223	5	3.11
23231	1	0.62
23232	1	0.62
23233	4	2.48
23313	2	1.24
23322	1	0.62
31222	2	1.24
31223	1	0.62
32213	1	0.62
32222	9	5.59
32223	12	7.45
32232	1	0.62
32233	2	1.24
32312	1	0.62
32313	1	0.62

Table 4.41: Continued

Forehead size index **Nose bridge height** **Nasal index** **Nasofacial index** **Septum tilt**	**n**	**%**
32322	6	3.73
32323	2	1.24
32332	1	0.62
33222	4	2.48
33223	5	3.11
33233	1	0.62
33312	1	0.62
33322	1	0.62
33323	1	0.62
Total	161	100.00

4.4.3 <u>Middle region of the face</u>

4.4.3.1 Metrical analysis

The indices chosen include the nasal index, lip index, upper lip thickness and lower lip thickness. In Table 4.42 the middle part of the face, consisting of the nose and mouth, was metrically classified using these combinations. The majority of the population had a 2222 combination (28%), where the individual was classified with a medium width nose, medium mouth, with medium thick upper and lower lips. This combination was followed by the 2322 combination (10%). Between these two combinations only the lip index changed from being classified as of intermediate thickness to being thick. Not all the variations are shown in Table 4.42. A total of 54 combinations were not present in the study population. These can then be seen as rare combinations.

Table 4.42: Metrical combinations for the middle region of the face

Nasal index **Lip index** **Upper lip thickness index** **Lower lip thickness index**	**n**	**%**
2113	5	2.50
2122	3	1.50
2123	7	3.50
2131	1	0.50
2132	1	0.50
2213	10	5.00
2222	56	28.00
2223	18	9.00

Table 4.42: Continued

Nasal index **Lip index** **Upper lip thickness index** **Lower lip thickness index**	**n**	**%**
2231	4	2.00
2232	9	4.50
2321	1	0.50
2322	20	10.00
2323	2	1.00
2331	8	4.00
2332	7	3.50
3113	1	0.50
3122	1	0.50
3131	1	0.50
3213	3	1.50
3221	1	0.50
3222	19	9.50
3223	5	2.50
3231	3	1.50
3232	4	2.00
3321	1	0.50
3322	6	3.00
3331	3	1.50
Total	200	100.00

4.4.3.2 Morphological analysis of the middle region of the face

Three morphological features were chosen to classify the middle region of the face. The three features were the philtrum, cupid's bow and septum tilt. Only 199 subjects could be classified with this combination, as the one subject's philtrum could not be classified due to the presence of a moustache. The largest group of the population (24.62%) was classified with a 323 combination (Table 4.43). Following closely is a 223 combination (21.61%). These combinations respectively mean an absent philtrum, flat V-shaped cupid's bow, down-turned septum tilt and shallow philtrum, absent cupid's bow with down-turned septum tilt. Only eight variations of the combination were not present in the study population.

Table 4.43: Morphological combinations for the middle region of the face

Philtrum Cupid's bow Septum tilt	**n**	**%**
113	1	0.50
122	1	0.50
123	4	2.01
132	1	0.50
133	1	0.50
212	4	2.01
213	5	2.51
221	4	2.01
222	20	10.05
223	43	21.61
232	2	1.01
233	2	1.01
312	8	4.02
313	7	3.52
321	1	0.50
322	26	13.07
323	49	24.62
332	7	3.52
333	13	6.53
Total	199	100.00

4.4.3.3 Combination analysis of the middle region of the face

To classify the middle part of the face, two indices and two morphological features were chosen (Table 4.44). These include the nose-face width index, philtrum, cupid's bow and the lip index. Only 199 subjects could be classified, because the philtrum was included in this combination. One subject's morphology of the philtrum could not be determined as the subject had a moustache. Referring to Table 4.44, the most common combination for the population was a 2221 combination (12.06%), closely followed by 2321 and 2322 combinations (both 11.06%). The first combination (2221) means that the width of the nose is intermediate in relation to the width of the face, the philtrum is shallow, the cupid's bow is flat V-shaped and the relationship between the width of the mouth and the biocular diameter of the eyes is narrow. The 2321 combination differs from the previous combination as the philtrum is now classified as being absent. The 2322 combination differs from the former combinations, as the relationship between the width of the mouth and the biocular diameter of the eyes are now intermediate. Not all the possible variations of the combination are shown in Table 4.44. A total of 43 variations were not present in the study population. These can be seen as rare combinations.

Table 4.44: Morphometrical combinations for the middle region of the face

Nose-face width index Philtrum Cupid's bow Mouth width index	**n**	**%**
1122	1	0.50
1132	1	0.50
1211	2	1.01
1221	8	4.02
1222	4	2.01
1223	1	0.50
1232	2	1.01
1311	3	1.51
1321	2	1.01
1322	7	3.52
1323	1	0.50
1331	1	0.50
1332	2	1.01
2112	1	0.50
2121	2	1.01
2122	1	0.50
2211	3	1.51
2221	24	12.06
2222	15	7.54
2231	1	0.50
2232	1	0.50
2311	6	3.02
2312	3	1.51
2321	22	11.06
2322	22	11.06
2331	7	3.52
2332	6	3.02
3122	1	0.50
3131	1	0.50
3211	2	1.01
3212	2	1.01
3221	6	3.02
3222	9	4.52
3311	1	0.50
3312	2	1.01
3321	14	7.04
3322	8	4.02
3332	4	2.01
Total	199	100.00

4.4.4 <u>Lower region of the face</u>

4.4.4.1 Metrical analysis of the lower region of the face

The chin size, lip, vertical mouth height and mouth width indices were chosen to classify the lower part of the face (Table 4.45). The population was classified into various combinations, the two most common being, 2221 (16.50%) and 2222 (14.50%). The most common classification for the lower region of the face was an intermediate size chin, intermediate size lips and mouth. The only difference between these two combinations is the width of the mouth in relation to the width of the eyes, first being classified as narrow and then intermediate. Not all the possible variations are shown in Table 4.45. A total of 48 combinations were not present in the study population. These can then be seen as rare combinations.

Table 4.45: Metrical combinations for the lower region of the face

Chin size index Lip index Vertical mouth height index Mouth width index	n	%
1112	2	1.00
1211	1	0.50
1221	21	10.50
1222	11	5.50
1231	4	2.00
1232	3	1.50
1321	1	0.50
1331	9	4.50
1332	5	2.50
2111	4	2.00
2112	5	2.50
2121	1	0.50
2122	3	1.50
2211	3	1.50
2221	33	16.50
2222	29	14.50
2231	4	2.00
2232	15	7.50
2321	10	5.00
2322	2	1.00
2331	9	4.50
2332	9	4.50
2333	1	0.50
3111	2	1.00
3112	2	1.00
3113	1	0.50

Table 4.45: Continued

Chin size index **Lip index** **Vertical mouth height index** **Mouth width index**	**n**	**%**
3221	2	1.00
3222	6	3.00
3321	1	0.50
3332	1	0.50
Total	200	100.00

4.4.4.2 Morphological analysis of the lower region of the face

For the morphological classification of the lower part of the face, three morphological features were chosen. These included the philtrum, cupid's bow and chin shape. Only 185 subjects were classified using this combination as the philtrum and chin were used (Table 4.46). Again one subject's philtrum could not be identified due to a moustache. The morphology of the chin was not classified in 14 subjects due to receding chins and the effect of the shadows on the area. A large group of the population was classified with a 324 combination (33.51%). Thereafter 24.86% of the population was classified with a 224 combination (Table 4.46). Between the two combinations only the philtrum changes from being absent to shallow. In both the combinations the cupid's bow is flat V-shaped and there is no distinctive morphology on the chin. A total of 17 variations of this combination were not present in the study population. These variations can be seen as rare combinations for the study population.

Table 4.46: Morphological combinations for the lower region of the face

Philtrum **Cupid's bow** **Chin shape**	**n**	**%**
114	1	0.54
123	2	1.08
124	3	1.62
134	1	0.54
214	7	3.78
221	2	1.08
222	2	1.08

Table 4.46: Continued

Philtrum Cupid's bow Chin shape	n	%
223	11	5.95
224	46	24.86
234	4	2.16
312	1	0.54
313	2	1.08
314	12	6.49
322	2	1.08
323	8	4.32
324	62	33.51
331	2	1.08
333	3	1.62
334	14	7.57
Total	185	100.00

4.4.4.3 Combination analysis of the lower region of the face

Three indices and two morphological features were chosen to classify the lower part of the face (Table 4.47). These included the thickness of upper and lower lip, the morphology of the chin, the size of the chin and the jaw line. Only 186 subjects were classified with this combination, as the morphology of the chin was included. The morphology of the chin could not be determined from 14 subjects, due to receding chins and shadows on the relevant area. Two major groups were identified in the population, each consisting of 8.06% of the population (combinations 22421 and 22423). These combinations both mean that the population was classified with average (intermediate) thick lips, no distinctive morphology on the chin and an intermediate size chin. The jaw lines differ between the two combinations, being round pointed (1) in the first and angular narrow (3) in the second. Another major group classified constitutes 6.99% of the population (combination 22424). This combination classifies the group as having average (intermediate) thick lips, no identifiable morphology on the chin, an intermediate size chin and an angular broad jaw line (Table 4.47). Not all the possible variations of the combination are shown in

Table 4.47. A total of 353 variations were not present in the study population. These can be seen as rare combinations.

Table 4.47: Morphometrical combinations for the lower region of the face

Upper lip thickness Lower lip thickness Chin shape Chin size index Jaw line	n	%
13312	1	0.54
13321	1	0.54
13323	1	0.54
13411	1	0.54
13412	1	0.54
13413	3	1.61
13414	2	1.08
13421	5	2.69
13422	1	0.54
13423	2	1.08
13424	1	0.54
21222	1	0.54
21414	1	0.54
21421	1	0.54
22113	1	0.54
22124	1	0.54
22133	1	0.54
22212	1	0.54
22214	1	0.54
22222	1	0.54
22223	1	0.54
22311	2	1.08
22312	2	1.08
22313	3	1.61
22321	1	0.54
22322	1	0.54
22323	2	1.08
22324	4	2.15
22411	5	2.69
22412	5	2.69
22413	9	4.84
22414	3	1.61
22421	15	8.06
22422	7	3.76
22423	15	8.06
22424	13	6.99
22432	1	0.54
22433	1	0.54
22434	1	0.54
23111	1	0.54
23223	1	0.54
23312	1	0.54
23321	2	1.08
23323	2	1.08
23411	3	1.61
23413	3	1.61
23421	5	2.69
23422	5	2.69
23423	2	1.08
23424	2	1.08

Table 4.47: Continued

Upper lip thickness Lower lip thickness Chin shape Chin size index Jaw line	**n**	**%**
23433	1	0.54
31331	1	0.54
31334	1	0.54
31412	2	1.08
31421	8	4.30
31422	2	1.08
31423	2	1.08
31424	1	0.54
31431	1	0.54
31432	1	0.54
32324	1	0.54
32412	1	0.54
32414	2	1.08
32421	4	2.15
32423	6	3.23
32424	1	0.54
32433	1	0.54
32434	4	2.15
Total	186	100.00

4.5 INTRA- AND INTER-OBSERVER RELIABILITY

The intra-observer reliability was calculated using the intra class correlation (ICC), which is bounded by one, i.e. the closer to one the higher the reliability. The measurement between the trichion and glabella was not included in this calculation, as the measurement could only be taken from some of the photographs. Table 4.48 shows the ICC values for the remaining measurements.

Most of the ICC values for the author's intra observer reliability were close to one. Measurements for the length of the nose (n-sn) and the thickness of the upper lip (ls-sto) showed the least reliability, being 0.8960 and 0.8817 respectively. The intra-observer reliability for Inspector JE Naudé was also very close to one, with the thickness of the upper lip again being the least reliable (0.8389). This thus indicates that the thickness of the upper lip is the most difficult to measure reliably, although this value is within acceptable limits.

Table 4.48: Intra-observer reliability expressed by the intra class correlation (ICC)

	ICC	
Measurement	**Intra-observer reliability (Author)**	**Intra-observer reliability (Insp. JE Naudé)**
gn – v	0.9988	0.9989
gn – n	0.9608	0.9871
zy – zy	0.9982	0.9973
ex – ex	0.9451	0.9892
en – en	0.9443	0.9474
n – sn	0.8960	0.9743
al – al	0.9881	0.9863
ls – li	0.9740	0.9696
ch – ch	0.9318	0.9839
ls – sto	0.8817	0.8389
li – sto	0.9377	0.9337
li – gn	0.9799	0.9809

The inter-rater agreement was calculated to analyse the inter-observer reliability. Again the measurement between the trichion and glabella was not included in this calculation, as the measurement could only be taken from some of the photographs. The limits of agreement in Table 4.49 indicate the likely difference between the two observers for each of the measurements. For example, the li-sto measurement was measured as being 1.05 mm less, or up to 0.63 mm more between the two observers. The bias is used to adjust for the differences between the observers. For example, to adjust for the difference between the author and Inspector JE Naudé for the li-sto measurement, -0.21 should be added to the measurements taken by the author. This means that the li-sto measurement values of the author were consistently 0.21 more than the li-sto values of Inspector JE Naudé. It should be decided from the limits of agreement whether the differences between the observers are acceptable for each measurement. From Table 4.49 it can be seen that three measurements correlated well between the two observers. These measurements included gn-v (height of the head), zy-zy (width of the face) and al-al (width of the nose). Both the bias and limits of agreement were low for these measurements.

Measurements that proved to be the least reliable included some around the eye (en-en and ex-ex), mouth (ch-ch) as well as the gn-n (morphological height of the face) measurement. The bias and limits of agreement for these measurements were not extremely high in general, but were the highest of all the measurements. Regarding the sample size and the range of the measurements taken, the limits of agreement are small enough to be accepted as reliable.

Table 4.49: Inter-rater agreement

Measurement	Bias	Limits of Agreement
gn - v	0.00	(-0.98 ; 0.98)
gn - n	-0.91	(-3.12 ; 1.30)
zy - zy	-0.10	(-0.96 ; 0.76)
ex - ex	1.12	(-0.17 ; 2.41)
en - en	-0.77	(-2.26 ; 0.72)
n - sn	-0.57	(-2.35 ; 1.21)
al - al	0.04	(-0.53 ; 0.61)
ls – li	-0.34	(-1.40 ; 0.32)
ch - ch	0.40	(-1.91 ; 2.71)
ls - sto	-0.30	(-1.16 ; 0.56)
li - sto	-0.21	(-1.05 ; 0.63)
li - gn	-0.33	(-1.68 ; 1.02)

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 INTRODUCTION

The purpose of this study was to analyse the faces of a group of African males in order to create standards for facial classification and identification. The analysis was done using 200 facial photographs. Predetermined landmarks were marked on each photograph and measurements were taken between the various landmarks. The measurements were used to calculate indices to nullify the effect of the absolute size of the photographs. The indices in turn were used to classify various facial features as small/narrow, intermediate and large/wide. These index categories were calculated using two different methods (Method A and Method B as discussed in Chapter 3). The morphology of certain facial features was also described. The data from both the metrical (only Method A) and morphological analysis were used to create combinations, and the frequency of occurrence of each of these combinations was calculated for the study population.

This chapter will firstly focus on the drawbacks and problems experienced during this study, as well as the sample size and how it compares to studies done in the past. The most common and rare facial features of the study population will then be discussed and an indication given on how it can be used in practice. Lastly a conclusion will be given on where the field of facial identification finds itself today and suggestions will be given for future research.

5.2 DRAWBACKS AND PROBLEMS EXPERIENCED

5.2.1 Organisation

In order to analyse the facial features of the population, a substantial number of facial photographs was needed. This was extremely difficult to obtain, as the face is the centre of a person's identity. It would be impossible to analyse and publish the face and still keep the individual anonymous. It was also difficult to find a large enough group of volunteers, in one location and at the same time, to participate in the study. It was preferred that the whole group be photographed in one place, to standardize the conditions concerning the photography, for example the background and lighting. This proved to be a logistical problem. Only 200 subjects qualified to participate in the study. Although this is a substantial number, it is probably a too small sample to represent all the variations of the whole population. A larger study population for follow-up studies and a comparison between the results of these studies are recommended.

After a study population was identified, the ethical considerations were the next hurdle to overcome. The face had to be analysed without revealing the participant's identity. This was done by keeping the names of all the participants anonymous and only using numbers for distinction. This proved to be a very workable method. All the photographs were distinguishable, as each participant had their own number. Only the author is permitted to keep and study the photographs, as well as the negatives. Thereafter all photographs will be destroyed.

5.2.2 <u>Identification of landmarks</u>

The landmarks and measurements chosen for this study were previously used by scientists such as Hrdlicka (1943), Martin and Saller (1957), Farkas (1980, 1981, 1994) and Knussmann (1988), to list but a view. Not all the possible landmarks were used, as only anterior-posterior (a-p) view facial photographs were assessed. According to Farkas (1980), this view produces more accurate measurements than the profile view. Although careful consideration was taken when choosing the landmarks, measurements and morphological features, there was still some difficulty with the identification of some of the landmarks on a few of the photographs. On these photographs the lighting and shadows on the face affected the visibility of certain landmarks.

With some of the subjects, the facial shape influenced the visibility of some of the landmarks. For example, if the subject had a receding chin, the shadows affected the estimation of the precise position of several of the landmarks as well as morphology in the area.

Facial hair also played a role in obscuring landmarks. The trichion and philtrum were respectively affected by the absence and presence of hair on the face. The trichion could not be identified on 39 subjects, where the hairline has receded or the head was shaven. This landmark is likely to be unreliable in further studies, as male pattern temporal hair loss varies between individuals. The philtrum, on the other hand, could not be identified if the subject a moustache. Only one subject had a moustache. The trichion and philtrum were not included in the tests for intra- and inter-observer reliability.

Shading was used to classify the depth of the philtrum, as well as the nose bridge height on the 2D-images. The perception of these features may change with different degrees of shading. This should be kept in mind when comparing these features of an individual on two different photographs.

According to Herskovits (1970), the nasion was difficult to find in the American Negroid population. This also proved to be a problem during this study. The reason for this could be that the nasion is not a fixed landmark and the investigator must therefore interpret the description of the landmark to judge the exact point. This could cause variation when a photograph is measured. With some of the subjects the nasion was readily visible, forming an indentation.

The size of the eyes was not included in this study, as the camera flash affected each person differently. Therefore the eyes were not always in a standard or normal position, which would affect the measurements as well as the calculated indices. Sufficient lighting is very important to identify all the landmarks. Therefore a fixed lighting source, that will not influence the size of the eyes, is recommended for future studies.

The ears were excluded from this study, as they were not readily visible on all the a-p facial photographs. With some of the subjects the ears were partly visible, enough to observe a few of the landmarks present on the ear, but other subject's ears were not visible at all, as they were flat against the head. The positioning of the camera would not have improved the visibility of these ears, as they were already 'hidden' behind the side of the head. It is probably best if the ears are only studied on lateral view photographs. It may be possible to only score the ears as 'visible' or 'not visible' when analysing anterior view photographs

Measurements can only be compared where faces are expressionless or in a standard position. This is difficult to achieve as the slightest expression can alter measurements (İşcan 1993). In this study this problem was eliminated from the start, as all the photographs with expressions were eliminated, until 200 photographs, where none of the individuals had any clear facial expressions, were left.

5.3 PHOTOGRAPHY

The photography of this study was standardized as much as possible. The cameras were placed at a fixed distance of 1 m from the subject. All the photographs were taken in one location, under the same conditions. According to Farkas (1981), the greater the distance between the camera and the subject, the more distortion is found on the areas around the focus point of the camera. The camera-subject distance in this study was relatively short, which according to Farkas, minimized the distortion of the photographs. Knussmann (1988) proposed that the best quality photograph is taken when the optical axis of the camera passes more or less through the middle of the object being photographed. During this study the camera's optical axis was fixed to focus on the nose of the subject, giving the best quality photographs. The distance as well as the angle of the lens can influence measurements taken from the photograph (İşcan 1993). This problem was eliminated during this study, as the distance between the camera and the subjects was constant at 1 m and the angle of the lens was straight towards the nose of the subject. İşcan (1993) described the ideal size for photographs to take measurements from as 8x10" (20.3 x 25.4 cm). In this study the photographs were 19.9 x 24.7 cm, which correlated well with İşcan's recommendation.

As stated earlier, Porter and Doran (2000) found that facial photographs with an interpupillary distance of 6 cm, gave them the most accurate results. The average interpupillary distance of living subjects is 6 cm. According to these authors they used the interpupillary distance to standardise the magnification, while enlarging the photograph. It was found during this study that the pupils were not always distinguishable, as the eyes are dark brown in colour. Where pupils were visible, the interpupillary distance was measured as 3 cm. Although this is less than the value stated by Porter and Doran (2000), the size of the photographs was similar to the size stated by İşcan (1993).

It is recommended that photographs be taken with an additional light source and without a flash, as this may influence the size of the subject's eyes. This ensures that all the landmarks are visible on all the photographs and not obscured by shadows falling across the face.

5.4 SAMPLE SIZE

During this study 200 facial photographs were analysed using metrical and morphological methods. This is, to date, the single biggest sample size of a group of South African male faces used in a research study. The only study with a bigger study population consisted of 1243 subjects from East Africa (Oschinsky 1954). Other studies that analysed Negroid faces had study populations between 50 and 150 African-American males (Hooton 1932, Farkas 1994).

Although the population of this study is the largest consisting of South African individuals, it is by no means a clear representation of the whole South African male population. Therefore, more research is recommended in the field of facial identification in South Africa and a larger study population should be analysed.

5.5 REPEATABILITY

The intra and inter observer reliability tests were done after the initial analysis of the photographs. Therefore no measurements could possibly be remembered. The photographs for the intra and inter observer reliability were chosen at random and reprinted, to eliminate any previous marks on the photographs. The photographs were measured by Inspector JE Naudé, National Trainer at the SAPS, for the inter observer reliability.

The intra observer reliability was calculated using the intra class correlation, which is bounded by 1. From the intra observer reliability (Table 4.48), it was seen that most of the measurements were repeatable. Some of these included the gn-v (0.99), al-al (0.98) and ls-li (0.97) measurements. Measurements that did not correlate that well included the ls-sto (0.88) and n-sn (0.89) measurements. This may be due to the difficulty in locating the exact point for the various landmarks used in these measurements.

Landmarks on the lips also proved to be fairly unreliable. The associated measurements included the ls-sto (0.83) and li-sto (0.93) dimensions. This may be due to a difference in interpretation of the exact location of the landmarks found on the lips. More detailed descriptions of these landmarks are needed in order to put an end to this problem. The remainder of the measurements correlated well.

Considering the inter observer reliability, measurements from the eyes and mouth again proved to be the most unreliable. These measurements included the en-en and ex-ex measurements from the eyes and the ch-ch, ls-li and ls-sto measurements from the mouth (Table 4.49). A reason for the relatively poor reliability between the observers as far as these measurements are concerned, may be the difference in interpretation between the two observers. Although the descriptions of the landmarks were clear, certain variations at some of these landmarks could be interpreted. For example, the exocanthion of the eyes and the cheilions of the mouth were both described as the lateral point where the upper and lower parts of the eye and mouth join respectively. For both the exocanthion and the cheilion, this may be interpreted either on the inside of the connection or just to the outside of the said point. The difference in this interpretation caused the relatively poor reliability between the two observers. Both the intra observer reliabilities were however high. This thus implies that it is possible to take them accurately, but that the definitions for the landmarks need to be more precise. The most consistent measurements between the two observers were gn-v, zy-zy and al-al. It was found that the most reliable measurements consisted of landmarks which had a clear and concise description. This assisted the precise relocation of the said landmarks.

The field of facial identification requires the observer to have experience in the analysis of faces. Faces are difficult to analyse, as there are so many features that could be used and a wide range of variation for each feature. It is therefore important for the observer to choose well-described landmarks and features that can be easily repeated by other observers.

5.6 DISCUSSION OF RESULTS

A discussion of the results for each facial feature analysed, as well as for each region of the face, follows. Individual features will firstly be discussed, using metrical data from **Method A**. Results from **Method B** will only be mentioned when there is a significant difference from **Method A**. Common combinations, using metrical data from only **Method A**, will then be discussed, where some attention will be given to the combinations that are entirely absent in the study population, i.e. the rare features. Only some of these combinations will be discussed, as there are too many to discuss every single combination absent from the study population.

5.6.1 Individual features

As was expected from the analysis of individual metric features (**Method A**), a large group of the study population was classified in the intermediate category for most of the characteristics analysed. These characteristics included the size of the forehead (59%), the face (80%), shape of the nose (76%), the length (69%) and width (57%) of the nose, the size of the mouth (66%) as well as the vertical mouth height (60%) and the size of the chin (63%). Both the upper (69%) and lower (62%) lips were also most commonly classified as being intermediate in size, although the lower lip tended more towards being thick (26%) than thin (12%). These characteristics, because they occur so frequently, would therefore be of little help when trying to match a face to a photograph.

The classification of the lips worked on a reciprocal basis. This means that the thickness of the upper lip should compliment the thickness of the lower lip, as individual lip thickness was calculated in relation to total height of the mucous lips. For example, if the upper lip is thin then the lower lip should be thick and vice versa. The discrepancies between the classification statistics for the upper and lower lip thickness indices (Figures 4.18 and 4.20) can be attributed to the predetermined manner in which the categories for the indices were calculated.

Concerning the eyes, the most common feature was that they were situated closely together for the largest part of the study population (58%). Another common feature was a narrow mouth in relation to the width of the eyes (52%). The width of the eyes was measured between the lateral borders. A considerable difference was seen in the common features when using **Method A** and **B** respectively for these two indices. The major group in the study population changed from having eyes that are close together (Method A, 58%) to being intermediate (Method B, 47.5%). Similarly the width of the mouth in relation to the eyes changed from narrow (52%) to intermediate (46.5%).

Rare features for the study population, using **Method A**, included eyes that were situated far apart from each other (1%) and a wide mouth in relation to the width of the eyes, taken between the lateral borders of the eyes (1%). Leptorrhin (narrow) noses were completely absent in the study population. Therefore, not one combination with a leptorrhin (narrow) nose was seen in the study population. These rare characteristics were influenced when using **Method B** for these indices. The rare characteristic of the eyes situated far apart (1%) changed to 27.5% when using **Method B**. The characteristic of eyes situated close together became the smallest category when using **Method B** (25%). The rare characteristic of a wide mouth in relation to the eyes (1%), changed to 28.5% of the study population when using **Method B**. The smallest category for the mouth width index, when using **Method B**, was the narrow category (25%). The occurrence of leptorrhin (narrow) noses changed from being absent (**Method A**) to 25.5% (**Method B**). Because of this increase in occurrence of leptorrhin (narrow) noses, the smallest category for the nose when using **Method B** was the chamaerrhin (wide) noses (22.5%).

All the remaining indices using **Method B** produced a normal distribution of the study population, i.e. the major group being the intermediate category and the other two categories almost equal in size.

When considering the morphological analysis of the face, the most common facial shapes for the study population included oval (30%), inverted trapezoid (29%) and rectangular (25%) shapes. When analysing the chin, it was found that with most of the subjects (81%), none of the special morphological features described for the chin area was present. Only 14% of the study population had a convex mental sulcus present on the chin area. Looking at the septum tilt, it was found that a large group of the study population had a down turned septum tilt (62%). In most of the subjects the philtrum was absent (56%). Other common morphological features included a flat V-shaped cupid's bow (74%), an absent nasolabial fold (76%) and an intermediate nasal bridge (69%). The most variable feature for the morphological analysis was the jaw line.

Some of the rare morphological characteristics included a round (1%) and square (5%) facial shape, dimpled chin (2%) and an upturned septum tilt (3%). A deep philtrum (4%) as well as a long nasolabial fold (9%) were also rare features for the study population.

5.6.2 Combinations

Four regions of the face (the complete face, upper, middle and lower region) were analysed by using combinations of the above-mentioned individual features (Tables 4.36 – 4.47). This becomes important when only part of a perpetrator's face is visible, e.g., when wearing a mask. Three different methods were used for each region. These entailed metrical combinations, morphological combinations and combined metrical and morphological combinations. Metrical data from only **Method A** was used in the combinations. This method was used because it included the outliers in the study population, as the study focused on the identification of the rare facial characteristics in the study population.

5.6.2.1 Complete face

To classify the complete face **metrically**, the facial, chin size, lip and nasal indices were combined. As seen from Table 4.36, the largest group in the population (49%) was classified with a combination of 2222. This means that a combination of a mesoproscopic (intermediate) face, an intermediate size chin, intermediate size lips in relation to the width of the mouth and a mesorrhin (intermediate) nose occurred in nearly half of the study population.

A number of combinations were not at all present in the study population. Combinations that were not present in the study population (very rare) for the metrical analysis of the complete face were those with an euryproscopic (short, wide) face, short chin and thin lips in relation to the width of the mouth. Other rare combinations were an euryproscopic (short, wide) face, short chin and thick lips in relation to the width of the mouth and a leptoproscopic (long, narrow) face, short chin and thin lips in relation to the mouth width.

The facial shape, cupid's bow, septum tilt and jaw line were used for the **morphological** analysis of the complete face. From Table 4.37, it can be seen that with the morphological analysis most of the study population had an oval facial shape (30.5%), with inverted trapezoid (29%) and rectangular (24.5%) shapes following closely behind. Together with these facial shapes, a flat V-shaped cupid's bow and a down-turned septum tilt were also some of the more common combinations in the study population. The shape of the jaw line showed great variation in the study population, but a round pointed jaw line was mostly found in combination with an oval or inverted trapezoid facial shape. A round globular jaw line was mostly found with an oval facial shape. Angular narrow and angular broad jaw lines were mostly found in combination with inverted trapezoid and rectangular facial shapes respectively.

Many combinations were not present for the morphological analysis of the complete face. Firstly, no subjects with an absent or V-shaped cupid's bow and an upturned septum tilt were found. Secondly, no subjects were classified with a round facial shape, absent cupid's bow, down-turned septum tilt or square facial shape, V-shaped cupid's bow, intermediate septum tilt. Subjects with square or rectangular facial shapes, flat V-shaped cupid's bow and upturned septum tilt were not found.

Another combination not found in the study population, was subjects with a square facial shape, absent cupid's bow and intermediate septum tilt. Because only two subjects were classified with a trapezoid facial shape, most of the combinations including this facial shape were not present in this study.

The facial index, nose bridge height, lip index and jaw line were used to create combinations for the combined **metrical and morphological** analysis of the complete face. The most common combination for this analysis was 2223 (Table 4.38). This means that a large group (13%) of the study population had a mesoproscopic (intermediate) face, an intermediate nasal bridge, intermediate size mouth and an angular narrow jaw line. It was seen that there were no subjects with a combination of an euryproscopic (short, wide) face and flat nose bridge. Combinations with an euryproscopic (short, wide) face and a ridge (high) nasal bridge were also not found. The last combination not present for the metrical and morphological analysis of the complete face was subjects with a leptoproscopic (long, narrow) face, intermediate nasal bridge and thin lips in relation to the width of the mouth.

5.6.2.2 Upper region of the face

The forehead size, intercanthal, nasofacial and nose-face width indices were used to **metrically** classify the upper region of the face. From Table 4.39 it can be seen that the most common metrical combinations for the upper region of the face in the study population were a nose of intermediate length and width. Other common metrical combinations for the upper region of the face were intermediate or high foreheads and eyes situated close together or at an intermediate distance from each other. Two combinations were not at all present for the metrical analysis of the upper region of the face. The first was a high forehead, eyes situated far apart and a long nose in relation to the length of the face. The second was an intermediate size forehead, eyes situated far apart and a short nose in relation to the length of the face.

The philtrum, septum tilt and nose bridge height were used for the **morphological** analysis of the upper region of the face. Combinations with an intermediate nasal bridge (69.3%) were by far the most common in the study population (Table 4.40). Two other combinations that were common in the study population were a shallow or absent philtrum and an intermediate or down-turned septum tilt. All the combinations with a deep philtrum and upturned septum tilt were not found in the study population. This combination is thus rare for the study population.

The forehead size index, nose bridge height, nasal index, nasofacial index and septum tilt were used for the combined **metrical and morphological** analysis of the upper region of the face. From Table 4.41 it could be deducted that the most common combination for the study population was an intermediate size forehead, intermediate nasal bridge, mesorrhin (intermediate) nose, intermediate length nose in relation to the length of the face and a down-turned septum (14.9%). A large number of combinations were not present in the study population. The first combinations were all those which included a low forehead and flat nasal bridge. Some of the combinations with an intermediate size forehead were also not present in the study population. Other combinations that were not present included a mesorrhin (intermediate) nose and an intermediate or long nose in relation to the length of the face. Other combinations not present included a ridged nasal bridge, chamaerrhin (wide) nose and an intermediate size forehead with an intermediate or ridged nasal bridge. An intermediate nasal bridge, chamaerrhin (wide) and long nose combination as well as mesorrhin (intermediate) and short nose combination were not present.

Also not present was a combination of an intermediate nasal bridge, mesorrhin (intermediate) or chamaerrhin (wide) nose. A combination with an intermediate nasal bridge and a chamaerrhin (wide), long nose in relation to the length of the face was not found in the study population. Also not common in the study population was an intermediate size forehead, ridged nasal bridge, chamaerrhin (wide) nose and a long nose in relation to the face. Subjects with a high forehead, mesorrhin (intermediate) nose and a short or long nose in relation to the length of the face, were not present in the study population. Another two combinations not found in the study population were a high forehead, flat nasal bridge with a chamaerrhin (wide) nose as well as a high forehead and an intermediate nasal bridge.

The last combinations not present for the combined metrical and morphological analysis of the upper region of the face include a high forehead, ridged nasal bridge with a mesorrhin (intermediate) and short nose in relation to the length of the face as well as a combination with a high forehead, ridge nasal bridge, chamaerrhin (wide) and long nose in relation to the length of the face.

5.6.2.3 Middle region of the face

To classify the middle region of the face **metrically**, the nasal, lip, upper and lower lip thickness indices were combined. As seen in Table 4.42, the most common combination for the middle region of the face was upper lips of intermediate size, a mesorrhin (intermediate) nose, intermediate or thick lips in relation to the width of the mouth and intermediate to thick lower lips. Considering the metrical analyses of the middle region of the face, all combinations containing a leptorrhin (narrow) nose were again absent in the study population, as no subject was classified with a leptorrhin nose. Other combinations not present in the study population were a mesorrhin (intermediate) nose, thick lips in relation to the width of the mouth and a thin upper lip.

With the **morphological** analysis of the face, three features were used to classify the study population. These were the philtrum, cupid's bow and septum tilt (Table 4.43). The most common combination for this region of the face was a flat V-shaped cupid's bow and a down turned septum tilt (48.2%), although an intermediate septum tilt was also seen in the study population. The philtrum varied between shallow and being absent all together. For this classification all the combinations were present in some manner, therefore there were no combinations entirely absent for the morphological analysis of the middle region of the face.

The nose-face width index, philtrum, cupid's bow and mouth width index were used for the combined **metrical and morphological** analysis of the middle region of the face. From Table 4.44 it can be seen that the most common combination for the study population was a flat V-shaped cupid's bow, a nose of intermediate width in relation to the width of the face, the philtrum varying between shallow and absent and a narrow to intermediate mouth width. For the combined metrical and morphological analysis of the middle region of the face, a few combinations were entirely absent from the study population. These included most of the combinations with a deep philtrum and a narrow or wide nose in relation to the width of the face, a wide mouth with a V-shaped cupid's bow. Another combination not found in the study population was a nose of intermediate width in relation to the width of the face, a deep philtrum and an absent cupid's bow. The last combination not present in the study population was a wide nose in relation to the width of the face, a shallow philtrum and an absent cupid's bow.

5.6.2.4 Lower region of the face

The chin size, lip, vertical mouth height and mouth width indices were used to **metrically** classify the lower region of the face. Common combinations for the metrical analysis of the lower region of the face included intermediate size lips in relation to the width of the mouth and a chin size varying between short and intermediate length (Table 4.45). Combinations with a narrow to intermediate mouth width were also common in the study population and the height of the mouth was mostly intermediate in relation to the length of the face. These combinations were thus found to be common in the study population. A number of combinations were not present in the study population for the metrical analysis for the lower region of the face. These included mostly all the combinations with a wide mouth and thin lips in relation to the mouth width. Other combinations not found in the study population included a short chin and an intermediate or thick mouth in relation to the length of the face. Also not present was a combination of a short chin, thick lips in relation to the width of the mouth and a thin mouth in relation to the length of the face. Two other combinations not seen in the study population included an intermediate size chin, thick lips in relation to the mouth width and a thin or thick mouth in relation to the length of the face. A combination of a long chin and an intermediate or thick mouth in relation to the length of the face were also not present in the study population. The last two combinations not present for the metrical analysis included a long chin, intermediate or thick lips in relation to the width of the mouth and a thin mouth in relation to the length of the face.

The philtrum, cupid's bow and chin morphology were used to **morphologically** analyse the lower region of the face. Referring to Table 4.46, the most common combinations in the study population for the lower regions of the face were a chin without any of the morphology described during this study, a flat V-shaped cupid's bow and a shallow to absent philtrum. Only four combinations were absent in the study population for the morphological analysis of the lower region of the face. The first two combinations were a deep philtrum with either a V-shaped or absent cupid's bow. The other two combinations included a shallow philtrum with a V-shaped or absent cupid's bow.

The thickness of the upper and lower lips, chin shape, chin size index and the jaw line were used for the combined **metrical and morphological** analysis of the lower region of the face. As seen in Table 4.47, the most common combination for the combined metrical and morphological analysis of the lower region of the face was a chin with no distinctive morphological feature and a lower lip, upper lip and chin of intermediate size (23%). The jaw line varied in the study population, with all the groups almost equally represented. A large number of combinations were not present for the combined metrical and morphological analysis of the lower region of the face. These included most of the combinations with any of the described morphology present on the chin. As the major group of the study population was classified as having intermediate upper and lower lips, most of the combinations with either thin or thick lips were not found. An intermediate upper lip, intermediate lower lip, and a long chin with either a concave or convex mental sulcus combination was not present.

In conclusion, it can be said that some characteristics were more common in the study population than others. The most common features for the study population included a mesoproscopic (intermediate) face, flat V-shaped cupid's bow, a shallow to absent philtrum and a down turned septum tilt. Combinations with these features were thus common. Other features that were present in the study population, but not as common as the previously mentioned features, were an intermediate size forehead, mesorrhine (intermediate) nose, an intermediate length and width nose in relation to the length and width of the face, intermediate lips in relation to the width of the mouth, intermediate upper lips and intermediate to thick lower lips. Less common features included a narrow to intermediate relation between the width of the mouth and the lateral distance between the eyes, as well as an intermediate size chin. Combinations with these features were thus rare.

The rare features in the population, some not present at all in the study population, were an euryproscopic (short, wide) or a leptoproscopic (long, narrow) face, a low forehead, a leptorrhin (narrow), long nose and a deep philtrum. Other rare features also included thin lips in relation to the width of the mouth as well as very thick lower lips. Very thin upper lips with an absent cupid's bow were also not common. A long chin with any distinctive morphology was also rare in the study population.

5.7 COMPARISON TO OTHER STUDIES

Through the years various studies have been done, using morphology as well as metrical features of the face. During most of these studies, measurements were taken directly from the face of the subject, for classification purposes and to assist with operations (Martin and Saller 1957, Farkas 1986, Knussmann 1988). Only a few studies were done where measurements were taken from facial photographs. These and some other studies are discussed below. The sample size, measurements and results of these studies are compared to this study.

As early as 1932, Hooton described the observations of Day, as she studied small samples of the American Negroes and Negroids (Hooton 1932). A total of 135 males between the ages of 25 and 36 years were analysed. Only a few measurements were taken from the facial area. The only result found that could be compared to this study, was the nasal index (Hooton 1932). From this comparison it was seen that the majority of the noses of both the American Negroid and the South African Black males were classified as mesorrhin (intermediate). The American Negroid males however, tended more towards the leptorrhin (narrow) values (Hooton 1932) than the South African Black males.

In 1939, a study was conducted on 'Cape Coloured' males, to describe the physical anthropology of this group (Van Wyk 1939). A total of 133 subjects were measured from head to toe. Of the 14 facial measurements used by Van Wyk, eight were used in this study. From the study it was concluded that the 'Cape Coloured' males had mesoproscopic (intermediate) faces, mesorrhin (intermediate) noses and lips of intermediate size. The results of the present study showed the same common characteristics.

Gavan *et al.* did a study in 1952 comparing measurements taken from photographs to measurements taken directly from the subject. All the measurements correlated well with the measurements taken directly from the subject, except for the head breadth. Gavan *et al.* attributed this to photographic distortion and the lens-subject distance (Gavan 1952).

During his visit to Uganda in 1950, Oschinsky measured a great number of male individuals belonging to different tribes in British East Africa. A total of 1243 male individuals between the ages of 20 and 45 years were measured (Oschinsky 1954). The individuals were from tribes living in Uganda, Kenya, Ruanda-Urundi and Belgian Congo. To date this is the single biggest sample of African faces studied. Seven measurements and four indices calculated from the face during Oschinsky's study were used in this study. Unfortunately not all the results could be compared, as the three original tribes were subdivided into 25 individual tribes, each with their own standards and measurements (Oschinsky 1954). The Baganda tribe was chosen to compare to the results of this study, as this tribe contributed to most of Oschinsky's study population. A total of 425 individuals from the Baganda tribe were measured. Comparable results included the shape and width of the nose, as well as the distance between the eyes. All these indices were found to be similar for the Baganda and the South African Black males (Oschinsky 1954). The shape of the face, however, differed considerably. The Baganda was classified as having a very euryproscopic (short, wide) face, whereas the South African Black males were classified as having mesoproscopic (intermediate) faces. This indicates that there are some similarities and differences between these two groups. The differences signify that the standards for one African group should not be used for the identification of another African group.

In 1970, Fraser and Pashayan did a study using facial photographs. During this study the faces of 50 Caucasian subjects (25 males and 25 females) were analysed by taking 11 measurements from the face. A control group was also analysed (20 males and 30 females). The aim of this study was to prove that parents of children with cleft lips differ from the general population in certain dimension of the face (Fraser and Pashayan 1970). Five of the 11 measurements used by Fraser and Pashayan, were used as measurements during this study. These included the intraocular (en-en) and biocular (ex-ex) measurements as well as the bizigomatic (zy-zy), nose length (n-sn) and nose breadth (al-al) measurements. The facial shapes were also classified. From the study it was seen that most of the Caucasian study population was classified as having an oval or rectangular facial shape with eyes situated close together and a mesorrhin nose. Afterwards a group of Japanese subjects were also classified according to facial shapes (Fraser and Pashayan 1970). The most common facial shapes for the Japanese were rectangular and trapezoid facial shapes. The Black male study population of the present study was classified as having an oval or inverted trapezoid facial shape. This comparison, between the three different populations, showed that some facial shapes are more common in certain populations than in other, therefore standards must be created accordingly for each population.

Farkas (1980, 1981, 1994) conducted many studies in which he took facial measurements from living subjects of various populations, for craniofacial surgery. However, in 1994 a study was done taking measurements from facial photographs. The study population consisted of 36 Caucasian subjects (male and female). The standard landmarks were marked on the subject's face before frontal and profile photographs were taken (Farkas 1994). Measurements were then taken from frontal and profile facial photographs and compared to the measurements taken directly from the living subject. Farkas used 60 measurements during his study. These included linear distances, inclinations and angles. Only 20 of these measurements, which included nine inclinations and 10 linear distances, proved to be reliable from photographs. In the present study, three of the 10 reliable linear distance measurements were used. Only one measurement, Farkas labelled as 'cannot be taken from a photograph', was used in the present study. This measurement is between the vertex and the gnathion (gn-v). According to Farkas the measurement may be influenced by hair covering the vertex (Farkas 1994). No difficulty was experienced to take this measurement during the present study. The study population's hair did not influence the visibility of the vertex, as the hair was either flat on the head or cleanly shaven. The subject's faces were positioned in the Frankfurt plane, which also made the vertex more visible.

As in this study, Farkas also found it difficult to locate the trichion when the subject was bald. Other landmarks which were obscured by facial hair, were also difficult to examine, such as the subnasale and philtrum (Farkas 1994). Most of his reliable measurements were taken from the frontal-view prints. Frontal-view prints were also used in the present study. Not all the data was available from his study and could therefore not be used for a comparison.

Farkas also studied the faces of African-Americans during which he took various facial measurements from living subjects, between the ages of 19 and 25 years old (Farkas 1994). The mean values of the measurements were used to calculate indices, also used during this study. Comparing these results, it was seen that the African-American males tended more towards having a narrow nose in relation to the width of the face, whereas the South African Black males had a nose of intermediate width. The eyes of the African-American males were situated at an intermediate distance from each other, compared to the closely situated eyes of the South African Black males. The shape of both the African-American and South African Black male face was classified as being mesoproscopic (intermediate), but the face of the African-American tended more towards being leptoproscopic (long, narrow) than the South African counterparts (Farkas 1994). This shows a slight difference between diverse nationalities, which could be important during a case of facial identification.

In 1996, Vanezis *et al.* conducted a study on 50 Caucasian males between the ages of 18 and 60 years old. The aim of the study was to establish a practical morphological classification system of the face, to assist in identification of crime suspects. During the study Vanezis analysed facial photographs morphologically using 39 features (Vanezis 1996). Vanezis adapted the 39 features from a previously published table by İşcan (1993). Vanezis stated that the categories used were only applicable for adult Caucasian males. During this study, six morphological feature categories were used, which were adapted from the study done by Vanezis *et al.* Another six feature categories were adapted from the original study done by Vanezis *et al.*, and classified metrically by using indices. Differences in morphological features between ethnic groups can be seen when comparing the study done by Vanezis *et al.* to this study. For example, Vanezis found that most of the Caucasian males had a cleft chin, whereas it was found that the distinctive chin morphology, described during this study, was absent in most of the Black male subjects. A large group of the Caucasian males were classified as having an oval or square facial shape. In this study most of the Black males were classified as having an oval or inverted trapezoid facial shape. Most of the Caucasian males were classified with a deep philtrum, whereas most of the Black males did not have a visible philtrum at all. Looking at the septum tilt, very few Caucasian males were classified with a down turned septum tilt (Vanezis 1996). Most of the Black male subjects had a down turned septum tilt.

From these comparisons it can be deducted that some form of facial variation exist between the various population groups. Therefore it is necessary to have different classification standards for each of the different groups.

5.8 <u>HOW TO USE THE RESULTS OF THIS STUDY</u>

Because there is such a huge variability in all the features in the population, it was necessary to create combinations and divide the face into regions. This method proved to be successful to distinguish between common and rare characteristics. This method can also be successful in practice, for identifying an individual.

Facial identification can be a tedious analysis, as a vast amount of features can be used to analyse the face and great variation exist among the features. Because of the great number of features present on the face and the variation found, one is left with a great number of possible combinations. During this study the face was divided into four regions, narrowing down the area per analysis, for more comprehensive and relevant statistics. This is the first study where the face was divided into regions for analysis. This proved to be beneficial, because the observer could focus on one area at a time and analyse all possible combinations. This procedure may also be advantageous when a mask, hat or sunglasses obscure the face of the subject that is to be analysed. Attention can then be given to the regions that are still visible.

This method of subdivisions can also be applicable when designing a computer-assisted facial identification system. The identification time will be lowered, as the computer only focuses on regions of the face, instead of the whole face. This technique can also be incorporated while compiling a face from eyewitness testimony. When focusing only on regions of the face, the witness may recall more details, than when focusing on the whole face at a time.

The results of this study, as well as the previous studies mentioned could be incorporated into a manual for facial identification in South Africa. This will facilitate facial analysis as the landmarks and measurements for the analysis will be standardised and well defined. The manual can then be used by a number of observers and the repeatability would be quite high.

The repeatability of the measurements for this study was relatively high, which proved that any person familiar to the field of facial identification could use this method.

When comparing two photographs, namely one of an individual which is a possible match, and another of a suspect, it is recommended to first compare the rare facial features, as shown in this study. Because the features were classified as being rare, a match will be significant. The presence of rare features, or combinations of these features, on both photographs will therefore be highly suggestive of a possible positive match. The occurrence of more common characteristics on both of the compared photographs will be less significant. If a match is not found, the observer may then work through the different features to the more common ones. The more rare features correspond on the two photographs, the more significant the match. Techniques used during this study are however, at this stage, better equipped for exclusion in an identification case, than a positive match. It is also recommended that this method of facial identification be used in conjunction with other methods, such as factors of individualisation.

5.9 CONCLUSION

- Clear and definite descriptions of all the landmarks are needed before the analysis of facial photographs. This is important for accurate repeatability of the results, especially when it is done by various observers.

- It is recommended the facial photographs be taken with an extra source of light. This will enable the observer to see all the areas clearly on the face, without any interference from shadows. The camera should be placed at a fixed point from the subject's face and only be adjusted for height.

- More research in the field of facial identification is recommended. Although this study consisted of the largest South African study population ever used, it is by no means a clear representation of the South African Black male population as a whole.

- The method and characteristics described during this study could be highly beneficial in cases of disputed identity or comparing a masked or hooded face.

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