Addis Ababa University

College of Natural and Computational Science

Department of Zoological science

INHERITANCE VARIATION IN SOME HUMAN MORPHOGENETIC TRAITS AMONG SCHOOL AGE CHILDREN OF KALE PRIMARY SCHOOL, KOLFEA KERANIYO SUBCITY, ADDIS ABABA.

By

Tseganeh Mulugeta

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A Thesis submitted to Graduate School of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Masters of Science in Biology.

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DECLARATION

I the undersigned, declare that the thesis here by submitted for master of science in Biology to the school of graduate studies of Addis Ababa University is my own work and has not previously submitted at another university. The materials obtained from other sources have been duly acknowledged.

Name : Tseganeh Mulugeta Sign _____Date_____

contents

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Abstract

Morphogenetic characters are physical characters of an individual which are inherited and expressed in different ways. Therefore, this makes it ideal to know the extent of variation among population. However, few studies have been conducted in Ethiopia to know the extent of variation that exist in different races. The study was focused on six morphogenetic characteristics such as tongue rolling, ear lobe attachment, hair line distribution, bent little finger, hitchhiker's thumb, and palmaris longus muscle (PLM) among the students of kale primary school Addis Ababa Ethiopia. The aim of this study was to find out the inheritance variation of some morphogenetic traits among children of kale primary school having age between 13-18 years. A cross-sectional study was carried out on 325(170 males and 155 females) volunteer students to explore the extent of variation in some morphogenetic traits and to give awareness about the application of morphological variation of the human external ear and that could be translatable for forensic recording of fugitives. The investigator collected the required information by observing the subject and the result was analyzed and association study of traits were conducted by using chi-square test of independence with alpha value of 5% level of significance to identify which trait has association with gender. The study presented distribution of traits in the following order, widow's peak 116(35.7%) where most males 63(37.1%) exhibit this trait, tongue rolling 242(74.5%) and it was dominated by males 128(75.3%), free ear lobe 217(66.8%) it was also found more in males 115(67.6%), straight thumb 188(57.8%) the difference between gender was found marginal, bent little finger 59(18.2%) which was dominated by females 42(27.1%) and PLM presence 313(96.3%) and absence of this muscle was frequently observed in females 10(6.5%) and as we understand from this study, 96% were found to have PLM muscle, which indicates that there is a sufficient tendon that is essential for various medical procedures. Association evaluation showed no significant association was found between all morphogenetic traits and ages, however, it was found that there is significant association between gender and bent little finger($X^{2=}$15.950, p<0.001) and between gender and absence of PLM($X^{2=}$6.345, p<0.005). Since the study was conducted in heterogeneous population it is suitable for biomedical, anthropological and forensic studies.

Keywords: Dominant genes, Recessive genes, Hitchhiker's Thumb, Human traits, Morphogenetic traits, Palmaris Longus Muscle (PLM).

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1. Introduction

A trait is a distinct variant of a phenotypic character of an organism that may be inherited, environmentally determined or a mixture of the two Jaswant and Sarthak (2004). Inheritance is the passing of traits from parents to offspring. Our modern understanding of inheritance comes from a set of principles proposed by Austrian monk and researcher Gregor Mendel in 1865. Interestingly, Mendel didn't arrive at these principles by studying human beings, but rather by studying the common pea plant, *Pisum sativum* . Although scientists now know that there are many exceptions to the patterns Mendel described, these principles describe the two alternative alleles based inheritance such as trait for Height in *P. sativum* is governed by a pair of alleles; tall and dwarf. Moreover, because these so-called principles of Mendelian genetics hold true for organisms of many different types (including humans), they serve as the foundation for scientists' current understanding of heredity Miko and Lejeune (2009).

Mendelian traits are those that are controlled by pair of alleles and Human exhibits 200 traits of Mendelian inheritance Onyije *et al* (2012). The inheritance of characteristics which are called non-Mendelian traits are more complicated in nature (linkage, epistasis, polygene, incomplete or co-dominance, lethal gene, super gene, pleiotropism etc) are influenced by various interaction of genes Anna (1976).

Morphogenetic characters are physical characters of an individual and the pattern of inheritance of these traits may be autosomal dominant as well as autosomal recessive and factors for those dominant or recessive characters are depended on the genotype of their parents. Pattern of the genes either they are homozygous or heterozygous are linked with the intra-allelic interaction of genes. Human population provides an exclusive opportunity to study the morphogenetic variation among the endogamous populations living in different geographical and ecological circumstances Ben and Helen (1955).

Most morphogenetic traits are usually inherited in Mendelian fashion as a result of single gene as either autosomal dominant or autosomal recessive whereas some traits such as height, hair and skin colors are polygenic, being affected by more than one gene Adekoya *et al* (2020).

Hair morphology is one of the particular characteristics close to skin color and facial highlight Fujimoto (2008). Widow's peak refers to the descending V-shaped point at the middle of the head's hairline just above the forehead of some individuals Nwaopara *et al* (2008).

The tongue is a highly muscular organ of deglutition, taste and speech Sokoloff and Decon (1992). The characteristic feature of tongue rolling ability was first described by Sturtevant (1940) where tongue rolling as a movement in which the lateral edges of the tongue rolled together in an upward way tube and this movement was controlled by a pair of alleles.

The anatomy of the human external ear, also known as the auricle or pinna, is complex Hunter and Yotsuyanagi (2005) and it possesses certain individualistic characteristics like fingerprints and other characteristics of the human body Krishan *et al* (2019). Ear lobe can be classified into two categories specifically free and attached. Free ear lobes are those that hang underneath the point of attachment to the head. Attached ear lobes are connected specifically to the side of the head Munir *et al* (2015). However, numerous studies on earlobe inheritance have pointed out that there are numerous individuals with partially attached earlobes and El Kollali classified ear lobes into three sorts, based on whether the connection point was acute, right, or obtuse Ahmed and Yaas (2013).

Hitchhiker's thumb is a very flexible thumb, and capable of bend backward past the regular variety of motion. Known officially as distal hyperextensibility, this circumstance isn't painful and doesn't inhibit the thumb's feature in any way. The thumb bend ability is managed via way of means of its distal interphalangeal joint, the flexible factor at which the bones of your thumb are connected. People with hitchhiker's thumb have distal joints which can bend returned as a ways as ninety degrees. This appears much like the conventional roadside hitchhiker's pose, thumb out in hopes of hitching a ride. Hitchhiker's thumb can arise in a single or each thumbs. (Corey. "Hitchhiker's Thumb"*Healthline*,Healthline Media, 18 June 2019, www.healthline.Com/health/hit chhikers-thumb).

Kirner first time described the phenomena of bent little finger Munir *et al* (2015). The technical name for a little finger that bends in towards the ring finger is clinodactyly. It usually associated with other abnormalities in many genetic syndromes like keratosis palmaris and plantaris and in approximately 80% of individuals with Down's syndrome Ordu and Nwosu (2015). When the proximal phalange joint of little finger bends in towards the palm in the form of inverted V shape and can't be straightened out, it is known as streblomicrodactyly Dutta (1965).

The palmaris longus muscle (PLM) is known as one of the most variable muscles of the human body (*Fig 1*). The variations include changes in location and shape of their fixations and their muscular bundle, presence of fascicles accessories and complete agenesis Morais *et al* (2013). It is a fusiform muscle, belonging to the superficial anterior compartment of the forearm . Its initial part originates together with other superficial forearm flexors from the medial epicondyle and is covered by the anterobrachial fascia Olewnik *et al* (2018). The PLM is considered one of the most variable muscles in the human body, its agenesis is considered the most frequent anatomical variation Alves *et al* (2011). Bilateral absence of PLM is more common than unilateral absence and its absence is more often in females and on the left hand Fazan (2007).

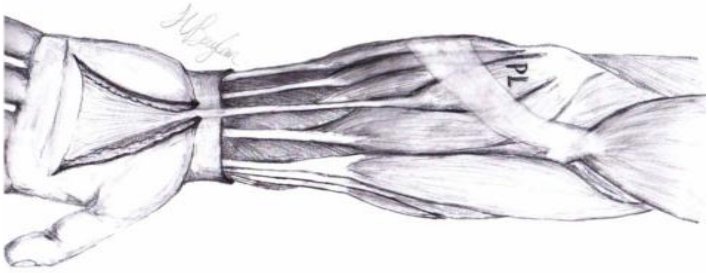


Fig 1:- The anatomical and morphological illustration of palmaris longus muscle in human arm Karacan *et al* (2017)

2. Literature review

2.1. The Genetic Basis of Inheritance of Some monogenic Traits in Human

2.1.1. Mendelian laws of inheritance

2.1.1.1. Widow's peak

Hair line shape might be straight or curved and its decided by a single gene that has two alleles (*Fig 2*). The expression of a dominant gene results widow's peak whereas failure to express results in a hair that runs straight Usha *et al* (2016). Widow's peak is a dominant inherited trait and typically doesn't skip generations. There are varying degrees of the peaks. People who do not have widow's peak have a hairline that run straight across Anibor *et al* (2014). The two alleles are mindful for controlling the shape of hairline. This characteristic takes after basic Mendelian inheritance pattern. The design of transmission takes after the Mendel's law of inheritance, which expect that (W) allele is for widow's peak which is dominant whereas (w) allele is for recessive straight hairline. In case an individual expresses the widow's peak hairline shape, the possible genotype is (WW) homozygous or (Ww) heterozygous whereas one that expresses straight hairline has the genotype (ww) Naz (2014).

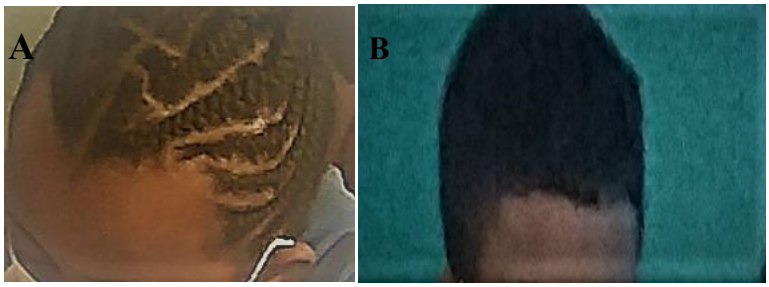


Fig 2:- Photographs showing the different forms of Hair line distribution among children of Kale primary school (Aug,2021). A.Widows peak and B.Straight hair line.

2.1.1.2. Tongue rolling

The ability to role tongue is strongly influenced by hereditary factors and controlled by pair of alleles at a single locus and the dominant gene is responsible for folding and rolling of the tongue lateral edges while the inability to roll and fold the tongue is associated with the recessive gene Cyrus and Beardmore (1989). Sturtevant in 1940 described two major phenotypes rollers and non-rollers (*Fig 3*) the roller phenotype being dominant Singh (2012).

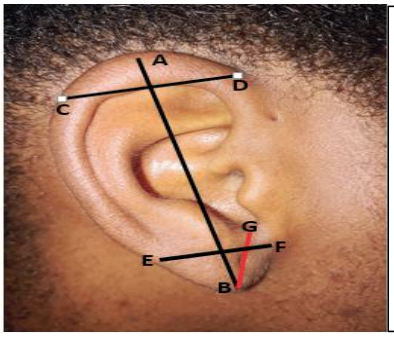
Fig 3:- Photographs showing tongue rolling ability among children of Kale primary school (Aug, 2021). A. Tongue roller and B. Non-tongue roller

2.1.1.3. Ear lobes attachment

The human ear lobes can be classified into two major types as free and attached (*Fig 4*A). Free earlobes hang free, to the side of the head while attached ear lobes are attached directly to the side of the head Gonzalez *et al* (1982). Hidden in 1922 claimed that free ear lobe is due to a dominant gene and Powell and Whitney in 1937 published a pedigree supporting the hypothesis of autosomal dominance and concluded that attached earlobes were recessive Dronamraju (1966).

Anthropometric research of the external ear from exclusive elements of the world prove that plenty variability exists depending at the age, sex and ethnic group, and even inside the identical person between the right and left ears Purkait and Singh (2007) . The human external ear is unique to individual and the variation could be in terms of total ear length, external width of the ear, ear lobe length and ear lobe width (*Fig*:- 4B). Total ear length is the distance between superior projection of the helix and inferior projection of the external ear, external width of the ear measured as the the distance between the anterior and superior points of the external ear and ear lobe length (measured from the mid point of the intertragic notch to the lowest point of the lobule and ear lobe width (measured as the transverse distance of the ear lobule passing through the center of the length of the lobule) Edibamode *et al* (2019).

Fig 4:- A. Photographs showing the different forms of the earlobe attachment. A Free. B Partially attached. C Attached Krishan *et al* (2019).



AB – Total length of ear
CD – Total width of ear
BG – Total lobular length;
EF – Total lobular width.

Fig:- 4B. Photograph showing the measured parameters of the lateral surface of the external ear with their respective distance and width Edibamode *et al* (2019).

2.1.1.4. Hitchhiker's thumb

Hitchhiker's Thumb could be a trait known as "Distal Hyperextensibility of the Thumb"This characteristic is recognized by the capacity to bend the distal joint of the thumb back as far as possible (*Fig 5*A). A few individuals can bend their thumb back as far as a 90 degree angle. It is accepted this characteristic is caused by a recessive gene (h), meaning 2 duplicates are required to show this characteristic Onyije *et al* (2012). The thumb expansion characteristic is supposedly due to a single gene. Straight thumb is dominant, with 75% of the U.S. Caucasian population showing this characteristic. As it was twenty five percent of the population has the recessive hitchhiker's thumb (http://gslc.genetics.utah.edu 20 Mar, 2020).

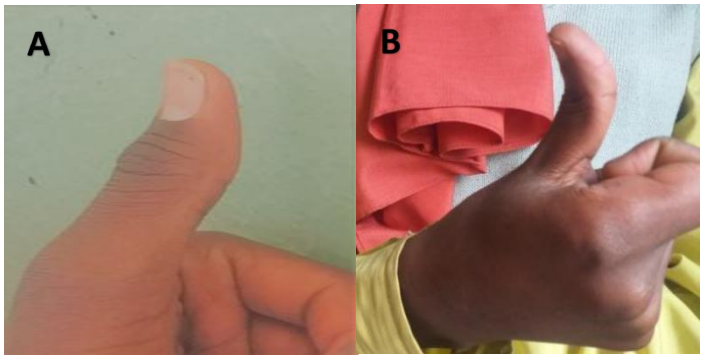


*Fig 5*A:- Photographs showing thumb flexibility among children of Kale primary school (Aug, 2021). A. Straight thumb and B. Hitchhiker's thumb.

The human body measurements of the hand, thumb, and different digits are applied in production of gloves, layout and sizing of hand equipment, controls, knobs, and other programs in diverse varieties of accuracy and power grips Basnet *et al* (2015). Asadujjaman *et al* (2019) conducted a survey on anthropometric variation in human hand by using a virtual slide calipers and pointed out that over all length of the thumb is the space from the tip of the thumb to the border crease with the palm (*Fig* 5B).

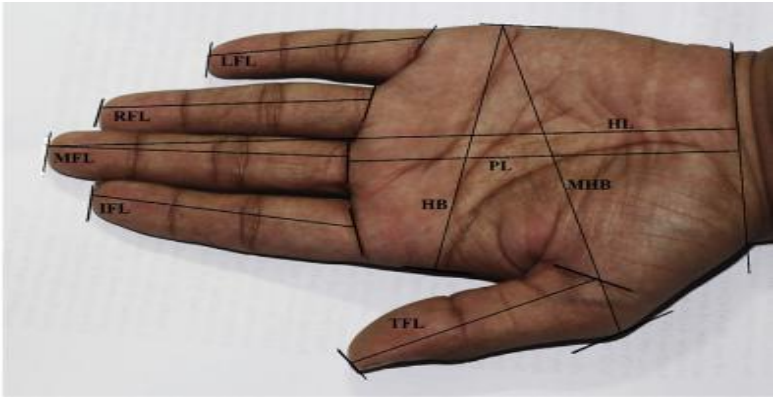


Fig 5B: Hand anthropometric measurements. HL: Hand Length, HB: Hand Breadth, MHB: Maximum Hand Breadth, PL: Palm Length, TFL: Thumb Length, IFL: Index Finger Length, MFL: Middle Finger Length, RFL: Ring Finger Length and LFL: Little Finger Length Asadujjaman, *et al* (2019).

Different studies have utilized various techniques to gauge the joint angle of the thumb and the other four fingers while grasping a chamber. A portion of these techniques utilized an angle sensor joined to the rear of the hand, though others utilized various camcorders recording the markers fastened to the rear of the hand Shimawaki *et al* (2019). Harris and Joseph (1949) and Glass and Kistler (1953) have used x-ray and protractor to measure the angle between the distal and proximal phalanges of the thumb respectively and they found continuous variation of thumb angle and Glass and Kistler concluded all thumbs with an angle equal to or greater than 50 degrees hitchhiker's thumbs without giving a reason.

2.1.1.5. Bent little finger

The variations in little finger represent two phenotypical distinct traits (*Fig 6*) which is governed by a single gene with two alternate alleles Marden *et al* (1964). This different variation in the curvature of the little finger is inherited from the parents and found to follow Mendelian mode of inheritance. Dutta (1965) found two extended families with bent little fingers. Six children of S x S parents were all S, whereas 22 out of 34 children of B x S families were B. This fits the appearance of bent little finger being caused by a single dominant allele.

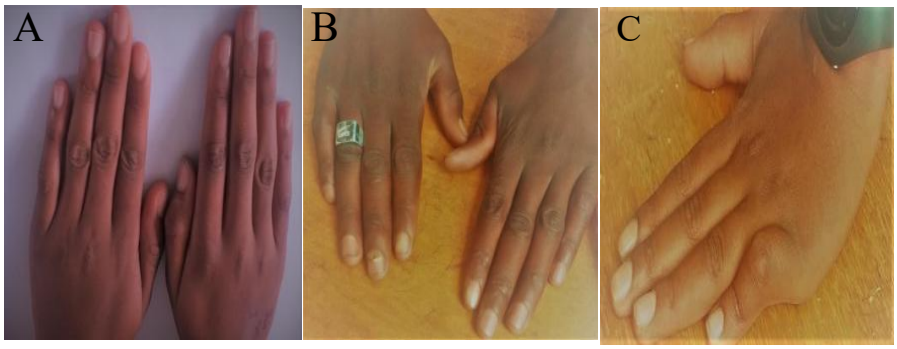


Fig 6:- Photographs showing variation in the curvature of little finger among children of Kale primary school (Aug, 2021). A. Straight little finger B. Bent little finger and C. Bent little finger with 90^0 angle.

2.1.1.6. Palmaris longus muscle (PLM)

The PLM is an inherited autosomal dominant trait and it's absence likely associated with a single dominant gene (which shows incomplete penetration and variable expressivity), and/or absence is due to the impact of mutations Vučinić *et al* (2016). Similarly, Michel (1978) mentioned that the absence of the Palmaris longus muscle was a dominant trait, and its presence a recessive trait (*Fig 7*). Thompson *et al* (1921) pointed out that the inheritance of the PLM and polydactyly inheritance is similar. Parents with unilateral absence may have children with a lack of the muscle in one or both arms, whereas parents with the bilateral lack of the muscle can have children with a lack of the muscle in one hand.

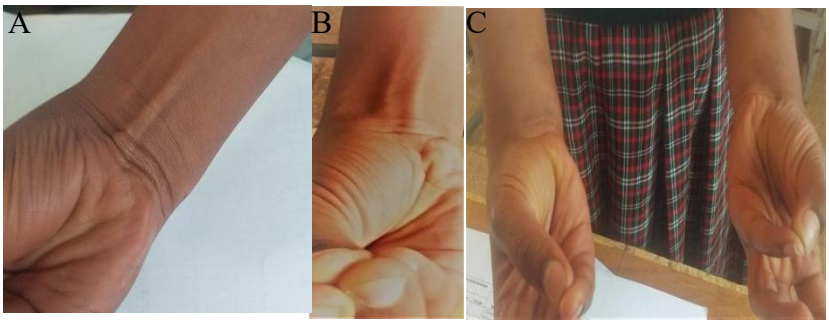


Fig 7:- Photographs showing the presence and absence palmaris longus muscle (PLM) among children of Kale primary school (Aug, 2021). A. and B PLM present and C. PLM absent on the arm.

2.1.2. None Mendelian Inheritance

Mendelian inheritance patterns are well established and readily recognizable as textbook examples for many single gene inheritance Ordu *et al* (2014). Non Mendelian inheritance of traits have complex genetic basis than one gene with two alleles and complete dominance and this include polygenic inheritance where a particular trait is being affected by more than one gene leading to gradual variation in the population with no clear distinction Nussbaum *et al* (2007) an example for this is ear lobe attachment Wiener (1937) watched ear lobes and isolated them into four subjective bunches, from 0 (totally free) to 3 (totally attached) and possible mating's, from totally 0x0 to 3 x 3, produced a few intermediate earlobes and he concluded that earlobes were decided by over one gene, or by one gene with more than two alleles and in a recent collaboration study by a group of researchers from sijia wang at Chinese academy of sciences in shanghai, and seth weinbeg at university of Pittsburgh in Pennsylvania used genetic sequencing data and ear lobe observations from people with different ethnicity and identified 49 genome region related to the ear lobe attachment Shaffer *et al* (2017).

Tongue rolling might have a non genetic character Sturtevant (1940) and Komai (1951) independently conducted a family study whether this trait follows Mendelian monogenetic inheritance and they found rolling offspring of non-rolling parents, so

the trait must be more complicated and some other researchers have argued that these traits are not genetically controlled but learned Odokuma *et al* (2008).

An independent study was conducted by Glass and Kistler (1953) and Beckman *et al* (1960) to check whether hitchhiker was simple Mendelian trait and they have found S offspring from H parents and this was inconsistent with a two-allele model in which the allele for S is dominant and this could be incomplete penetrance, where other genes or non-genetic factors can influence the trait.

The presence and absence of PLM might not be considered exclusively dominant or recessive given the very fact that children may have phenotypes different from those observed in several phenotypes those expected for a feature purely dominant or recessive in keeping with Mendelian inheritance patterns Morais *et al* (2013) .

2.1.3. Molecular Basis of Inheritance

Variation in individual of the same population are caused by the DNA sequence difference which is found entirely in the genome and it varies between two individuals in every 200-500 base pairs Jeffreys (1987) and this sequence brings variation more often in the DNA between genes because natural selection maintains sequences that involved in expression of gene and protein coding Rosenblum (1983). The molecular basis of various traits that leads to variation in human have been studied. One of them is hair color which is determined by the amount of eumelanin (which is dark brown) and pheomelanin (which is reddish). Valverde *et al* (1995) found that many amino acid variants in melanocortin 1 receptor (MC1R) gene in red-haired individuals but rare in those with other hair color and Box *et al* (1997) isolated three amino acid that are frequently associated with red hair polymorphisms and the amino acids arginine (R), arginine and aspartic acid (D), cysteine (C), tryptophan (W), and histidine (H) are found in red hair at the R151C, R160W and D294H position of the protein. Sulem *et al* (2007) concluded that MC1R has a strong association with red hair however Beaumont *et al* (2007) indicated that red hair is not determined only by the genotype of an individual at MC1R locus alone where 74% of individuals who were homozygous for tryptophan at position 160 have red hair, while 4% of individuals who were heterozygous for this amino acid had red hair.

In the past two decades the molecular basis of more than 2000 inherited monogenic disorders has been investigated Lai-Cheong (2006). Phenylketonuria (PKU) was the first known metabolic disorder recognized to cause mental retardation which is caused by a missing enzyme known as phenylalanine hydroxylase (PAH) as a result of mutation in PAH gene on chromosome 12 Blau *et al* (2014). PAH is involved in metabolism of L-phe to L-Tyrosine and failure to metabolize phenylalanine leading to various abnormalities such as physical retardation and intellectual impairment as a result of build up of phenylalanine by products in the body and lack of PAH activity results in lack of tyrosine and its downstream products, such as melanin, L-thyroxine and cate-cholamine neurotransmitters Williams *et al* (2008). Another metabolic genetic disorder is hyperuricemia which is caused by the either accumulation or limited excretion of serum uric acid (SUA) and high (SUA) causes various diseases such as gout and has been also known with metabolic syndrome, such as heart disease, diabetes, hypertension and renal disease Liu *et al* (2021). Inherited hayperuricemic disorder can be caused by high metabolic production of purines and reduced renal secretion and the molecular defect is linked with absence of the enzyme hypoxantin-guanine phosphoribosyl transferase (HPRT) and the gene is located on the long arm of x chromosome and point mutation, deletion or insertion on this gene leads to losing its biochemical property William and Naham (2005).

Camptodactyly phenotype has been observed in carriers with chromosomal abnormalities or gene mutations Deng *et al* (2016) suggested that potential molecular link between the talin 2 gene (*TLN2)* and camptodactyly pathogenesis and they have reported camptodactyly is transmitted as an autosomal dominant.

2.2. Clinical significance of palmaris longus muscle in reconstructive surgeries

Reconstructive surgery is used to treat parts a body affected by various reasons such as, genetic defects, abnormality of different body parts due to disease, or defects caused by injuries some of common reconstruction procedures include, hand reconstruction to improve strength and flexibility and to deformation due to arthritis and webbed fingers, facial, and other techniques to fix any defect of the body caused by trauma and infection. (clevelandclinic.org/health/treatments/11029- reconstructive-surgery 16,Oct, 2021).

There are different reconstructive surgeries to treat patients to restore their natural body function among them Autologous tendon grafting is the first and the most preferable technique in reconstructive surgery of the upper limb Alva *et al* (2013). The second alternative is Allografts of PLM in spite of this strategy has limited positive result due to various factors such as, lose of biochemical property of the tendon by irradiation, disease transmission, and its high cost Grieb *et al* (2006). On the other hand engineered materials from nylon, carbon fibers and silicone have been utilized. However, this materials have been found to trigger incendiary response or an antigenic reaction driving to failure at fixation sites and inefficiencies in long-term biocompatibility Cooper and Kaeding (2010)

The PLM can be harvested without risk of affecting function of the hand and wrist Alva *et al* (2013) due to its limited action in the carpal flexion which makes it an ideal donor for plastic and reconstructive surgeries Sebastin *et al* (2005). Cetin *et al* (2008) have also supported insignificant impact of PLM on hand strength and function. As many studies suggested PLM muscle has numerous anatomical variations this include, absence on either or both side of the hand, splitting of tendon at terminal region in to 2 or 3 separate tendons, location of the muscle belly (central, distal or digastric), it can be entirely muscular or fibrous and may have various insertions Tesfamichael and Assegedech (2014) and this variation are believed to be due to evolution of human Smedt (2002). This anatomical variations has provided multiple significance's in hand reconstructive surgeries such as, palm-to finger tip tendon reconstructions, triceps, distal biceps and collateral ligaments of the elbow and metacarpophalangeal joints reconstructions Alva *et al* (2013). However it doesn't mean there is no complication during harvesting this muscle some of them include damage to the median nerve, palmar cutaneous branch of the median nerve, medial cutaneous nerve of the forearm, adjacent tendons and flexion contracture at the wrist Hattori *et al* (2007). Therefore, prior to choosing the PLM tendon for surgical reconstruction the anatomical variation, usefulness and potential illness of harvesting the muscle should be taken in to account Pai *et al* (2008).

2.3. Inheritance variation of some morphogenetic traits in different population.

A study conducted on inheritance pattern of ear lob attachment among 760 Nigerians from 200 families with 400 parents and 360 offspring within the ages of 5 months-60years, showed that simple dominant, recessive pattern with the detached dominant over the attached earlobe and do not differ among the tribes with no significant difference in gender distribution of the trait in the population. The results obtained suggest that observation of pattern of earlobe attachment trait might be suitable for genetic analysis and can help in settling paternal dispute Ordu *et al* (2014).

Association study of some human morphogenetic traits with ABO and rhesus was carried out by Kooffreh *et al* (2015) in clalabar Nigeria and they reported that higher percentage of population 177(69.2%) had free earlobe while 77(30.8%) had attached earlobe with no significant association with gender and with regards to tongue rolling lower percentage of tongue rollers (48.4%) in the population and a higher percentage of non rollers of tongue (51.6%) with significant association with gender where more males 72(59.5%) are roller than females 49(40.5%).

A research conducted by Ebeye *et al* (2014) on morphogenetic traits among the Esan Ethinic group of Nigeria in 400 volunteered subjects (176 males, 224 females). The volunteers were between the ages of 17-60 and their parents and grandparents were from Esan backgrounds. Results showed 12.5% of males and 21.3%o females had cheek dimples while 31.5% of males and 34.7% of female had no dimple, 29.0% males and 40.0% females had unattached earlobe while 15.0% males and 16.0% females had their earlobes attached. Results for widow's peak showed 14.7% males and 16.5% females had widow's peak while 29.3% males and 39.5% females didn't have a peak. A study on pattern of morphogenetic traits combination amongst the population of Ekpoma, Nigeria was carried out by Nwaopara *et al* (2008) and they found that a large number of the study population 111 (57.51%) did not display the widow's peak characteristic whereas a lower number of the population 82 (42.49%) did.

Assessment of morphogenetic trait of attached ear lobe and tongue rolling was carried out by Onyije (2012) and he found that the prevalence of tongue rolling was 193 (57.2%) among the entire population of 337 subjects. The frequency of male rollers 104 (30.8%) was higher than female rollers 89 (26.4%) 71 males 21.0% and 73 females 21.6% can't roll their tongue. Similarly, high prevalence of free ear lobe was indicated [208 (61.6%)] and which was higher in females [107(31.7%)] than males [101(29.9%)].

A study on the expression of some selected morphogenetic traits by Usha *et al* (2016) among 1130 individuals of Thrissure district India showed that 65.5% had a free ear lob, and 53% were able to roll their tongue and these traits were expressed more frequently in the population as a dominant traits and only 30% of the study population had a widow's peak and 63.6% had straight thumb as a recessive trait.

An investigation have been also conducted by Adekoya *et al* (2020) among 1000 randomly chosen students on some human morphogenetic traits inheritance and there association and they have found that 63.9% of the sampled subjects were able to roll their tongue while 36.1% were unable to roll their tongue. On the other hand, straight little finger was found to be more expressed (63.3%) among sampled individuals than bent little finger (36.7%). The study also showed that a higher percentage of the participants had free earlobes (74.6%) than those who had attached earlobes (25.4%). Furthermore, the frequency distribution of hitchhiker's thumb showed a higher percentage of single jointed thumb (53.5%) compared to double jointed hitchhiker's thumb (46.5%) although the difference between the two phenotypes was marginal. Similar study on 2000 individuals in Quetta, Pakistan was also carried out by (Munir *et al* (2015) and they have obtained higher prevalence of free earlobes (58.2%), bent little finger (64.4%) and hitchhiker's thumb (62.6%) among females. Higher prevalence of hitchhiker thumb 32.3% (male 15.5% and female 16.8%) and bent little finger 7.1% (male 1.6% and female 5.5%) was also indicated among 310 (male and female) in south Nigeria by Onyije *et al* (2012).

A study to investigate prevalence of absence of palmaris longus tendon in Nepalese Population was carried out by Sharma *et al* (2019) among 270,145 (53.7%) females and 125 (46.3%) male medical students, they have implemented four tests-Schaeffer's

Test, Thompson's Fist, Mishra's Test and Puspa Kumar's two finger sign and they have seen PLM absence in 40 (14.8%) individuals and they have concluded that 18 (14.4%) males and 22 (15.2%) females had absence of palmaris longus. Similar study was also conducted by Alves *et al* (2011) in 200 Chilean individuals, 114 female and 86 male. The result showed that 9% of the total population had bilateral agenesis of PLM on the other had its indicated that there is association of PLM agenesis with sex among 25 (21.93%) cases of females 12 (10.52%) presented bilateral agenesis on the other hand from 15(17.44%) males who presented agenesis only 6 (6.98%) were bilateral agenesis.

Prevalence study of palmaris longus by Yong *et al* (2017) among 1502 Malay population showed that absence of plmaris longus was 11.7% and left side absence of palmaris longus was much common and they have concluded that there is a significant association between absence of palmaris longus with gender in which female had higher prevalence of absence of palmaris longus than male. The palmaris longus muscle could be a variable muscle. The foremost common variety is its absence. A few in vivo and in vitro studies have shown the prevalence or absence of the PLM muscle in several ethnic bunches. Between 5.5 and 24% of Caucasian populations (European and North American) and 4.6 to 28% of Asian population (Chinese, Japanese, Indian, Turkish, Malaysian) have been detailed to need the palmaris longus muscle. Africa had prevalence of palmaris longus absence of 3.8% in Ghana, 50.8% in Egypt, 6.7% in Nigeria, and 1.5% in Zimbabwe Yong *et al* (2017). A study conducted by Kayode *et al* (2008) however showed that high incidence of PLM agenesis among different population of Nigeria. They have concluded that out of 600 participants 187(31.25%) of them did not have PLM on either of their forearm and the majority 112(18.75%) of them have displayed bilateral absence.

Limited number of studies were carried out on the morphogenetic traits inheritance in Ethiopia. A study on the assessment of morphogenetic traits and blood groups among 270 individuals in Amhara region by Zeneb (2018) showed that the ability to tongue rolling and free ear lobe attachment were high in males than females while straight thumb, straight hair line shape and absence of mid digital hair were high in females.

A prevalence study on agenesis of palmaris longus muscle was conducted by Tesfamichael and Assegedech (2014) among 712 (504 male and 208 female) medical students of Gonder university and they have found that 109 (15.3%) of the total subjects had either unilateral or bilateral agenesis of PLM. Bilateral absence is frequently observed in both sexes and it was 58 (8.1%) while unilateral absence was found in 51 (7.2%) of the study subjects.

3. Statement of the problem

Various reviews have suggested that human morphogenetic traits can be used in conjunction with other methods to solve complex criminal processes, such as studying the different parts of the body, such as the shape of the ears and the hair line, as well as other human differences. However students are unaware of how variation in human external body parts are valuable in the field of forensic investigation because students were not learning the application of inheritance variation of human observable traits in school biology education. Therefore, if students learn the physical differences between human beings, including the shape of the hair, the shape of the ear, and other differences in school biology education it gives them awareness how to gather information and identify the suspect when it is difficult to identify the entire face of a suspect or when it is difficult to get enough information about the identity of the suspect if they were in the area where the crime was committed or if they were attacked by a stranger.

On the other hand, one of the gaps in the medical field in our country is reconstructive surgery to correct the body part. Although there are modern methods of treating injuries in different parts of the world, the origin of them is to solve the question of where to find the tissue or organ needed to treat the affected part of the body and how our body responds to the transplanted tissue or organ. Therefore it was necessary to know the results of various scientific studies such as anthropometry, genetics, anatomy and physiology. According to various medical journals, the palmaris longus muscle is one of the most commonly used treatments for patients who need reconstructive surgery without any side effects. However, let alone the morphological differences in this muscle in our country, it has not been adequately researched on the extent to which this muscle is present in the community. This shows that little attention has been paid to the issue, which has contributed to the low growth of medical facilities working on reconstructive surgery. Despite the above benefits human morphogenetic traits weren't studied and used in project work of genetic lessons of Ethiopian High school curriculum.

3.1. Significance of the study

This study will help us to understand the morphogenetic traits variation in humans and the related issues. For example, hitchhiker thumb and bent little finger are some of the most misconception in the community which are always believed to be caused by injuries. Therefore, this study helps to address this issue. It also contributes significantly in areas such as forensic science and enable students to establish observable human traits for forensic investigation. Studying the differences of palmaris longus muscle (PLM) in humans enable us to understand the contribution of this muscle to medical science i.e tendon graft in many medical procedures such as cosmetics, plastic and reconstructive surgery. Therefore, the result of this study can be used to give information to clinical practitioners and others who are working in medical fields that can be used to know the extent of this muscle that present in the population. In addition to the above benefits, this study creates an opportunity to include student human observable traits project in high school genetics lesson and enable them to understand mechanisms of inheritance of Mendelian traits and also to enable them to establish key identifying traits for identification of fugitives.

4. Objectives

4.1. General objective

The general objective of the study was to investigate the frequency of earlobe attachment, tongue rolling ability, hair line distribution, and specific hand traits among school children's that could be applied in forensic investigation and medical fields.

4.2. Specific objectives

The specific objectives of the study were

- To determine phenotypic frequency of attached and free among earlobes.
- To determine phenotypic frequency of tongue rolling, and widow's peak.
- To determine the phenotypic frequency of monogenic hand traits such as Hitchhiker Thumb, Bent Little Finger and the Palmaris Longus muscle.

5. Materials and Methods

5.1. Study population

The study was carried out in heterogeneous population of Kale primary school students admitted during the 2020/2021 academic year from grade 7-8. Prior to starting examination all students with age ranges between 13-18 and Students who were willing to participate in the study were selected.

5.2. Description of the study area

The study was conducted at Kale primary school which is located in Kolfe-Keranio sub-city, Woreda 15 in Addis Ababa Ethiopia (*Fig 8*). Kale primary school is a public school. This primary school has an enrollment of 2200 students with the total number of teachers being 107. The school has students from preschool to grade eight.

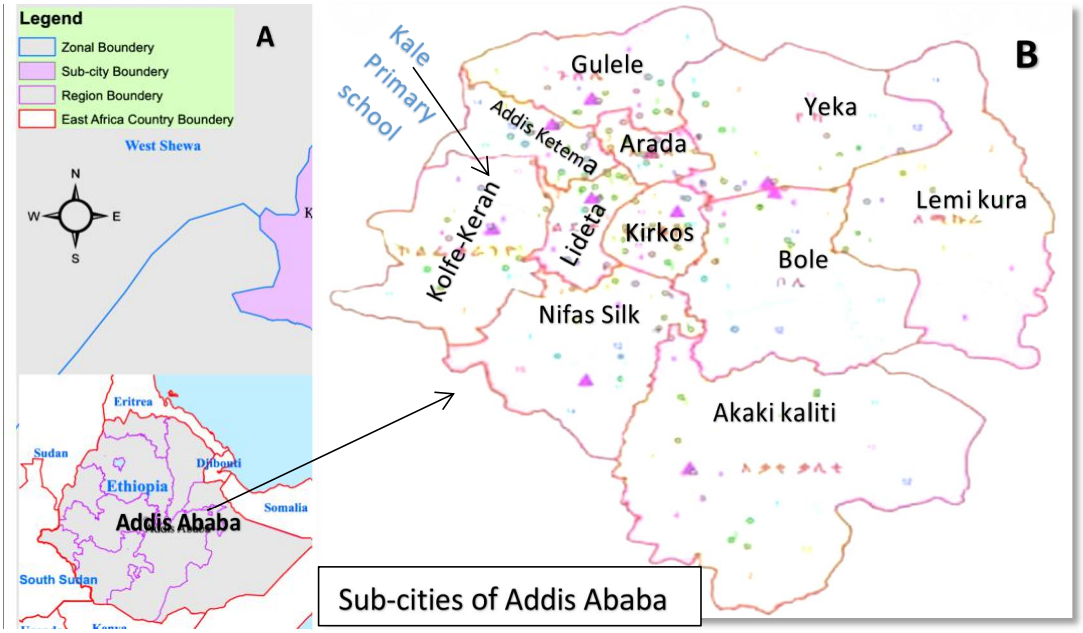


Fig :- 8 Map of the study area A. Map of Ethiopia with neighboring countries and the capital city Addis Ababa Nasser *et al* (2018) and B. Sub-cities of Addis Ababa,(http://images.app.google/PzqE4VGMA9bPG9jv8, Dec.18)Kale primary school is highlighted in Kolfea Keranio sub-city.

5.3. Study design and population

A cross-sectional study was conducted among volunteer children of Kale primary school whose grades were 7 and 8. Their ages were between 13 and 18 years. A total of 325 study participants were randomly selected from a total of 548 students.

5.3.1. Socio-demographic data of study participants

The sociodemographic characteristics of the study participants were presented in table 1. The study was conducted in heterogeneous population and focused on inheritance variation of morphogenetic traits on the basis of gender and age. A total of 155 [81 (52.3%) males and 74 (47.7%) females] students held from grade seven and 170 [89 (52.4%) males and 81(47.6%) females] students from grade eight making the total sample (N=325). The majority of the participants 146 [77 (52.7%) males and 69 (47.3%) females] from grade seven and 117 [63 (53.8%) males and 54 (46.2%) females] from grade eight ages between 13-15. Only 62 individuals 9 [4 (44.4%) males and 5 (55.6%) females] and 53 [26 (49.1%) males and 27 (50.9%) females] ages between 16-18 from grade seven and eight, respectively.

Table: 1 Demographic characteristics of the study population

			Age					
			13-15		16-18		Total	
Grade			N	%	N	%	N	%
Grade 7	Gender	Male	77	52.7%	4	44.4%	81	52.3%
		Female	69	47.3%	5	55.6%	74	47.7%
	Total		146	100.0%	9	100.0%	155	100.0%
Grade 8	Gender	Male	63	53.8%	26	49.1%	89	52.4%
		Female	54	46.2%	27	50.9%	81	47.6%
	Total		117	100.0%	53	100.0%	170	100.0%
Total	Gender	Male	140	53.2%	30	48.4%	170	52.3%
		Female	123	46.8%	32	51.6%	155	47.7%
	Total		263	100.0%	62	100.0%	325	100.0%

5.4. Method of data collection

5.4.1. Materials used for data collection

Prior to examination all conventions that were exhorted by health minster to prevent covid transmission were actualized. The subject body temperature was checked using infrared thermometer in case their is symptoms of covid and socio-demographic data and inheritance variation in morphogenetic traits were collected. Recording of morphogenetic traits were based on direct observation whether each of the following characters such as, Widow's peak, Tongue Rolling, Ear Lobes, Hitch-hikers thumb, Bent little finger and the Palmaris longus muscle varies among the students using a standard chart for correct identification of the traits.

5.4.2. Procedure of observing morphogenetic traits

A place for morphogenetic characteristics observation was organized by accepting authorization from the school principal. Earlier to examination a brief clarification was given to the students how the study embraced. Participants who were not capable of giving informed consent, assent form was provided to them and their parents or legal guardian allowed to give the consent on their behave and it was obtained on the following day (Annex II). Individuals who reached the legal age of consent were allowed to fill the informed consent based on their will and the signed consent form was collected (Annex I). Finally all subjects that show interest in the study were taken from the study population for further examination.

5.4.3. Method for observing morphogenetic traits.

A schedule for morphogenetic traits identification was prepared based on grade and the data were collected at student's laboratory. The phenotypic data collected were include, ear lobes attachment, tongue rolling, hitch-hikers thumb, widow's peak, bent little finger and palmaris longus muscle with reference to standard photograph.

5.4.3.1. Protocols for collecting the essential information

To avoid clumping of students outside the examination room a few students were examined per day and only one student was allowed to enter to the examination room at a time and his/her body temperature was checked before the examination started using infrared thermometer. The examiner was covered the face with a mask during examination and recorded data for tongue rolling, ear lobs attachment, hairline distribution, hitch-hikers thumb, bent little finger and palmaris longus muscle by observation.

Examination of tongue rolling, and hitchhikers thumb, were performed after the researcher demonstrating standard photographs to the subject. The extent of ear lobe attachment was collected by physical examination of the participant in case it is attached or free according to Lai and Walsh (1966). The classification of earlobes in which the lowest point on the earlobe was the attachment point "attached," and they classified all other earlobes as "free". Widow's peak was decided by looking at the participant forehead to know whether the hair runs straight over or descends downwards. Bent Little Finger was determined by physical examination of individuals by asking the participant to place his/her hands on a flat surface and stretch all their fingers to check whether little finger bent or not.

Longer Palmaris muscle was decided by physical examination of both arms of the subject utilizing initially by the standard test of Schaeffer (Fig. 9A) where each subject was asked to oppose the thumb to the little finger and then flex the wrist Hiz *et al* (2011). The cases were further examined using Thompson's test (Fig. 10) when the PLM has failed to be observed by Schaeffer test. The subject was asked to make a fist, then flex the wrist and finally the thumb is opposed and flexed over the fingers Yong *et al* (2017) and finally when both methods were not fit to show PLM, the recently developed Hiz-Ediz test (Fig. 9B) was performed by applying resistance to flexion of fingers and wrist while all fingers were at the opposite position with the wrist at slight flexion Hiz *et al* (2011). When the PLM was not seen beneath the skin at the distal of the lower arm on the wrist and was not palpated at the same position, the PLM was considered missing.

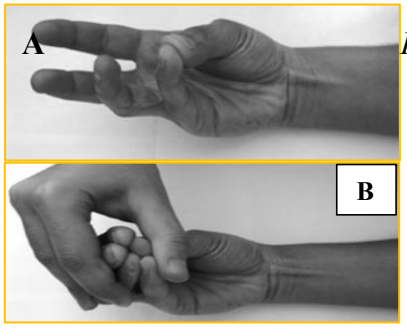


Fig 9:- A. Standard test (Schaeffer's test): The subject is asked to oppose the thumb to the little finger and then flex the wrist and B. Hiz-Ediz test: The subject is asked to flexion fingers and wrist while all fingers were at the opposite position with the wrist at slight flexion Hiz *et al* (2011).

Fig 10:- Thompson's test. The subject is asked to make a fist, then flex the wrist and finally the thumb is opposed and flexed over the fingers Yong *et al* (2017).

5.5. Data analysis

The raw data obtained from the investigation were transferred into computer using spread excel sheet and then, analyzed using SPSS (Statistical Package for the Social Sciences), (IBM,SPSS Statistics for windows, version 28).

5.6. Ethical consideration

The ethical approval was obtained from Addis Ababa University Ethical Review board on April 7/2021(Annex,. VII). The selected study participants whose age below 18 were requested to consult their parents/guardian; if they were volunteer to allow their children to participate in the study and the signed assent brought from their parents and then the student sign the consent form then after (Annex,. II). Those who were 18 years old filled the consent form by their own and decide based on their will after briefing the objective and significance of the study (Annex,. I).

5.7. Inclusion and Exclusion criteria

5.7.1. Inclusion criteria

The study participants were included according to the following criteria. For recording of data that were collected by direct observation or that do not require additional procedures such as tongue rolling, ear lobe attachment, and hair line shape the participant should have normal ear which is not swollen by any means or that don't have any defect, for tongue rolling able to roll without pain and hair line shape free from any kind of scalp infection. For bent little finger, Hitch-hiker thumb and

palmaris longus muscle evaluation the participant should be healthy to perform all tasks that going to be performed like bending, stretching and fist their arms and palms easily.

5.7.2. Exclusion criteria

The study participants with the following characteristics: Age below 13 years, any medical history of hand surgery, Participant who has a dislocated joints due to injury and a scalp infection (tinea capitis) were excluded from the study.

6. *Results*

6.1. The Distribution of Mendelian monogenic traits

The distribution of the Mendelian morphogenetic traits in study population was shown in Table 2. The result showed the frequency of strait hair lines was observed in large participants than a widow's peak 209 (64.3%) and 116 (35.7%) respectively. It was also indicated that the frequency of window's peak was slightly higher in males 32 (36.0%) as compared with females 28 (37.8%). From the study the majority of the study population 242 (74.5%) were able to roll their tongue in to tubes, and when this trait is compared gender wise the highest frequency 65 (80.2%) of tongue rollers were males from grade seven as the same time the lowest number of tongue rollers females 50 (67.6%) were also found in this group. The recessive trait of non-tongue rolling has been found in 83 (25.5%) individuals out of this the the highest occurrence of this trait was in 26 (29.2%) males and 24 (32.4%) females from grade eight and grade seven respectively and the lowest record 16 (19.8%) of non-rolling males was observed from grade seven. The result also showed that free ear lobe attachment is predominant 217 (66.8%) in the study population and the ratio was almost equal both in males and females and 108 (33.2%) from both gender had attached ear lobe and this trait was observed in most 33 (37.1) males students of grade eight. The frequency of hitchhiker thumb was observed in 137 (42.2%) individuals and its indicated that 38 (46.9%) most male students had this trait while 32 (43.2%) was the highest incidence of hitchhiker in females. Straight thumb was observed in 188 (57.8%) individuals and its was frequently observed in 52 (58.4%) males and 51 (63.0%) females from grade eight students. The characteristic shape of the little finger was studied and about 266 (81.8%) didn't show bent little finger and the prevalence of bent little finger was 54 (19.71%) of the population and the occurrence of this trait was more in grade seven females 25(33.8%) as compared with males 10(12.3%). Palmaris longus present in 313(96.3%) of the study population and in a few individuals 12(3.7%) agenesis of PLM was recorded. The highest prevalence of agenesis of PLM was observed in 7 (9.5%) females from grade seven and only 2 males one from each grade lack PLM.

Table 2: The percentage wise difference of morphogenetic traits inheritance among grade seven and eight male and female students. (M, males and F, females).

Morphogenetic traits		***Grade***				***Total***
		Seven		***Eight***		
		M(%)	***F(%)***	***M(%)***	***F(%)***	
Hair line	Widow's peak	31(38.3)	28(37.8)	32(36.0)	25(30.9)	116(35.7)
	strait	50(61.7)	46(62.2)	57(64.0)	56(69.1)	209(64.3)
Total		81(100)	74(100)	89(100)	81(100)	325(100%)
Tongue rolling	Roller	65(80.2)	50(67.6)	63(70.8)	64(79.0)	242(74.5)
	Non-roller	16(19.8)	24(32.4)	26(29.2)	17(21.0)	83(25.5)
Total		81(100)	74(100)	78(100)	81(100)	325(100)
Ear lobe	Free	59(72.8)	49(66.2)	56(62.9)	53(65.4)	217(66.8)
	Attached	22(27.2)	25(33.8)	33(37.1)	28(34.6)	108(33.2)
Total		81(100)	74(100)	89(100)	81(100)	325(100)
Hitchhiker	Straight	43(53.1)	42(56.8)	52(58.4)	51(63.0)	188(57.8)
	Bent	38(46.9)	32(43.2)	37(41.6)	30(37.0)	137(42.2)
Total		81(100)	74(100)	89(100)	81(100)	325(100)
Bent-little finger	Bent	10(12.3)	25(33.8)	7(7.9)	17(21.0)	59(18.2)
	Straight	71(87.7)	49(66.2)	82(92.1)	64(79.0)	266(81.8)
Total		81(100)	74(100)	89(100)	81(100)	325(100)
Palmaris longus muscle	Present	80(98.8)	67(90.5)	88(98.9)	78(96.3)	313(96.3)
	Absent	1(1.2)	7(9.5)	1(1.1)	3(3.7)	12(3.7)
Total		81(100)	74(100)	89(100)	81(100)	325(100)

6.2. The distribution of Mendelian monogenic traits among age groups

The distribution of morphogenetic trait among different age groups was presented in Table 3. It is shown that most 95 (36.1%) of prevalence of widow's peak in the population fall in 13-15 age group and 53 males (37.9%) and 42 females (34.1%) have displayed this trait. Out of 21 (33.9%) widow's peak observed in 16-18 years of age the ratio of males 10 (33.3%) almost equal with 11 (34.4%) females. The table also revealed 200 (76.0%) individuals whose age ranges between 13-15 can roll their tongue and equal ration of male and female rollers were found on the second age

group. Ear lobe attachment was also indicated in different age groups and it was found that attached ear lobe is less frequently observed in females whose ages beyond 15. The recessive trait for hitchhiker with in each age group was enlisted and this trait was found to be common in males and almost half of males 63 (45.0%) and 12 (40.0%) respectively displayed the characteristic hitchhiker thumb. Bent little finger occurrence was higher in females as compared with males and 36 females (29.3%) whose age was between 13-15 had bet little finger and the highest incidence of male1s 3 (9.3%) with this trait was also found in this age group. Palmaris longus muscle found absent in most 8 (6.5%) female students whose age ranges between 13-15 and also indicated that all 2 (1.4%) males with PLM absence fall with in this age group.

Table 3:-Distribution of morphogenetic traits among different age groups (M, males and F, females).

Age							
Morphological-traits		13-15			16-18		
		M(%)	F(%)	Total(%)	M	F	Total
Hair line	Widow's peak	53(37.9)	42(34.1)	95(36.1)	10(33.3)	11(34.4)	21(33.9)
	Straight	87(62.1)	81(65.9)	168(63.9)	20(66.7)	21(65.6)	41(66.1)
Total		140(100)	123(100)	263(100	30(100)	32(100)	62(100)
Tongue rolling	Roller	107(76.4)	93(75.6)	200(76.0)	21(70.0)	21(65.6)	42(67.7)
	Non-roller	33(23.6)	30(24.4)	263(24)	9(30.0)	11(34.4)	20(32.3)
Total		140(100)	123(100)	263(100)	30(100)	32(100)	62(100)
Ear lobe	Free	99(70.7)	78(63.4)	177(67.3)	16(56.3)	24(75.0)	40(64.5)
	Attached	41(29.3)	45(36.6)	86(32.7)	14(46.7)	8(25.0)	22(35.5)
Total		140(100)	123(100)	263(100)	30(100)	32(100)	62(100)
Hitch-hiker	Absent	77(55.0)	76(61.8)	153(58.2)	18(60.0)	17(53.1)	35(56.5)
	Present	63(45.0)	47(38.2)	110(41.8)	12(40.0)	15(46.9)	27(43.5)
Total		140(100)	123(100)	263(100)	30(100)	32(100)	62(100)
Bent-little finger	Bent	13(9.3)	36(29.3)	49(18.6)	4(13.3)	6(18.8)	10(16.1)
	Straight	127(90.7)	87(70.7)	214(81.4)	26(86.7)	26(81.3)	52(83.9)
Total		140(100)	123(100)	263(100)	30(100)	32(100)	62(100)
Palmaries longus muscle	Present	138(98.6)	115(93.5)	253(96.2)	30(100)	30(93.8)	60(96.8)
	Absent	2(1.4)	8(6.5)	10((3.8)	0(0.0)	2(6.2)	2(3.2)
Total		140(100)	123(100)	263(100)	30(100)	32(100)	62(100)

6.3. Association of monogenic Mendelian traits

The distribution of different expressed phenotypes of morphogenetic traits were recorded among the sample population (N=325) presented in table 4. When morphogenetic traits were related to gender the number of recessively expressed phenotypes in some morphogenetic traits such as hitchhiker thumb, bent little finger and palmaris longus muscle were more frequent in the male individuals than the female despite the number of males (170) greater than females (155) in the sampled population.

Association evaluation between gender and the evaluated traits showed that all the studied traits did not significantly relate with gender ($p > 0.05$) except bent little finger and palmaris longus muscle. Similarly, it was also revealed association evaluation between each morphogenetic traits did not significantly relate each other ($p > 0.05$) with regard to age all the studied traits did not significantly associate with age($p > 0.05$). The prevalence of bent little finger was higher in females 42(27.1%) than males 17(10.0%) and the study revealed that the presence or absence of this trait was significantly related to gender type ($\chi^2 = 15.95$, df = 1, $p < 0.001$). Similarly, higher incidence of PLM agenesis was found among 10 females (6.5%) and despite the number of sampled males higher than females only 2 males (1.2%) lack PLM muscle. The absence of PLM was significantly more prevalent and associated to the female than the male ($\chi 2 = 6.345$, df = 1, $p < 0.05$).

Table 4:- Prevalence of morphogenetic trait and test of independent association between gender and evaluated trait and between each traits observed at 95% confidence interval df=1 and Fishers exact test for expected count less than 5.

Morphogenetic traits		Gender				Total		Chi-square					
		Male		Female				With in gender		Hair line with tongue rolling And ear lobe		With in age	
		N	%	N	%	N	%	X^2	p	X^2	p	X^2	p
Hair line shape	Curved	63	37.1%	53	34.2%	116	35.7%			with tongue rolling		0.111	0.739
	Straight	107	62.9%	102	65.8%	209	64.3%	0.290	0.59	0.486	0.486		
Tongue rolling	Roller	128	75.3%	114	73.5%	242	74.5%	0.130	0.718	With ear lobe		1.819	0.177
										X^2	p		
										0.145	0.704		
	Non-roller	42	24.7%	41	26.5%	83	25.5%			Tongue rolling with ear lobe attachment			
Ear lobe attachment	Free ear lobe	115	67.6%	102	65.8%	217	66.8%	0.124	0.725	X^2	p	0.175	0.675
	Attached ear lobe	55	32.4%	53	34.2%	108	33.2%			0.427	0.514		
Hitchhiker Thumb	Straight	95	55.9%	93	60.0%	188	57.8%	0.564	0.453	Hitchhiker Thumb with bent little finger and PLM		0.061	0.805
	Hitch-Hikers Thumb	75	44.1%	62	40.0%	137	42.2%			With bent little finger			
										X^2	p		
Bent little Finger	Bent	17	10.0%	42	27.1%	59	18.2%	15.950	<0.001	2.927	0.085	0.211	0.646
	Straight	153	90.0%	113	72.9%	266	81.8%						
Palmaris longus muscle(PLM)	Present	168	98.8%	145	93.5%	313	96.3%	6.345	0.012	With PLM		Fishers exact test	
										X^2	p		
										1.504	0.22		
	Absent	2	1.2%	10	6.5%	12	3.7%			Fishers exact test PLM with bent little finger		p	
										p		1.00	
										0.241			

6.4. The distribution of dominant and recessive traits among the study participants

The distribution of dominant and recessive expressed phenotypes of morphogenetic traits assessed among sample population (Fig. 11) revealed that the population possessed more recessive phenotypes in some selected morphogenetic characteristics such as hair line distribution, bent little finger and palmaris longus muscle (PLM) than the dominant phenotypes. Dominant palmaris longus muscle (PLM) was the least observed 12(3.7%) in the study population. However, only tongue rolling, ear lobe attachment and hitchhikers thumb showed more dominant expressed phenotypes than the recessive phenotype.

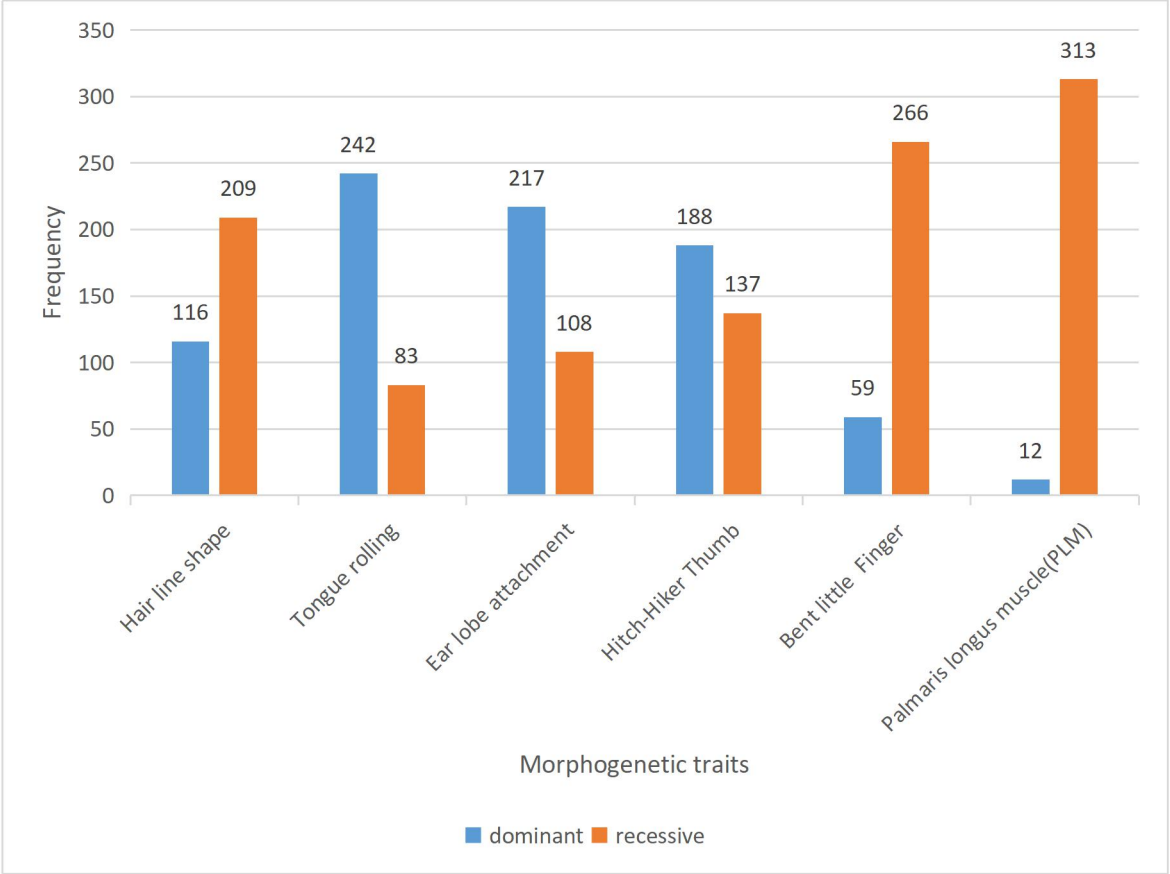


Fig11:- Distribution of Mendelian dominant and recessive expressed phenotypes of morphogenetic traits evaluated among sample population.

7. Discussion

Human morphogenetic traits, which are controlled by a single gene with a pair of alternative alleles, were studied. In this study, one of the trait studies was hair line shape. Widow's peak was seen in about 35.7% of the study population, which is lower than that of strait hair line and this is consistent with the findings of Ebeye *et al* (2014) and Nwaopara *et al* (2008). Similarly, some differences between males and females have been observed. Accordingly, most of the males have widow's peak and the same goes for males with strait hair line and this is in contrast to the results of Ebeye *et al* (2014) and Zeneb (2018) who reported high levels of strait hair line are seen in women. In Ethiopia, there are different hairstyles to express the culture and preserve beauty. According to Mercer (1987) in black hair style politics, hair styling is deeply personal and has economic, political and psychological implications. When it comes to modernity, it is not uncommon in urban cultures to wear traditional hairstyles such as braids and the like because of some people think those with indigenous hair style are up themselves or think they are special Mulusew (2014) the other is the low distance traveled to promote our country's hair style in a way that is consistent with which hairs line shape for instance, Widow's peak is not compatible with the traditional type of braids and females with this type of hair line pattern usually do not choose this hairstyle.

The frequency distribution of tongue rolling ability was found to be more in the sampled populations that there were more rollers 242 (74.5%) than non-rollers 83 (25.5%). This study is in line with previous studies, which, according to Usha *et al* (2016) at thrissure district of India , show that most people are able to roll their tongues, and some are unable to do so. Similarly, Adekoya *et al* (2020) and Onyije (2012) in a separate study of students at the University of Lagos in Nigeria and Bayelsa State, Nigeria found that most subjects were able to roll their tongues. Kooffreh *et al* (2015) and Onyije (2012) in their study, most males were more likely to roll their tongues than females, which is consistent with this study. Chi-square analysis of variance indicates that $p > 0.005$ and that there is no relationship of tongue rolling between the two sexes, but according to Kooffreh *et al* (2015), tongue rolling and sex have a statistical relationship, which is inconsistent with this study.

The size of the human ear the position and shape is one of the parts of the body that make a difference in a person's appearance Ekanem *et al* (2010). As shown in Table 4, 115 (67.6%) males and 102 (65.8%) females have a free ear lobe, which is significantly higher in the population and this result has been shown to be related to other researchers (Adekoya *et al*., 2020, Munir *et al*., 2015, Ebeye *et al*., 2014 Onyije, .2012). However, with Ebeye *et al* (2014) and Onyije (2012) it is inconsistent with what gender free ear lobe is most commonly seen. According to Ebeye *et al* (2014), most females have a free ear lobe, which can be attributed to the inclusion of a large number of women in the sample. Kooffreh *et al* (2015) reported that the ear lobe attachment was not significantly associated with gender. It was also reported in this study ($p > 0.005$) and it can be mentioned that the two studies are consistent. On the other hand, Zeneb (2018) as mentioned, free ear lobe attachment is more common in men and is therefore similar to this study. Various studies have shown that each person's ear type like fingerprints, DNA or other methods we use to distinguish one person from another are found to describe only one person Krishan *et al* (2019). Although this study did not address the differences in the shape of each external human ear but studies have showed that morphological analysis of the human external ear provides a way for facial reconstruction of fugitives in forensic examination and personal identification Guyomarc'h and Stephan (2012). In another study Edibamode *et al* (2019) noted that ear shape variability plays a significant role in criminal investigations, noting the difference in the length of the ear lobe between men and women, and that most women have long ear lobes. Thus, it is clear that such information can be obtained during a criminal investigation.

Various studies have been conducted on the hitchhiker thumb and bent little finger. Adekoya *et al* (2020) and Onyije, *et al* (2012) showed that most of the samples had straight thumb and little finger, which is similar to this study. Looking at these two traits by gender, however, the hitchhiker thumb was observed in 75 (44.1%) males, which contradicted the results of Munir *et al* (2015) and Onyije *et al* (2012). But it agrees with bent little finger, and the chi-square analysis confirms that ($p < 0.005$) and related to sex and is observed in most females.

Palmaris longus muscle is a different muscle in humans and may not be present, according to various studies (Cetin *et al*,. 2013, Karacan *et al*,. 2017 and Pai *et al*,. 2008). In this study, 12(3.7%) were found to have no PLM, and 2(1.2%) were males and 10 (6.5%) were females. This revealed that the overall absence of this muscle is smaller than that reported in most standard book of hand surgery (Hiz *et al*,. 2011). The sample size of Sharma *et al* (2019) and Alves *et al* (2011) is small compared to this study but indicates a high number of PLM agenesis and this may be due to the fact that the study was conducted on non-Africans where low incidence of PLM agenesis is observed in Africans blacks compared with different populations Cetin *et al* (2013). However, this is not to say that it has nothing to relate with this study, for example, according to Sharma *et al* (2019), PLM agenesis is more common in females. Alves *et al* (2011) and Yong *et al* (2017) bilateral agenesis of PLM are more pronounced in females than in males and according to Tesfamichael and Assegedech (2014) more closely related to the study of Ethiopians. Overall, PLM agenesis Yong *et al* (2017) reported that 3.8% of Ghanaian lack PLM which makes it inline with the results of this study. From the above reports it can be said that there is low incidence of PLM absence among African black population but a report by Kayode *et al* (2008) have revealed high incidence of lack of this muscle which has not been reported in such large case among Africans previously. The PLM tendon fits all the requirements such as, length, thickness and availability for various surgical procedures Troha *et al* (1990). It was mentioned that 96% of the participants in this study had PLM which can be said that the lack of PLM in our country is low compared to other countries. Therefore, there is an adequate supply of tendon for various health facilities, and for patients who need reconstructive surgery for a variety of reasons. In addition, if we use this muscle out of the patient without the need for donations for various treatments, there is no harm to the body and can greatly reduce health problem in this area.

8. Conclusion and Recommendation

8.1. Conclusion

Some of the morphogenetic traits that were explored in this study, the dominant phenotype is expressed by most of the participants and the most prominent of these were tongue rolling , free ear lobe attachment, and straight thumb were seen in many participants but no matter how palmaris longus muscle and bent little finger occur dominant trait, it is observed in a few participants. On the other hand, recessive traits are more common in straight hair, PLM and straight little finger. Similarly, when we look at dominant phenotypes by gender widow's peak, tongue rolling, free ear lobe attachment, and straight thumb are common in boys while bent little finger and bilateral absence of palmaris longus muscle has been found to be a common condition in most girls.

The relationship of morphogenetic traits with gender apart from bent little finger and palmaris longus muscle, it can be said that there is no relationship of morphogenetic traits with gender. Similarly, it indicates that all traits nothing to do with age and that these traits can be seen if the necessary gene is found in the age range. The results of this study were not studied in relation to any ethnic group, and the study was conducted in heterogeneous population, which provides clear information in morphogenetic inheritance variation in Ethiopia. The results of this study can be used as input for medical, anthropological, forensic pathology, and population diversity studies in our country.

8.2. Recommendation

The monogenic traits covered in this study were conducted in small population hence it is recommended that to conduct the study in large population with different races. This will give a better picture for the frequency of the traits among Ethiopian populations. The finding of the study indicated that there is variation in population, thus it is recommended that to include student project in high school biology lesson of Genetics. This will enhance the students understanding of the Mendelian inheritance from practical point of view. Moreover, it is important to emphasize the use of this genetic information for forensic science and for reconstructive surgery in high school curriculum also helpful for development of life skill of the students for future use.

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10. Annexes

I. LETTER OF INFORMED CONSENT

Adult-in-Life Study Addis Ababa University: Department of Zoological Sciences.

Title of Research Project: **Inheritance variation in some human morphogenetic traits among school age children of kale primary school**.

Name of principal investigator:- _____

Phone Number of principal investigator: _____

Dear participant you are being asked to take part in a research study entitled above and before you agreed to participate in this study its important that you have understand how the study is conducted and your participation in this study is voluntary and its up to you whether or not to take part in the study. If you decided to take part in the study, you will be asked to sign the consent form.

CONFIDENTIALITY: The records from this study will be kept as confidential as possible. No individual identities will be used in any report or publications resulting from the study.

If you have any questions about the study, please contact Mr. _____ by calling [_____]. you can also contact school principal: Mr,_____ Mobile _____ with any questions about the rights of research participants or research related concerns.

CONSENT: I HAVE READ AND UNDERSTAND THE PROVIDED INFORMATION AND HAVE HAD THE OPPORTUNITY TO ASK QUATIONS. I UNDERSTAND THAT MY PARTICIPATION IS VOLUNTARY AND AGREE TO PARTICIPATE IN THE RESEARCH STUDY AND MY SIGNATURE BELOW INDICATES THAT I HAVE DECIDED TO PARTICIPATE IN THE STUDY AND I UNDERSTAND THAT I WILL BE GIVEN A COPY OF THIS CONSENT FORM.

We are kindly requesting your interest in this study. Please complete the attached consent form and indicate whether you do or do not want to participate in the survey.

Yes ☐ ☐ **No** (Mark X for your choice)

Name of the student: ---------- Signature ----------Date ----------

Investigator : ----------Signature----------Date----------

II. LETTER OF ASSENT

Adult-in-Life Study Addis Ababa University: Department of Zoological Sciences.

Title of Research Project: **Inheritance variation in some human morphogenetic traits among school age children of kale primary school**.

Name of principal investigator:- _____

Phone Number of principal investigator: _____

Dear Parent/Guardian/

We are very excited to inform you that your child will have the opportunity to participate in the questioner entitled.

CONFIDENTIALITY: The records from this study will be kept as confidential as possible. No individual identities will be used in any report or publications resulting from the study.

If you have any questions about the study, please contact Mr. _____ by calling [_____]. you can also contact school principal: Mr,_____ Mobile _____ with any questions about the rights of research participants or research related concerns.

CONSENT YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE YOUR YOUTH IN RESEARCH STUDY. YOUR SIGNATURE BELOW INDICATES THAT YOU HAVE DECIDED TO YOUR YOUTH TO PARTICIPATE IN THE STUDY AFTER READING ALL OF THE INFORMATION ABOVE AND YOU UNDERSTAND THE INFORMATION IN THIS FORM, HAVE HAD ANY QUESTIONS ANSWERED AND HAVE RECEIVED A COPY OF THIS FOR YOU TO KEEP.

We are asking permission for your youth to participate in this program. Please complete the attached consent form and indicate whether you do or do not want your youth to participate in the survey.

Yes ☐ ☐ **No** (Mark X for your choice)

Name of Parent/Guardian/: ---------- Signature ----------Date ----------

Name of the students: ----------Signature----------Date----------

III. ፈቃደኝነት ማረጋገጫ ቅጽ

አዲስ አበባ ዩኒቨርስቲ የስነ-እንስሳት ሳይንስ ጥናት ትምህርት ክፍል

የምርምር ፕሮጀክት ርእስ ፦ በአዲስ አበባ በቃሌ አጸደ ህጻናት እና አንድኛ ደረጃ ት/ቤት በልጆች መካከል የተወሰኑ የሰው ልጅ በሚታዩ ውጫዊ የስነ-ቅርጽ የዘር-ውርስ ልዩነት ጥናት ኮ/ቀ/ክ/ከ ወረዳ 15 አዲስ አበባ ኢትዮጵያ።

የዋና ተመራማሪ ስም፥- _____

የዋና ተመራማሪ ስልክ ቁጥር፦_____

የውድ ተሳታፊያችን ከላይ በተጠቀሰው የምርምር ጥናት ላይ እንዲሳተፉ እየተጠየቁ ነው። እናም በዚህ ጥናት ለመሳተፍ ከመስማማትዎ በፊት ጥናቱ እንዴት እንደሚከናወን እና በዚህ ጥናት ውስጥ ያለዎት ተሳትፎ በእርስዎ ፈቃደኝነት ላይ የሚወሰን ነው። በጥናቱ ውስጥ ለመሳተፍ ወይም ላለማተፍ ከወሰኑ የስምምነት ቅጹ ላይ ባለው ቦታ ፊላጎትዎን ያመልክቱ ።

ስምምነት፡ የቀረበውን መረጃ አንብቤ ተረድቻለሁ እናም ጥያቄዎቼን የመጠየቅ እድል አግኝቻለሁ። ተሳትፎዬ በፈቃደኝነት ላይ እንደሆነ ተረድቻለሁ እናም በምርምር ጥናት ላይ ለመሳተፍ የተስማማሁ ሲሆን ከዚህ በታች ባለው ፊርማዬ ለመሳተፍ እንደወሰንኩ አረጋግጣለሁ።

ሚስጥራዊነት: ከዚህ ጥናት የተገኙ መረጃዎች ሚስጥር ሙሉ በሙሉ በከፍተኛ ደረጃ የተጠበቀ ነው። ከጥናቱ በተገኙ ማናቸውም ዘገባዎች ወይም ህትመቶች ላይ ማንነቶች ጥቅም ላይ አይውሉም። ስለ ጥናቱ ማንኛውም ጥያቄ ካለዎት በሚከተሉት ስልክ ቁጥሮች ደውለው ማረጋገጥ ይችላሉ። አቶ _____ ስልክ_____ ወይም የት/ቤቱ ርእሰ መምህር አቶ_____ስልክ_____

ለመሳተፍ

እፈልጋለው ☐ **አልፈልግም** ☐ (X ምልክት ያመልክቱ)

የተማሪ/ ስም_____**ፊርማ**_____**ቀን**_____

የተመራማሪ/ስም_____**ፊርማ** _____**ቀን** _____

ማሰታወሻ፦ፈጥናቱ እንደተጠናቀቀ መረጃዎቹ እንዲወድሙ ይሆናል።

እናመሰግናለን!!!!!!!!

IV. በወላጅ/በአሳዳጊ የሚሞላ የስምምነት ማረጋገጫ ቅጽ

አዲስ አበባ ዩኒቨርስቲ የስነ-እንስሳት ሳይንስ ጥናት ትምህርት ክፍል

የምርምር ፕሮጀክት ርእስ ፡- በአዲስ አበባ በቃሌ አጸደ ህጻናት እና አንድኛ ደረጃ ት/ቤት በልጆች መካከል የተወሰኑ የሰው ልጅ በሚታዩ ውጫዊ የስነ-ቅርጽ የዘር-ውርስ ልዩነት ጥናት

ኮ/ቀ/ክ/ከ ወረዳ 15 አዲስ አበባ ኢትዮጵያ።

የዋና ተመራማሪ ስም፥- _____

የዋና ተመራማሪ ስልክ ቁጥር፡- _____

ውድ ወላጅ/አሳዳጊ/የለእርስዎ ለማሳወቅ የምንፈሊገው ልጆ/የሚያሳድጉት ልጅ በሚከተለው/phenoty pictraits/ ጥናት መረጃ በመስጠት እንዲሳተፍ መልካም ፍቃዶ እንዲያደርጉልን ነው።

ሚስጥራዊነት: ከዝህ ጥናት የተገኙ መረጃዎች ሚስጥር ሙሉ በሙሉ በከፍተኛ ደረጃ የተጠበቀ ነው። ከጥናቱ በተገኙ ማናቸውም ዘገባዎች ወይም ህትመቶች ላይ ማንነቶች ጥቅም ላይ አይውሉም።ስለ ጥናቱ ማንኛውም ጥያቄ ካለዎት በሚከተሉት ስልክ ቁጥሮች ደውለው ማረጋገጥ ይችላሉ። አቶ _____ ስልክ_____ ወይም የት/ቤቱ ርእሰ መምህር አቶ_____

ውድ ወላጅ/አሳዳጊ/ የእሮሶን መልካም ፍቃድ ልጆ/የሚያሳድጉት ልጅ/የሚያሳድጉት ልጅ በጥናቱ እንዲሳተፍ ከላይ የተጠቀሰውን መልእክት በአግባቡ ተረድተው በተለመደው ፊርማ እንዲያረጋግጡልን ነው። ለመልካም ፍቃዶ በቅድሚያ እናመሰግናለን።

እንዲሳተፍ

ፈቅጃለሁ ☐ **አልፈቀድኩም** ☐ (X ፊምልክት ያመልክቱ)

የወላጅ/አሳዳጊ/

ስም_____**ፊርማ**_____**ቀን**_____

የልጅ ስም_____**ክፍል** _____ **ፊርማ** _____**ቀን** _____

ማስታወሻ፡- ፈጥናቱ እንደተጠናቀቀ መረጃዎቹ እንዲወድሙ ይሆናል።

እናመሰግናለን!!!!!!!!

V. Morphogenetic traits scoring sheet

Addis Ababa University, Department of Zoological Science

Research Title: INHERITANCY PATTERN OF SOME HUMAN MORPHOGENETIC TRAITS AMONG SCHOOL AGE CHILDREN OF KALE PRIMARY SCHOOL KOLFEA KERANIYO SUBCITY ADDIS ABABA ETHIOPIA

Place of Collection _____ Collector's Name _____ Date of Collection: _____

Principal Investigator: _____ Mob: _____ email _____

School Principal: _____ Mob: _____ email: _____

Advisor: _____ Mob: _____ email: _____

	Participant Information					Morphological traits scoring Form											
	Age		Sex		Grade	Widows peak		Tongue Rolling		Ear lobs		Hitach-Hikers		Bent little Finger		Long palmer Muscle	
	10-15	>15	M	F		Curved Hairline	Straight Hairline	Roller	Non-Roller	Attached	Free	Present	Absent	Straight	Bent	Present	Absent
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
Total																	

N:B Each morphological scoring sheet should have the attachment of consent forms filled and signed by each participant parents/guardians.

Morphological traits guiding chart should be used during scoring (It should be color print)

VI. <u>በአንዳንድ የሰው ልጅ የሰውነት ክፍሎች የዘር-ውርስ ልዩነት መረጃ መሰብሰቢያ ቅጽ</u>

የምርምር ፕሮጀክት ርእስ፡ በአዲስ አበባ በቃሌ አጸደ ህጻናት እና አንድኛ ደረጃ ት/ቤት በልጆች መካከል የተወሰኑ የሰው ልጅ በሚታዩ ውጫዊ የስነ-ቅርጽ የዘር-ውርስ ልዩነት ጥናት ኮ/ቀ/ክ/ከ ወረዳ 15 **አዲስ አበባ ኢትዮጵያ።**

የመሰብሰቢያ ቦታ_____**የሰብሳቢው ስም**_____

የሚሰበሰብበት ቀን----------

ዋና ተመራማሪ----------

ስልክ----------ኢሜል----------

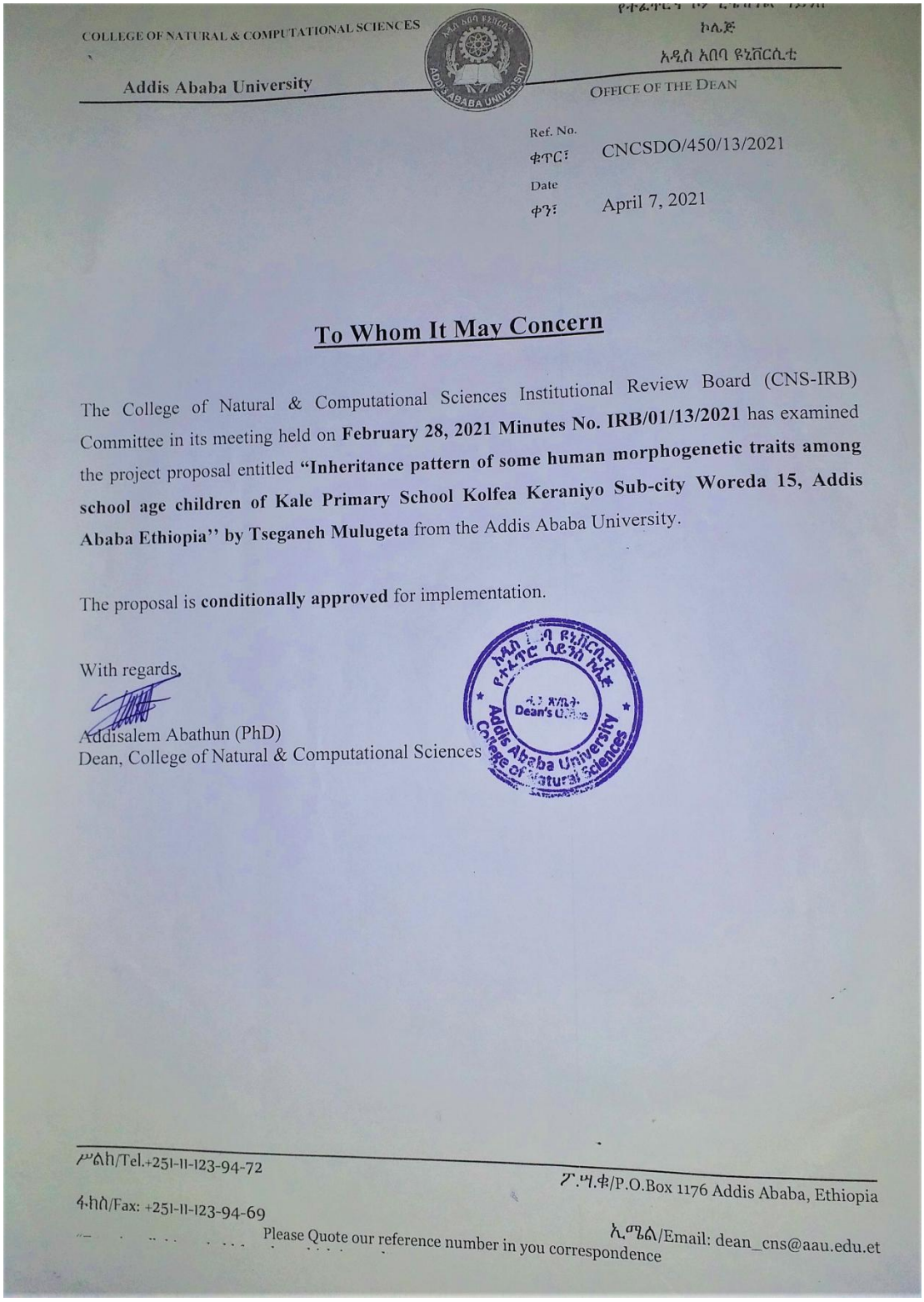
በየት/ቤት/ዋና ርእሰ መምህር----------ስልክ----------ኢሜል----------

አማካሪ----------በስልክ----------ኢሜል----------

ተሳታፊዎች						የጽጉር አቀማመጥ		ምላስ ማንከባለል		የጆሮ እንልጥል		የአውራ ጣት ወደዋላ የመለጠዋ ደረጃ		የታጠፈ ትንሽ ጣት		ረጅም የፓልመር ጡንቻ	
ቁጥር	እድሚ		ጾታ		ክፍል												
	10-15	>15	ወ	ሰ		የታጠፈ የጸጉር መስመር	ቀጥ ያለ የጸጉር መስመር	ሚያንከባልል	ማያንከባልል	የተጣበቀ	የተንጠለጠለ	ሚለጥዋ	ማይለጥዋ	ቀጥ ያለ	የታጠፈ	አለ	የለም
ጠቅላላ																	

ማሳሰቢያ:- የእያንዳንዱ የስነ ልኬት ውጤት ወረቀት በእያንዳንዱ ተሳታፊ ወላጅ ተሞልቶ የተፈረመበት የስምምነት ቅጾች አባሪ ሊኖረው ይገባል። ሰንጠረዡን የሚመራ በሰው ልጅ የሚታዩ ውጫዊ የስነ ቅርጽ ባህሪዎች መግለጫ መረጃ በሚሰበሰብበት ወቅት ጥቅም ላይ መዋል አለበት።

VII.Ethical clearance Obtained from AAU



COLLEGE OF NATURAL & COMPUTATIONAL SCIENCES

Addis Ababa University

ኮሌጅ

አዲስ አበባ ዩኒቨርሲቲ

OFFICE OF THE DEAN

Ref. No.
ቁጥር፣ CNCSDO/450/13/2021

Date
ቀን፣ April 7, 2021

To Whom It May Concern

The College of Natural & Computational Sciences Institutional Review Board (CNS-IRB) Committee in its meeting held on **February 28, 2021 Minutes No. IRB/01/13/2021** has examined the project proposal entitled **"Inheritance pattern of some human morphogenetic traits among school age children of Kale Primary School Kolfea Keraniyo Sub-city Woreda 15, Addis Ababa Ethiopia'' by Tseganeh Mulugeta** from the Addis Ababa University.

The proposal is **conditionally approved** for implementation.

With regards,

Addisalem Abathun (PhD)
Dean, College of Natural & Computational Sciences

Addis Ababa University College of Natural Sciences Dean's Office

ሥልክ/Tel.+251-11-123-94-72

ፋክስ/Fax: +251-11-123-94-69

ፖ.ሣ.ቁ/P.O.Box 1176 Addis Ababa, Ethiopia

ኢሜል/Email: dean_cns@aau.edu.et

Please Quote our reference number in you correspondence