THE CHANGES OF THE POSITION OF POINT A AND POINT B TO THE FACIAL PROFILE : A LONGITUDINAL STUDY FROM 8 YEARS OLD TO 18 YEARS OLD

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The lateral cephalograms of 40 children (20 boys and 20 girls) from Oregon Health Sciences University, Child Growth Study, were examined annually from 8 years old to 18 years old to study the changes of the position of point A and point B. 6 measurements for S-A and S-B (directly, projected to FH plane, projected to vertical line to FH plane) were made.

The A-B/FH and annual growth in each subject were calculated. A trial to make a definition of peak adolescent growth was made. The peak adolescent growth in an individual subject was determined if the maximum growth was three times greater than the average of a year before on-set, on-set, off-set and a year after off-set. The annual growth data were centrally arranged at the peak growth. A calculation of the growth directions were also made. ANOVA and Scheffé tests were used to test the significance between each ages for annual growth and A-B/FH.

The mean and standard deviations for the 6 measurements, A-B/FH and the annual growth were shown. From the annual growth data, males seemed to have a peak growth in all measurements except S-B/FH at 14.5 years old, and females had a peak growth at the age of 10.5 and 12.5 in S-A, S-A/V and S-B/V and at the age of 12.5 in S-B. S-A/FH and S-B/FH did not show any peak growth statistically. A-B differences parallel to FH plane, which is one of the greatest interests for orthodontists, stayed the same through 9 to 17 years old.

According to the definition of peak adolescent growth spurt made in this study, 60~75 percent of the male subjects and 40~70 percent of the females in each measurement had peak growth. The means and standard deviations of the peak growth that centrally arranged were shown. This mean represents the true amount of the peak growth. The mean age of the peak growth by this method were 13.5 years old around point A, 14.3 years old around point B in male, and about 12 years old for females' point A and B. The mean ages of peak growth showed some differences between the data from annual growth and from individually examined data.

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INTRODUCTION

The cephalometric technique and its application to orthodontics was established in 1931 by Broadbent (6), and the attempt to look for useful landmarks and reference line begun. The first serial growth study, the Bolton study, was introduced.

The various applications of this technique had been made, and was categorized by Moore (50) into four, i.e. Assessment, Comparison, Expression, and Prediction. For the Assessment, cephalometrics may be used to study the growth and development of the facial structures.

Recently, the number of investigators in facial growth appears to be diminishing. From a clinical standpoint, the biology and dimensional change of the face still remains a mystery. A special concern that is present is the relative positional change of the maxilla and the mandible to each other during orthodontic treatment in young children.

There are many studies about the facial profile (31)(35)(49). They usually measured the distance between two cephalometric points. But the lines between the two points were not usually parallel to a horizontal plane nor to the vertical. It is said that the rate of growth in vertical and horizontal direction was different (52). In addition to it, facial growth involves some rotational movements (22). But no study showed conclusively how much facial growth had influenced on the facial profile.

The purpose of this paper is to evaluate the maxillary and mandibular growth in both vertical and horizontal directions of the facial profile in a non orthodontic treatment group of normal children.

REVIEW OF LITERATURE

Early days of Human Growth Study

The first steps in the application of instruments of precision to measuring physiological process by recording temperature and pulse and especially by the repeated weighing of the body and the measuring of food and out put of waste under specific environmental states such as time of day, were taken by Santorio Santorio (1) in 1614. As early as 1725, Wasse (1) had reported the account of the diurnal variation in height. In the eighteenth century, studies on the linear measurement began. In the middle of the eighteenth century, Camper (1), a skilled physician and anatomist, proposed using the angle made by the intersection of the axis of the face with the axis of the skull (the facial angle). To illustrate the changes from birth to old age, he (1) arranged drawings of the head and skull of a newborn, of a year old child, of a healthy man, and of an old woman.

By the beginning of the nineteenth century, the idea of taking many measurements of the body and its parts and then using the mean of each dimension began to be used. (1)

According to Scammon (2), the first longitudinal growth study was made by Guano de Montbeillard and published by Buffon in 1776. In this paper, Scammon made the conclusion that Montbeillard already had the idea of a puberal spurt.

In 1931, Davenport (3) established curves of mean annual increments of both weight and stature. He also observed the variance in age and amount of adolescent growth spurt. In 1937, Shuttleworth (3) showed the method that the individual curves were arranged at the point of maximum velocity coincide. The mean curve of this method characterized the individual growth better than the average curve at each age.

Cephalometry

Todd (5) was the first person who used the craniostat for the study of human skull. He used the orientation called the nasion parallel plane that parallels with the Frankfort plane but passing through the nasion. Though his method was not completed, he found some forward and downward maxillary growth in his study.

In 1931, Broadbent (6) and Hofrath (7) simultaneously published the method of the craniostat using a radiographic image. By this technique Broadbent demonstrated the changes in the living head that may be due to developmental growth or orthodontic treatment. He also showed some technique of superimposition and found sella-nasion was the most stable plane. Later, Broadbent (1937)(8) designated point R as a registration point that was midpoint on the perpendicular from the Bolton-nasion plane to sella turcica, and demonstrated the normal developmental growth of the face by superimposition at R.

Brodie (9)(10) studied white children ages from 3 months to 8 years old, and from 8 years to 17 years old. These were probably the oldest longitudinal cephalometric study of the human head that used the several landmarks for the purpose of describing facial profile.

Around 1950, many investigators developed their own cephalometric analysis. (11-14) In 1947, Wylie (12) chose the Frankfort horizontal plane as an orientation plane, and projected all points except two points on the mandible toward this plane. In this method, only anteroposterior displasia was measured.

In 1948, Downs (11) also used the Frankfort horizontal as a plane of orientation. He used mainly angular measurements and showed range, mean, and standard deviation in his twenty clinically excellent occlusions.

In 1952, Riedel (13), used the cranial plane sella-nasion and found a slightly greater SNA SNB angle in adults (over 18 years) than children (8～11 years) and a smaller ANB angle in adults.

Histological Study of Facial Growth

Enlow (15)(16) studied dried skull preparations of the human maxilla and mandible. He used the microscopic method and determined the distribution of the various types of endosteal and periosteal bone tissues, and mapped these. He explained the growth and remodeling using his theories "area relocation" and "V principle". Postnatal growth of human maxilla and mandible in that forwardand downward movement of the growing bone as a whole was a result of growth which taken place in a posterior direction with corresponding repositioning of the entire bone.

Cephalometric Study of the Maxilla and Mandible

There are several cephalometric studies for the maxilla itself or the mandible. Björk (17)(18) used the metal implant method. This made it possible to examine the bone separately and accurately.

On the other hand, Savara made the detail measurements for the maxilla and the mandible from serial cephalograms. Though there were several studies for facial profile, he completely eliminated the influence of the relocation from facial growth by measuring the bone itself.

Björk (1966)(17) studied the sutural growth of the upper face using the implant method with 45 normal boys having different types of malocclusions. The average direction of sutural growth of the upper face in the sagittal plane was 51° and ranged from 0° to 82° . He mentioned the direction of growth followed a curvilinear course. The timings of the growth were 11 1/2 years (the pre-puberal minimum) and 14 years old (the puberal maximum). The amounts of growth were 0.25mm (the pre-puberal minimum) and 1.5mm (the puberal maximum).

Savara (19) and Singh (18) studied the size of maxillae in 52 boys and 50 girls from mixed longitudinal data. They measured maxillary height, maxillary length, and found that the age of peak growth were: 11～12 years old in girls' maxillary height, 14～15 years old in boys' maxillary height, 10～11years old in girls' maxillary length, 13～14 years old in boys' maxillary length. They also showed that the maximum circumpuberal increments were 2.3mm in girls' maxillary height, 2.4mm in boys', 1.6mm in girls' maxillary length, 1.7mm in boys'.

In 1962, Harris (20) reported the mandibular growth aged from 4 to 12 years old from Michigan growth study and found the females' growth was 12 months earlier than the males'. They also mentioned the preadolescent period and the beginning of an adolescent spurt.

Björk (21) studied the growth of the mandible using his implant study. He examined 45 Danish boys with different types of malocclusions. He concluded that the mean age of the prepuberal minimum of condylar growth was 11 years 9 months old and that of the puberal maximum of condylar growth was 14 years 6 months old, and the amount of growth were 3mm at a prepuberal minimum and 5mm at a puberal maximum. He also mentioned the direction of condylar growth was not necessarily linear.

In 1969, Björk (22) studied about 100 children for mandibular growth rotation. He mentioned the mandibular rotation at the age of adolescence and categorized it into five types (three types of forward and two types of backward rotations).

Savara and Tracy (23)(24) measured the mandible in their mixed longitudinal study (50 girls, 52 boys). The age of peak growth were 12～13 years in girls' ramus height and body length, and 13～14 years in boys'. Maximum circum puberal increments were 0.23mm in girls' ramus height, 0.21mm in girls' body length, 0.26mm in boys' ramus height and 0.21mm in boys' body length.

Tofani (1972)(27), Lewis, Roche and Wagner (1982)(28) measured the similar distances (body length, ramus height total length) with Savara in their mixed longitudinal data. Though their main concern was a correlation between mandibular growth and other maturational indicators, for the longitudinal growth data, they agreed with Savara.

Proffit (29) showed the growth curves for the maxilla and mandible against the background of Scammon's curves. He described that growth of the jaw was intermediate between the neural and general body, with the mandible following the general body, curve more closely than the maxilla.

Björk (17) observed the 6 months difference between the mean peak growth of the condyle and that of maxillary sutures.

According to the studies of Savara, Singh and Tracy(18)(19)(23)(24), the peak growth of the maxilla was 1 or 2 years earlier than that of the mandible in girls, but in boys, the maximum increment of maxillary height occurs one year later than that of ramus height and body length, and the peak growth of maxillary length occurs the same year with that of the mandible. Both in boys and in girls, and in the maxilla and in the mandible, vertical growth occurred later than the horizontal growth in relative growth rate.

Cephalometric Study of the Facial Profile

Ricketts (30) observed that the face showed an exploding growth around from the coordinated point of the Frankfort horizontal at pterygoid vertical and basicranial axis at vertical to foramen rotundum. So it is important to know the change of the facial profile as same as the growth of the facial bones.

Since Ridel (13) introduced the measurement of SNA, SNB, many investigators, (31)(32)(33), have made the longitudinal studies for these angles. In all studies, SNA and SNB showed slight increase (about 2°) from 12 years old to 18 years old or adult age, and ANB showed almost no changes (less than 1°) in these ages.

In 1954, Björk (34) measured the ss-n-pog angle (as same as S-N-Pog) with 243 Swedish boys at the age of 12 and 20. He found the significant difference at the 99 per cent level of ss-n-pog angle between the age 12 and 20.

Almost at the same time with these angular measurement studies, linear measurement studies for the facial profile began.

In 1952, Lande (31) measured 27 boys longitudinal records. He found a significant forward movement of 1mm for point A, 2.2mm for point B, for the 12 to 18 year age interval.

Björk (34) measured the ar-ss, ar-pog at the age of 12 and 20 and found a significant difference at 99 per cent level.

In 1971, Nanda (35) studied 40 children (20 boys and 20 girls) from 5 years to 18 years. He measured S-A, S-B and found that the growth curve of S-A and S-B has a puberal acceleration, and that the relative amounts of increase during the entire 12 year old period were greater 19 per cent for S-A and 24 per cent for S-B.

Bergersen (36) studied the facial profile related to skeletal maturation and concluded that the facial growth had a closer relationship to the skeletal age than the chronological age. He estimated 100 per cent of the individuals had growth spurt for S-Gn, 83 per cent for S-N and 35 per cent for S-Ans.

Mitani (1977)(49) studied 30 Japanese children (17 boys and 13 girls) and he concluded that the girls' peak growth seemed to occur 2 years earlier than the boys' and that the age of peak growth for the maxilla was mostly like that of the mandible.

Criticism of Angular Measurements and Its Modification

In 1963, Dreyer and Joffe (37) pointed out the difficulty of using Downs' facial angle for the comparison in the growth change of the mandible in the same individual, as it was influenced not only by the position of pogonion, but by the position of three other points (nasion, orbitale and porion). Nanda (35) mentioned a similar influence on SNA, SNB angle by the growth on nasion.

For the sella-nasion plane, Lewis and Roche (38-40) reported the annual elongation during adolescent that were considerably large. They also found some adolescent spurt both in boys and girls. They mentioned that the site of apposition were increment in thickness of the frontal bone, enlargement of sella and reposition of sella. But according to Nakamura et al.(41), the increment of sphenoid bone is very small relative to that of anterior cranial base.

Taylor (1969)(42) pointed out the geometric factor of the position of the nasion that had influenced on the ANB angle depending on the facial divergency. He used two new points constructed perpendicular from point A and B to the sella-nasion plane, and measured the distance from the sella.

Beatty and Colonel(1975)(43) defined the new point X constructed perpendicular from point A to the sella-nasion plane. He used X instead of nasion for angular measurements and tried to eliminate the influence of the growth of the nasion.

In 1956, Stoner et al. (44) made use of what they called the A-B distance for the analysis of the treated case by C.H. Tweed. In order to measure the change of point B during treatment, they superimposed tracings on S-N at N and measured the linear distance in millimeters between the B points before and after treatment by dropping perpendiculars from the Frankfort plane and measuring the distance between them. Point A and Point P were measured in the same manner.

The Adolescent Growth Spurt

Marshall and Tanner (45) defined the word "puberty" morphological and physiological changes that occur in the growing boy or girl as the gonads change from the infantile to the adult state. And they generally defined "the adolescent growth spurt" as an acceleration followed by a deceleration of growth in most skeletal dimensions and in many internal organs.

Though Tanner (46) had a doubt whether adolescent spurt occurred in most measurements, many investigators found puberal spurts in all individuals. There is no established definition of adolescent growth spurt for facial growth, but some authors tried to find it by their own way.

Hunter (47) used Stolz and Stolz's method for determining the adolescent growth period. He took the average of the increments of growth during examinations. The onset was recorded at the first point below the mean prior to the apex, and the end of the puberal growth period was recorded at the first point below the mean following the apex.

Lewis and Roche (28,38,39) employed definite numbers like 1mm for mandibular growth, 0.5mm for cranial base of girls and 0.75mm for cranial base of boys. A spurt was defined as an annual increment exceeded the immediately preceding annual increment by at least this definite amount.

Taranger and Hägg (48) defined the onset of adolescent spurt of body height: the smallest annual increment from which there was a marked continuous increase in the growth rate to peak height velocity. Also they used the definite number for off set of adolescent spurt: the first annual increment below 20mm after peak height velocity.

MATERIALS AND METHODS

Subjects used in this study were 40 children (20 boys and 20 girls) from Oregon Health Sciences University, Child Growth Study. The subjects were Caucasians of predominantly Northwestern European ancestry. Parents of the subjects were of middle socio-economic status and resided in or near Portland, Oregon. The serial lateral cephalograms of the subjects from 8 years to 18 years were examined annually. Several films were missing: For boys, 14 out of 220 films, and 7 out of the 14 films were from the 18 year old sample. As for girls, 7 out of 220 films were missing and 3 out of the 7 were from the 18 year old sample. All subjects had normal skeletal profiles. 13 boys and 10 girls had normal acceptable occlusions. 7 boys and 10 girls had Cl I malocclusions. In boys' malocclusion cases, 5 had Cl I crowdings, 2 had +3～+4mm over jets because of the spacing. In girls' Cl I malocclusion cases, 6 had crowdings less than -2mm, 2 had -4～5mm crowdings, 1 had a cross bite unilaterally in the first molar region and 1 had scissors bite in the second molar region unilaterally. A summary about the occlusions of the subjects is shown in Table 1. Each cephalogram was traced and measured by the author. S-N plane at point S was selected for superimposition. Björk's method (51) was employed for detailed superimposition, because during growth, sella turcica changes its form by apposition on tuberculum sellae and by resorption at the posterior wall and at the floor. The Frankfort-horizontal plane, point A, point B and point S were transferred from a 13 year old headfilm to each films to minimize the errors of landmark locations. Perpendicular lines were made from these points to the Frankfort-horizontal plane in each cephalogram. The following distances were measured:

- sella — point A (S-A)
- sella — point A projected to Frankfort-horizontal plane (S-A/FH)
- sella — point A vertical to Frankfort-horizontal plane (S-A/V)
- sella — point B (S-B)
- sella — point B projected to Frankfort-horizontal plane (S-B/FH)
- sella — point B vertical to Frankfort-horizontal plane (S-B/V)

The measurements were made to the nearest 0.1mm. No adjustments were made for enlargements.

To calculate the measurement errors, 33 cephalograms were retraced. To reproduce the same procedures, 2 girls and a boy were selected and traced from the ages 8 to 18. From the original 13 year old cephalogram, the three points (S, A, B) were transferred only onto the retraced 13 year old's, and the same procedures on the originals were followed.

Standard errors of the measurement (SEM) were calculated by the following formula:

$$SEM = \sqrt{\frac{\Sigma d^2}{2N}}$$

d = difference between duplicate measures

N = number of scores

SEM in this study were as follows:

SA	0.35mm	S-B	0.27mm
S-A/FH	0.31mm	S-B/FH	0.44mm
S-A/V	0.52mm	S-B/V	0.44mm

The annual growth rates were calculated and plotted on the graph for each subject to determine the adolescent growth spurt.

In this study, on-set and off-set of the adolescent growth spurts are determined graphically as an age of which the annual growth velocity immediately changes. At the age of on-set, the growth velocity immediately increases toward the peak adolescent growth spurt. After this spurt, when the growth velocity suddenly reduces, the age of off-set is defined. In each subject, if the obvious velocity change was not observed, this measurement was considered not to have an adolescent peak growth.

The age of the peak adolescent growth was determined the following way: The highest point between the on-set and the off-set was chosen. If this annual growth was three times great as the average of a year before on-set, on-set, off-set and a year after off-set, it was determined to be the peak adolescent growth. Dued to the limitation of the age investigated or the missing of the data, some average described above were made from the three.

The means, standard deviations, were calculated for chronological age, annual growth, and the spurt around the adolescent growth. The means and ranges were shown for the age of adolescent peak growth. From the measurements, growth directions from 8 years old to 18 years old, 8 years old to the age of peak adolescent growth, the age of peak growth to 18 years old, were calculated.

The F-tests and T-tests were employed to test the significance between sexes for 6 measurements and the centrally arranged peak adolescent growth. The F-tests, the analysis of variance (ANOVA) and the Scheffé tests were used to test the significance between each ages for annual growth.

For ANOVA, the same number of subjects are required. There were some missing data in this study. To calculate the missing measurements, the average of the measurements a year before and after was used. The data of 8 years old and 18 years old were omitted because the missing measurements could not be compensated.

RESULTS

The means and standard deviations of the 6 measurements are shown in Tables 2 and 3, and Figs. 2～7. A-B/FH are calculated from S-A/FH and S-B/FH, and are shown in Table 6. T-tests are made between males and females, and are shown in Table 13.

The means and standard deviations for the annual growth are shown in Tables 4 and 5, and Figs. 8～13. The results of the ANOVA for the annual growth are in Tables 14～25, and the results of Scheffé tests are shown in Tables 26～36.

As one of the great interests for this study was the anteroposterior change of A-B differences parallel to the horizontal plane in the ages of adolescent, A-B/FH were calculated from original measurements. Means and standard deviations are listed in Table 6 and the results of ANOVA are shown in Tables 37 and 38.

According to the definition of peak adolescent growth made in this study in each measurement of the male and female subjects, 60～75 percent of the former and 40～70 percent of the latter had peak growth. Numbers and percentiles of the subjects are shown in Table 7. Also the mean ages and ranges of the adolescent peak growth are shown in Table 8.

Each subjects' peak growth was centrally arranged. The means and standard deviations of the peak growth, and 1～3 years before and after, are shown in Tables 9 and 10, and Figs. 14～19.

Growth directions from 8 years old to 18 years old, from 8 years old to the peak growth, and from the peak growth to 18 years are calculated from horizontal and vertical measurements.

DISCUSSION

Dimensional Changes

The graphs of the 6 measurements in males almost show a straight line, except for some peak growths, that make the gradients steeper. This means that males still have growth both S-A and S-B in all directions. On the other hand, graphs of females were flattened after the age of 14 in measurements related to point A and after the age of 16 in point B. Gradients of S-B or S-B/V are steeper than that of S-A or S-A/V, and that of S-A/FH is similar to that of S-B/FH. Gradients of the graph of vertical measurements are steeper than that of horizontal, especially for point B. This indicates the changes of the point A or B to the sella are more vertical than horizontal directions. There are some significant differences in the dimensions between sexes even before the age of adolescent (Table 13). After the age of adolescent growth, significant differences can be seen in all 6 measurements.

For the treatment of growing children, for the correction of anteroposterior disharmony of their faces, orthodontists have been interested in A-B difference changes. From the original data, A-B/FH in each year were calculated. In male, a 1.9mm decrease was seen from 8 year olds to 17 year olds.

In female, A-B/FH seemed to stay the same through the 11 years. To test the statistical differences between the ages, ANOVA's were used in this study (Table 37,38). No significant differences were found. A-B differences parallel to FH plane stayed the same through 9 to 17 years old. The total mean and SD are as follows:

	mean	SD	
male	7.8	3.0	
female	6.8	3.8	(mm)

Nanda (35) measured S-A and S-B and reported the differential growth between them. The growth curve for S-B (he did not show that of S-A) was as the same as that of this study. "The mandible had a greater forward growth, resulting in a straighter facial profile." This was mentioned, because in his study, the relative amounts of increase from 5 years old to 18 years old were 19 percent for S-A and 24 percent for S-B. New horizontal and vertical measurements clarified that growth of S-B/V had as twice influence to S-B as S-B/FH. Point B has forward growth but as the same amount as point A, so A-B/FH stays constant. Many investigators described the growth of the mandible using SNB angle, but it should be noticed that SNB becomes greater even when it only moves downward.

Annual Growth

Graphically, there seems to be a peak adolescent growth for S-A, S-A/FH, S-B and S-B/V in male, and S-B and S-B/V in female. There are maximum growths at 14.5 years old in 4 measurements listed above in male and 12.5 years old for S-B and S-B/V in female. At 10.5 years old for S-A and S-A/V, a maximum growth shows but are not like peak spurts. A ceasing period can be observed in every measurement among females. The growth ceasing age was 14.5 years old except for S-B and S-B/V, and the age for these two was 17.5.

Since the definition of peak adolescent growth in this study was made to determine whether each subject had a peak spurt or not, it did not suit to find a peak growth from the averages. Therefore, ANOVAs' were employed for the annual growth in each measurement between ages to test the significant differences. If an annual growth is larger than other annual growths statistically, it can be considered to be a peak spurt. In all measurements but S-B/FH in male, significant differences can be seen in ANOVA (Tables14～25). The probabilities were $\alpha = 0.05$ for S-B/FH in female, $\alpha = 0.01$ for others. For comparisons between each ages, Scheffé tests were used. In male, S-A showed a significant peak growth at 14.5 years old and a smaller peak at 12.5 years old. It seemed to cease growing at the age of 16.5. S-A/FH presented similar results. It showed significant peak growths at 14.5 years of age and ceased at 16.5. S-A/V did not have a clear peak growth graphically, but 12.5, 13.5 and 14.5 years old were significantly greater than other ages. Significant peak growths were presented at 14.5 years of age in S-B and 13.5 and 14.5 in S-B/V. By contrast with measurements for point A, those for point B did not show any ceased growth at 16.5 years old. In female, a significant peak growth was seen at the ages of 10.5 and 12.5 in S-A, 10.5 and 12.5 in S-A/V and 12.5 in S-B. Also in S-B, a smaller peak was seen at 10.5 years old. S-B/V had two peaks at 10.5 and 12.5 years of age. There were no clear peaks for S-A/FH and S-B/FH. For all annual growths in female, the growth after 14.5 years old were significantly smaller.

The ages of peak adolescent growth found in this study were very similar to Björk's (17)(21), Savara's (19)(23), Singh's (18) and Tracy's (24).

Lande (31) observed a 1mm forward movement of point A and 2.2mm of point B in boys from 12 to 18 years of age interval, using superimposition S-N registered at N. But Figs. of annual growth in this study show 1mm forward growth of point A every year until 16 years old in male and 13 years old in female. Also it shows that point B moves more than 1mm forward every year until 17 years old in male, and 0.8～0.9mm every year until 13 years old in female. Though Lande used point N for the registered point, point S was used in this study. The difference of the results aroused from this. It seems reasonable to use the registered point at S for describing the true amount of growth to anterior cranial base.

According to the definition of the peak growth made in this study, the percentile of the subjects that had a peak adolescent growth were almost the same between male and female, and between each measurements. Mean ages in male are varied from 13.4 in S-A/V to 14.6 in S-A/FH. Those in female are from 11.9 years old in S-A/FH to 12.2 in S-A. The differences in direct, horizontal and vertical measurements were found only in point A of the male. The mean of S-A/FH was almost 1 year older than those of S-A or S-A/V. In male, the mean ages for peak growth around point A was about 13.5 and around point B was about 14.3. The mean age of peak growth for point A was 9 months earlier than point B. In female, the mean ages of the peak growth were about 12 years old for both point A and B.

The amounts of growth centered at the age of peak adolescent growth are shown in Tables 9 and 10. Obviously, those peak growths are larger than the maximum growth of the annual growth means. Those means indicate the actual amounts of growth that the normal children have in the particular year. The statistical differences of the amount of the peak growth between sexes are shown in Table 39, although some of the F-tests show significant differences at $\alpha = 0.05$. Amounts of the peak growth were greater in male than in female except S-A/FH. This makes the facial dimension of males are greater than the females' after adolescent period.

Growth Direction

Björk (17) mentioned the sutural growth directions of the upper face was 51° and ranged from 0° to 82° in boys. He did not mentioned the growth direction of any point that was located at the anterior border of the mandible. The growth direction for S-A in male was 52° ,that was very close to Björk's results. The details of the results are in Tables 11 and 12. Both in male and female, the direction of S-B was greater than S-A which indicated S-B had more vertical growth than S-A. Some growth directions of S-B in female were negative, which indicated backward movements. This probably means the subject had more backward rotations than forward or downward growth. The growth directions before and after the peak growth were also examined. No special characteristics were found.

SUMMARY

The lateral cephalograms of 40 children (20 boys and 20 girls) from Oregon Health Sciences University, Child Growth Study, were examined annually from 8 years to 18 years to study the changes of point A and B. 6 measurements for S-A and S-B (directly, projected to FH plane, projected to vertical line to FH plane) were made. The A-B/FH and the annual growth were calculated.

The means and standard deviations for the 6 measurements, A-B/FH and the annual growth were shown. These 6 measurements revealed that the growth in vertical directions were as twice as much as horizontal directions and the growth of vertical directions had twice the influence to S-A and S-B as horizontal. A-B/FH stayed the same through 9 to 17 years old. For annual growth, there weren't any differences for the age of peak growth in the 3 directions. Males had peak growth at the age of 14.5 both in S-A and S-B; females, at the age of 12.5 in S-B. In females' S-A, there was no particular peak from annual growth data.

A trial to make a definition of peak adolescent growth was made. According to the definition, 60～75 percent of the male and 40～70 percent of the female had peak adolescent growth in each measurements. Each subjects' peak growths

were centrally arranged. The means shown in this method indicated the actual amounts of peak growth. Mean age of peak growth were around 14.5 years old in male except S-A which was 13.5 years old, and 12 years old in female.

The growth directions were calculated from vertical and horizontal measurements. The directions from 8 to 18 years old were 52° (S-A in male) 61° (S-B in male) 56° (S-A in female) and 60° (S-B in female). No significant changes were found before and after the peak growth.

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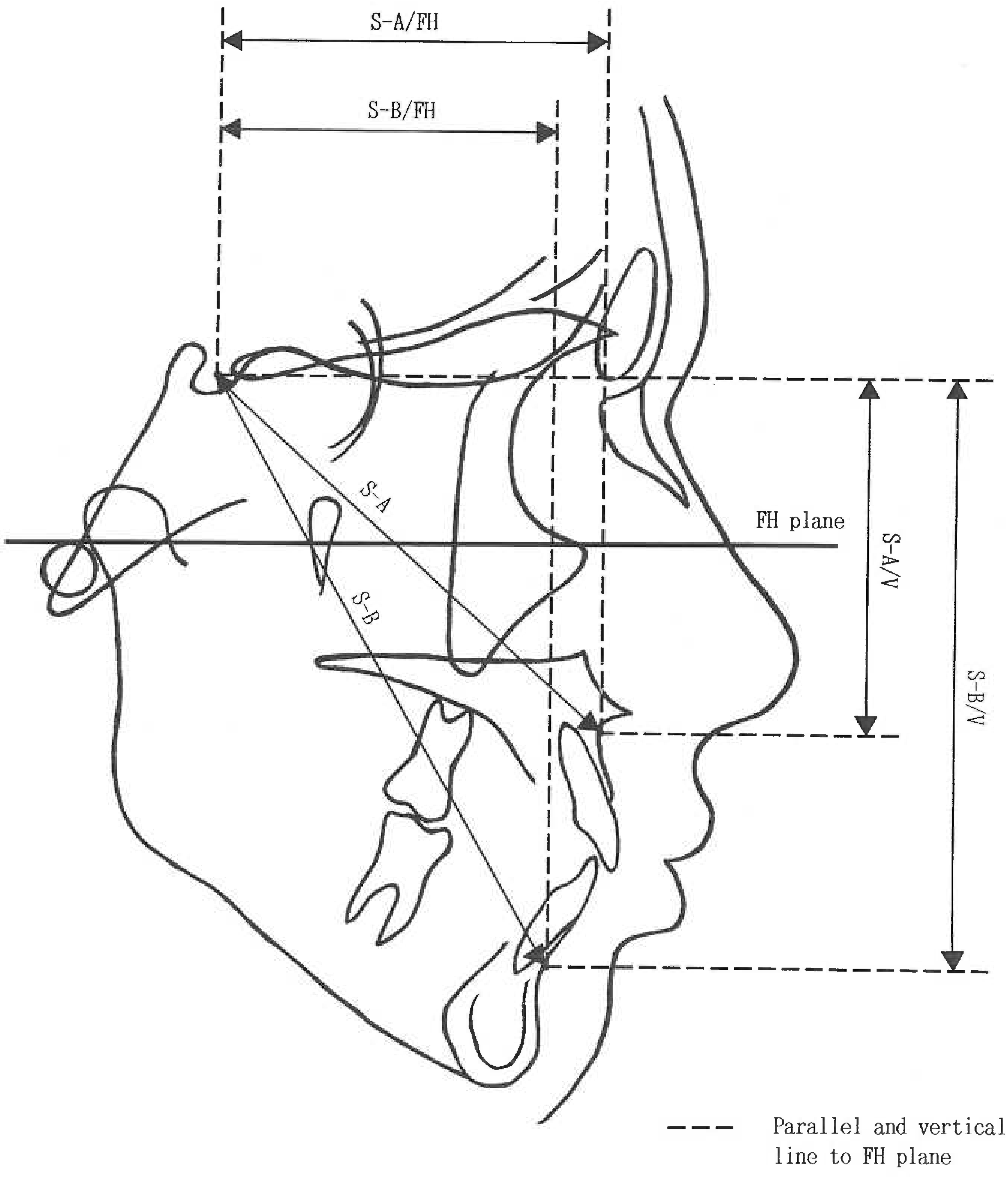
APPENDIX

Fig 1. Measurements used in this study



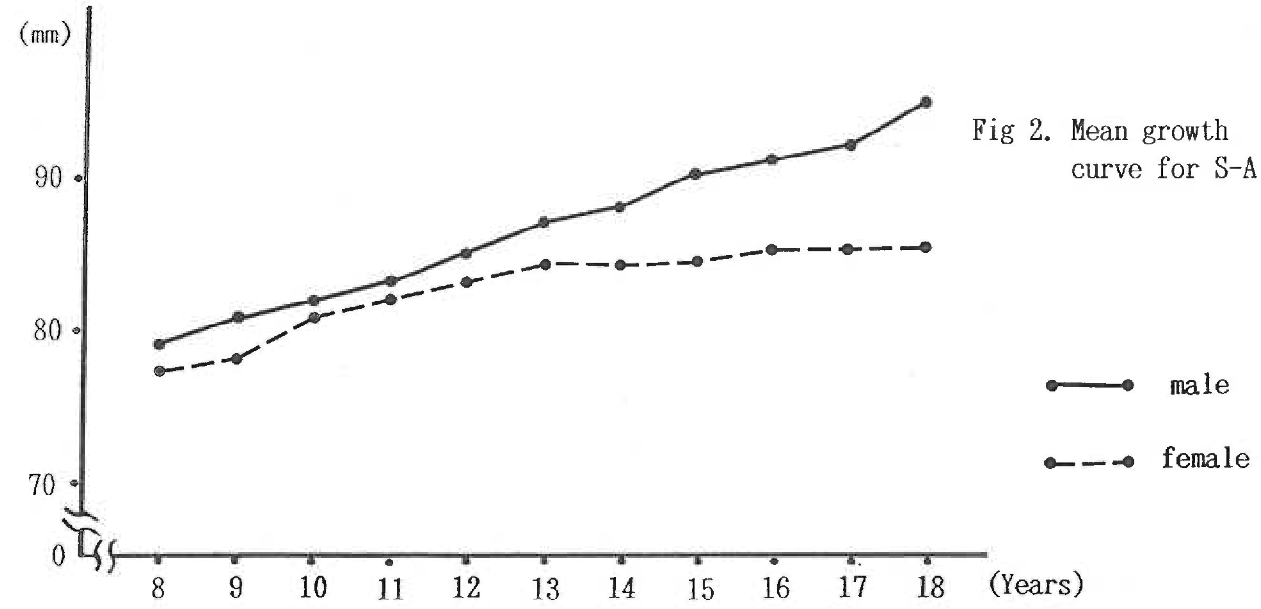


Fig 2. Mean growth curve for S-A

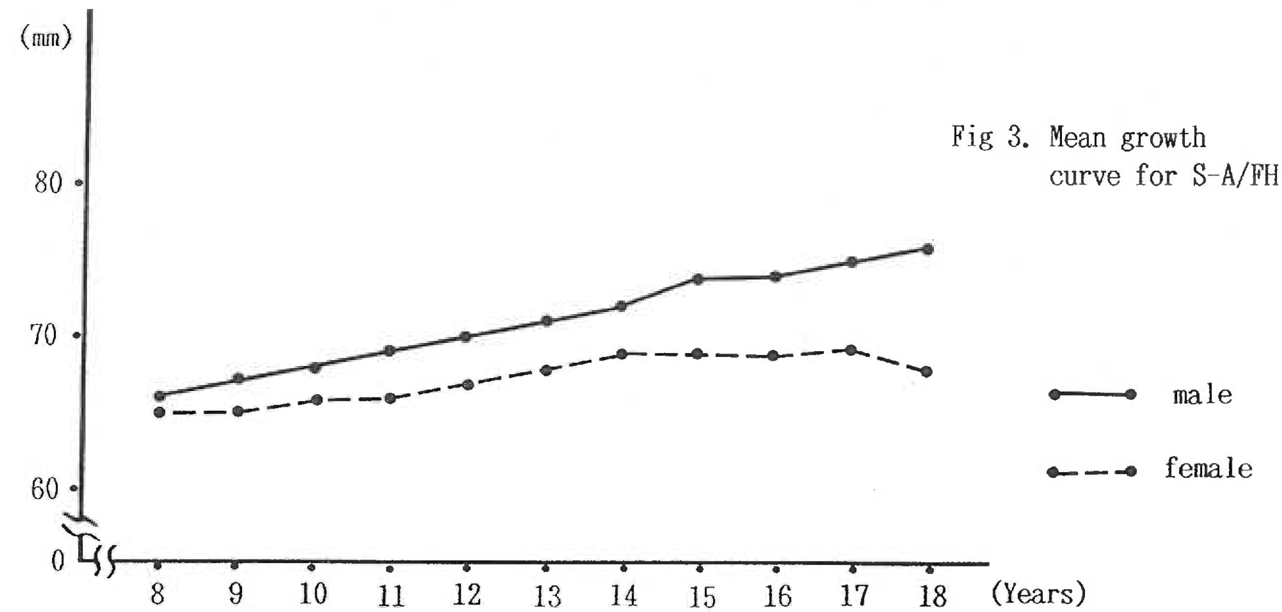


Fig 3. Mean growth curve for S-A/FH

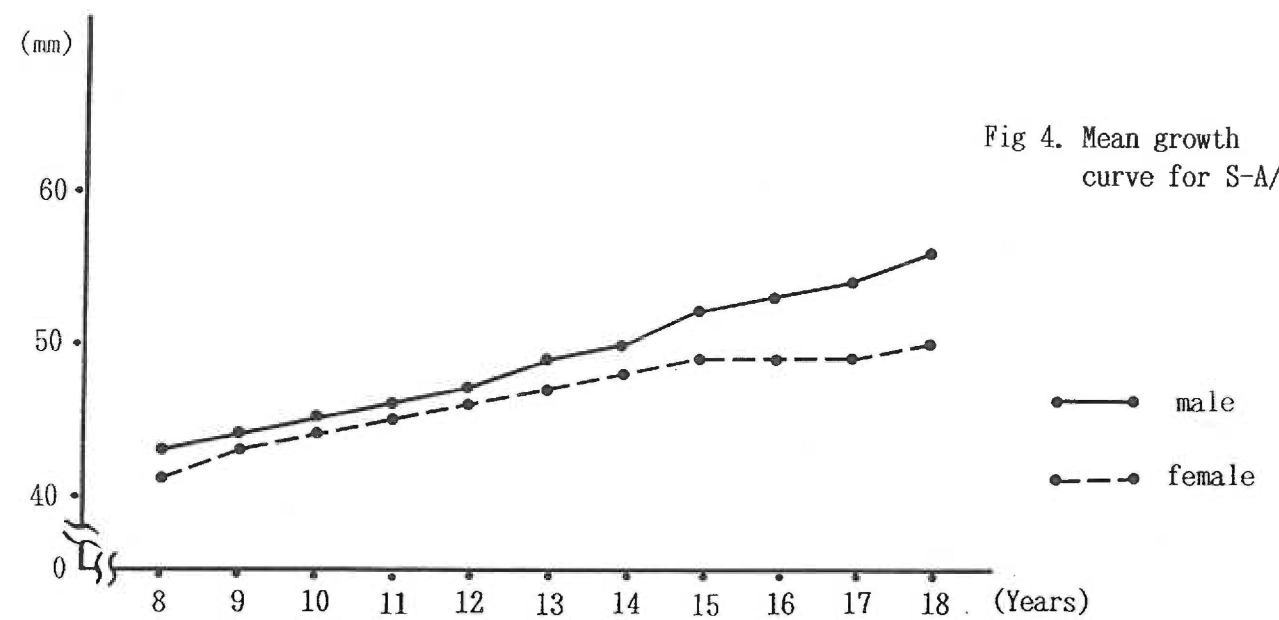


Fig 4. Mean growth curve for S-A/V

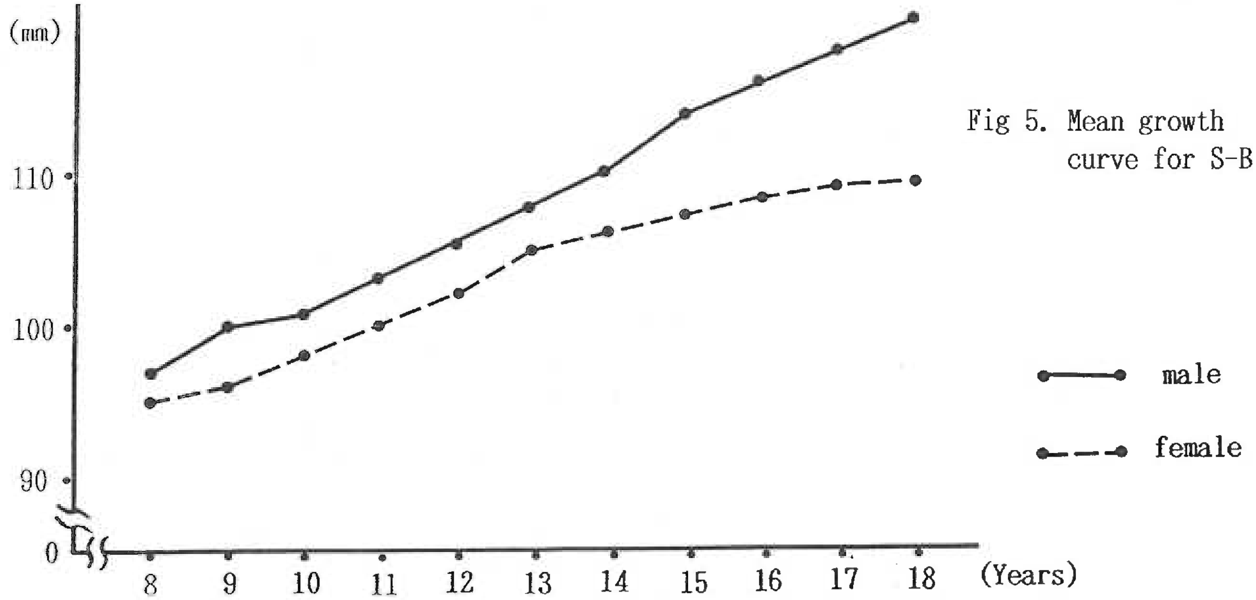


Fig 5. Mean growth curve for S-B

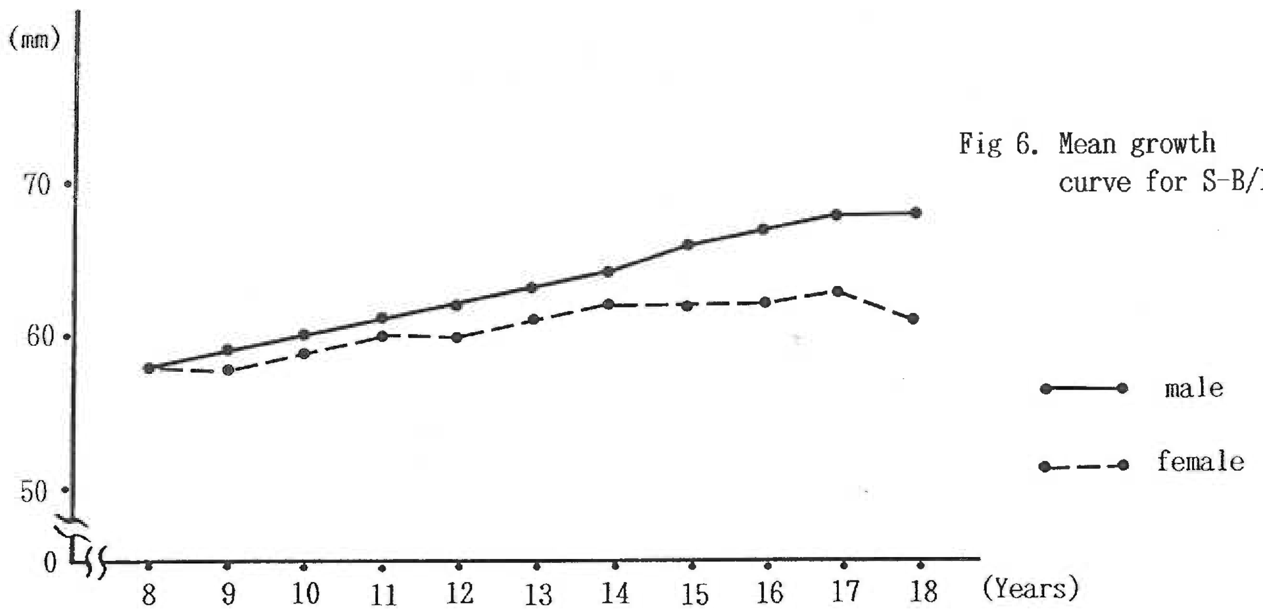


Fig 6. Mean growth curve for S-B/FH

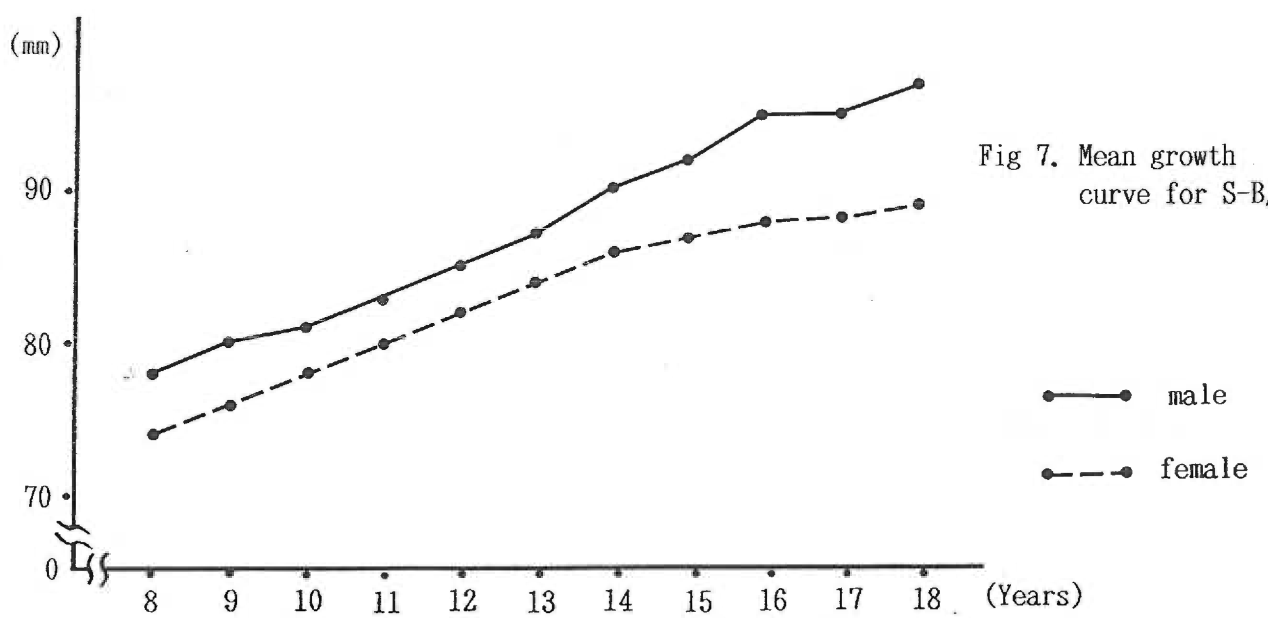


Fig 7. Mean growth curve for S-B/V

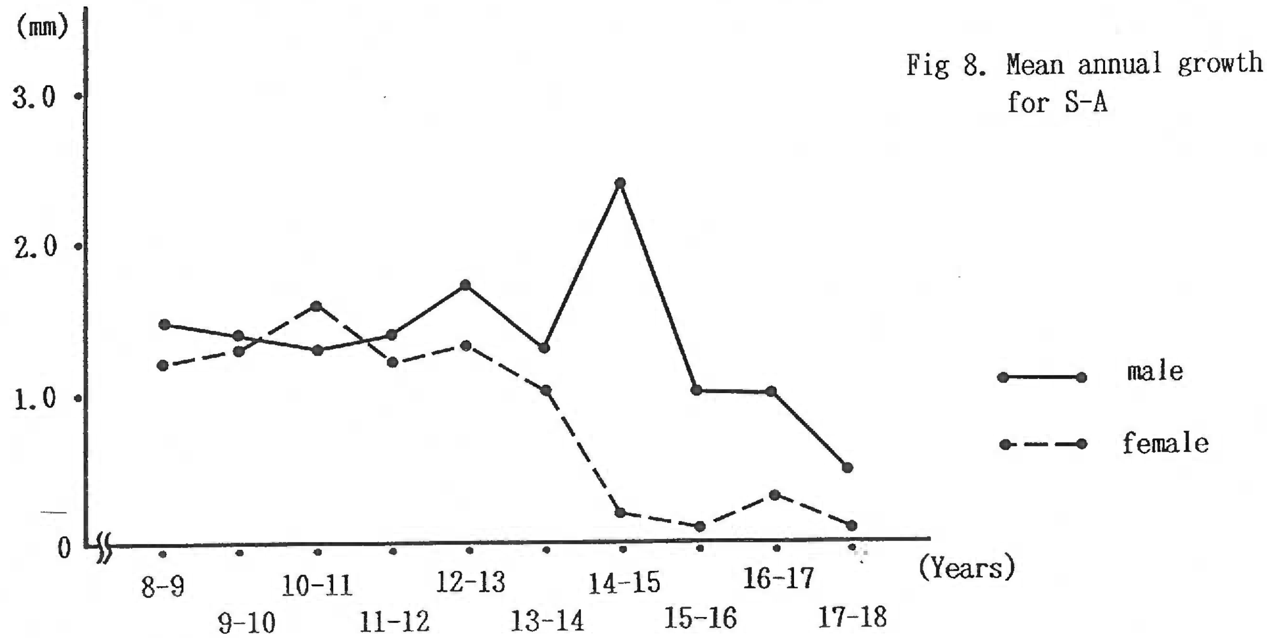


Fig 8. Mean annual growth for S-A

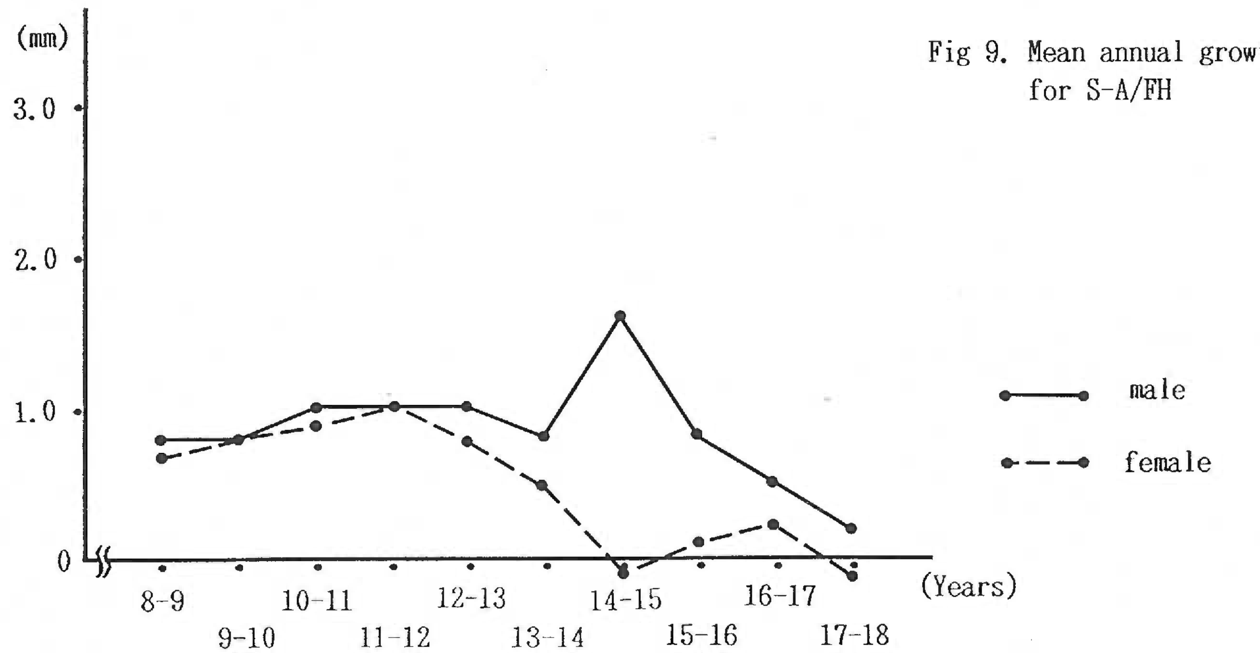


Fig 9. Mean annual growth for S-A/FH

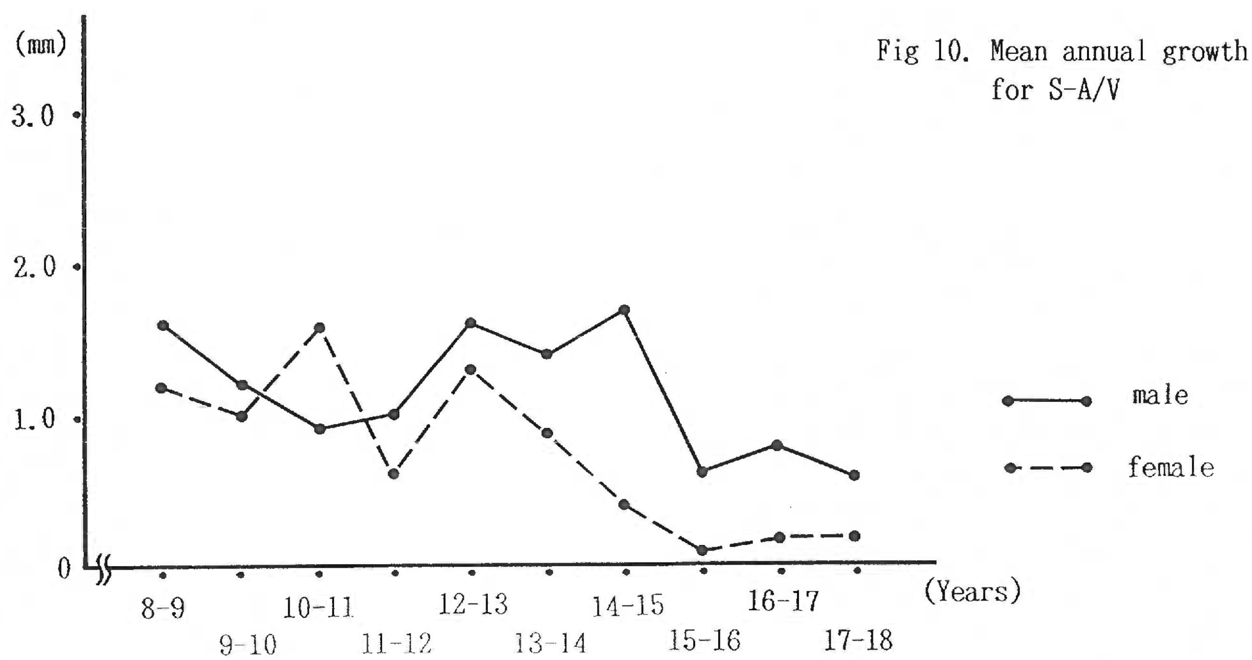


Fig 10. Mean annual growth for S-A/V

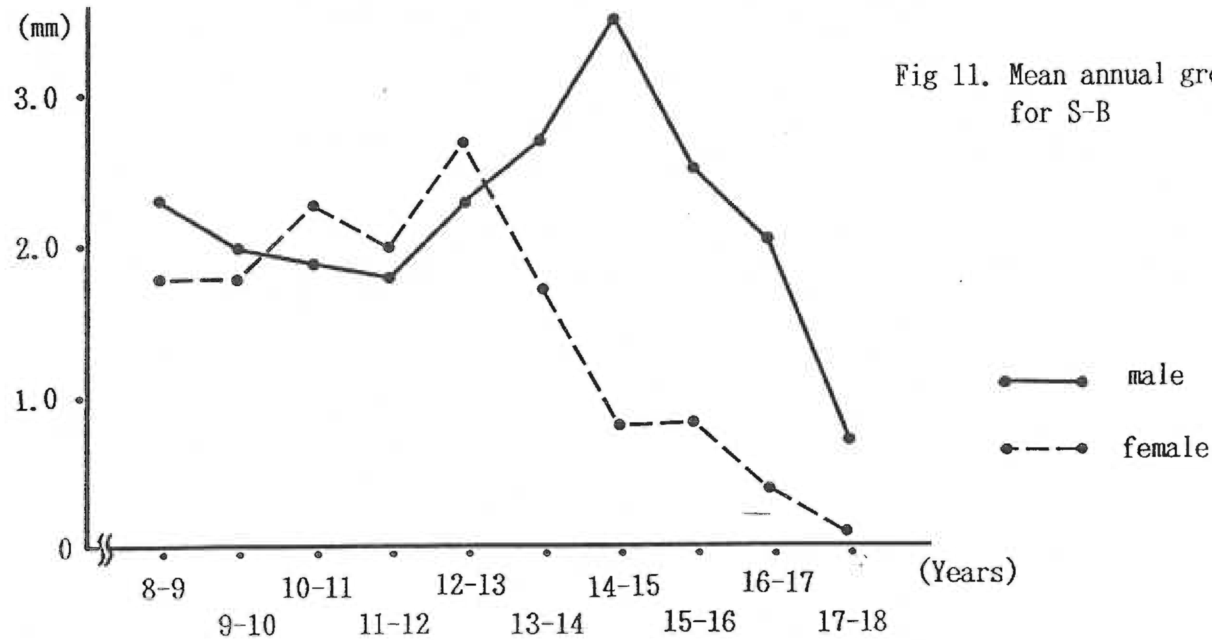


Fig 11. Mean annual growth for S-B

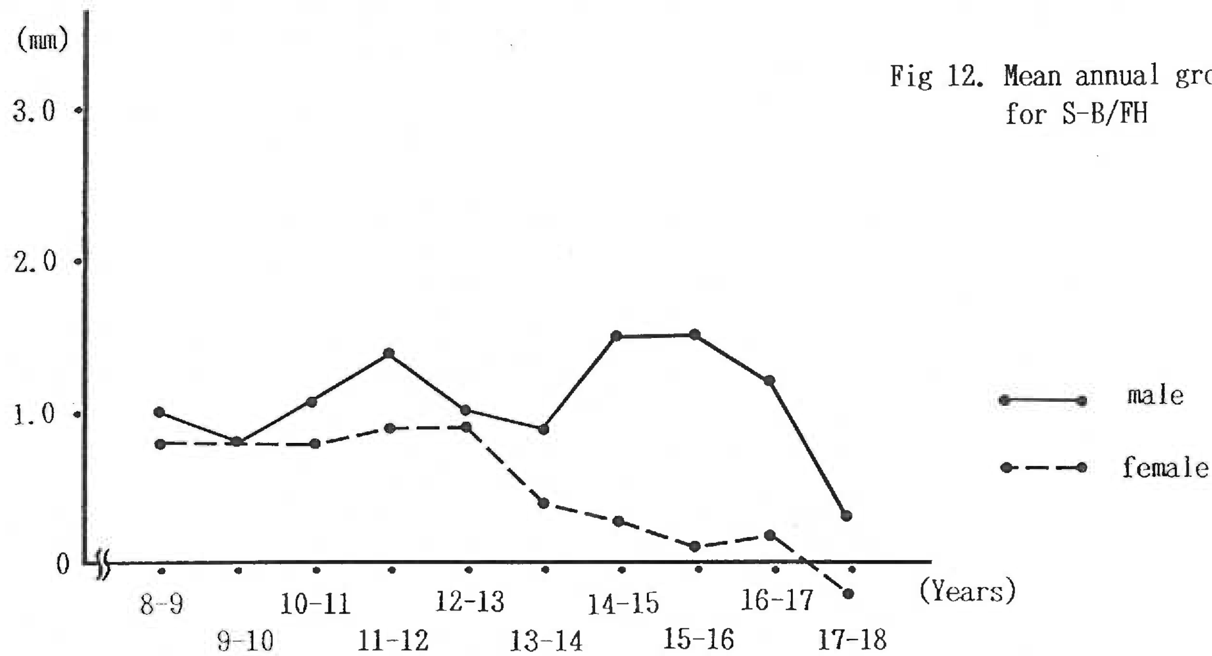


Fig 12. Mean annual growth for S-B/FH

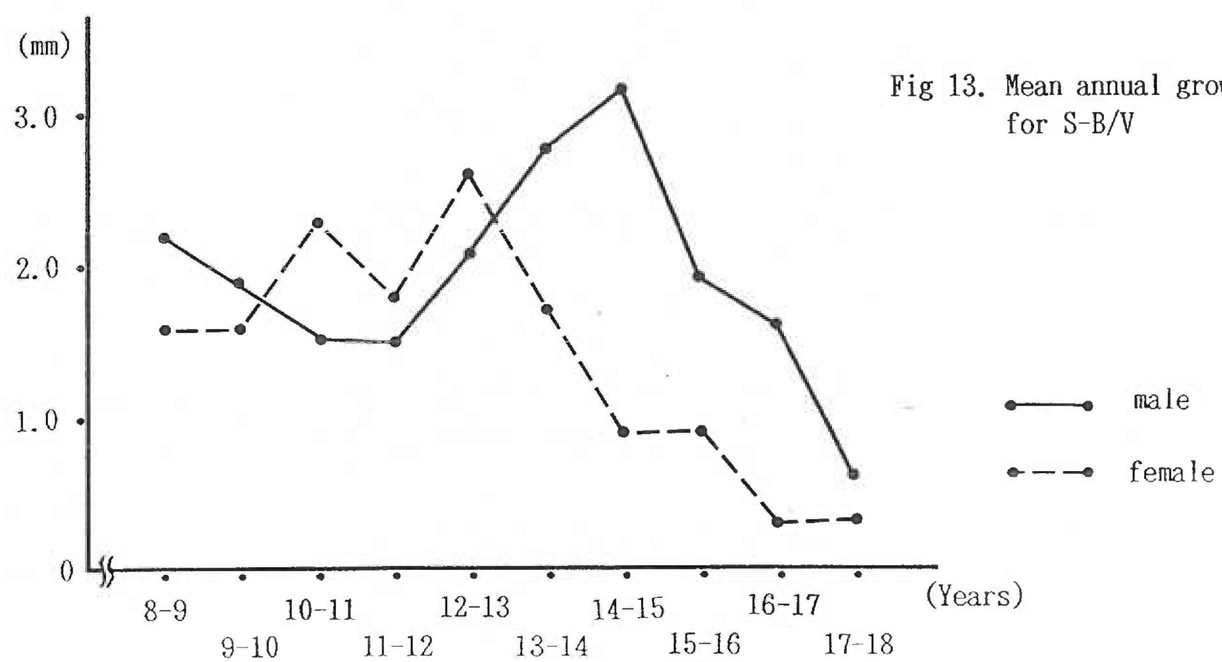


Fig 13. Mean annual growth for S-B/V

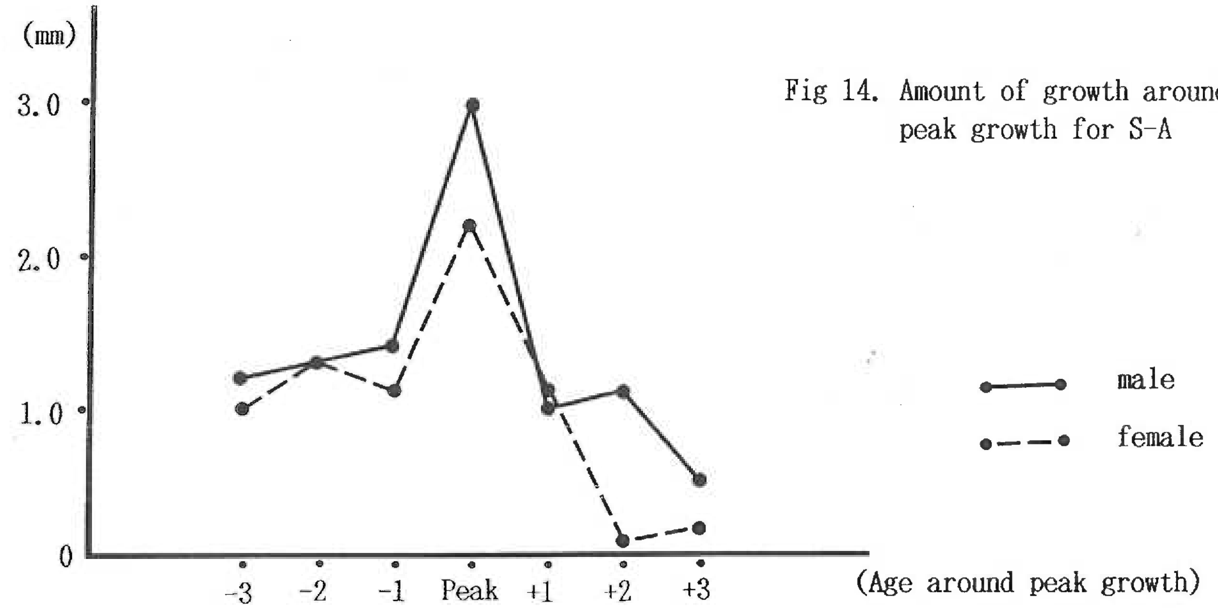


Fig 14. Amount of growth around peak growth for S-A

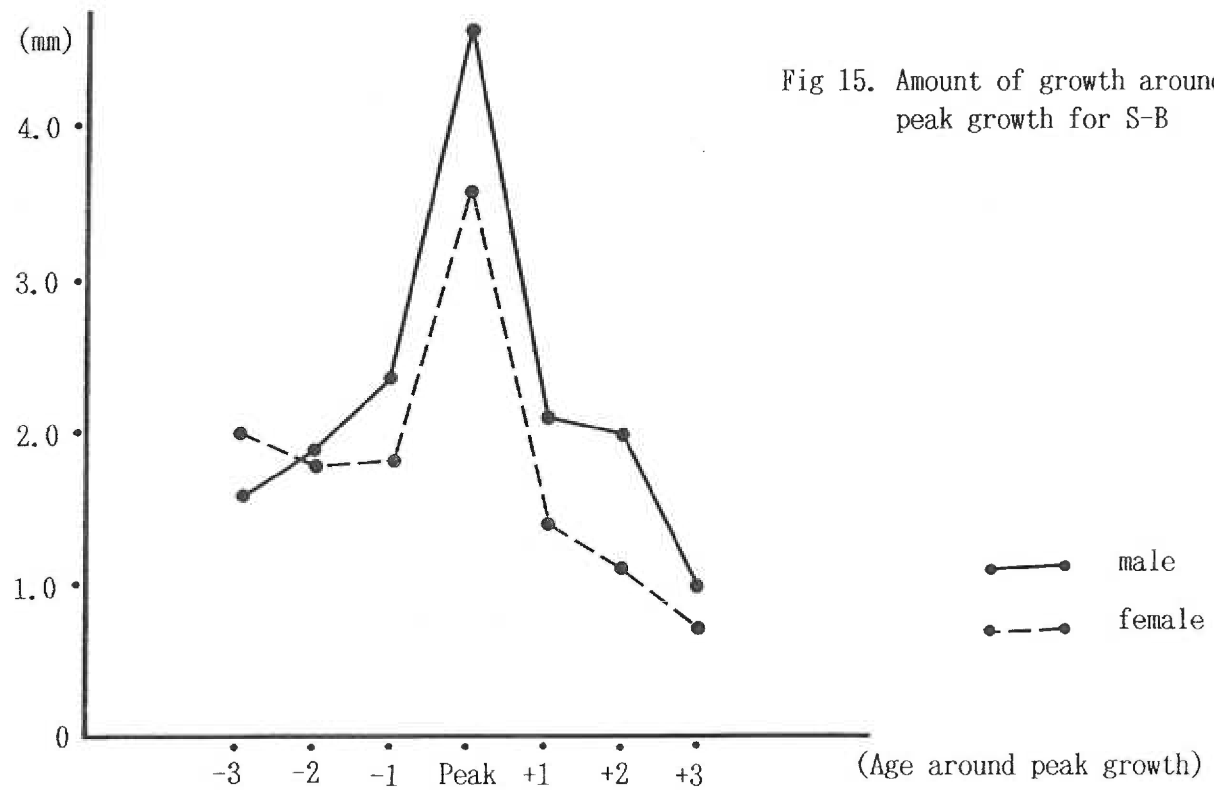


Fig 15. Amount of growth around peak growth for S-B

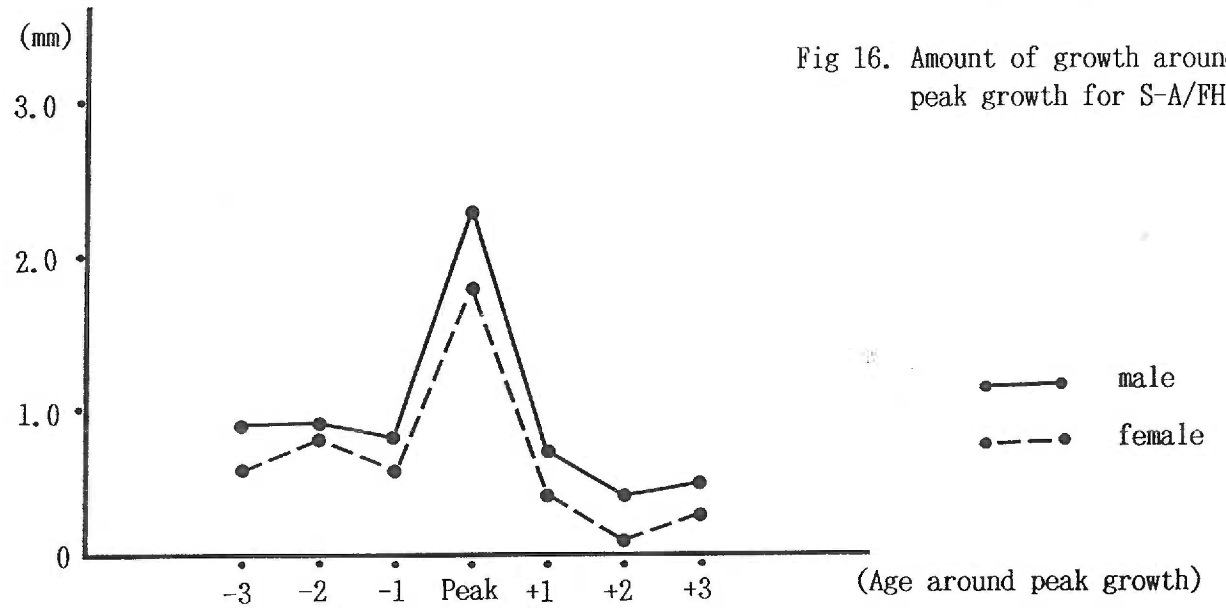


Fig 16. Amount of growth around peak growth for S-A/FH

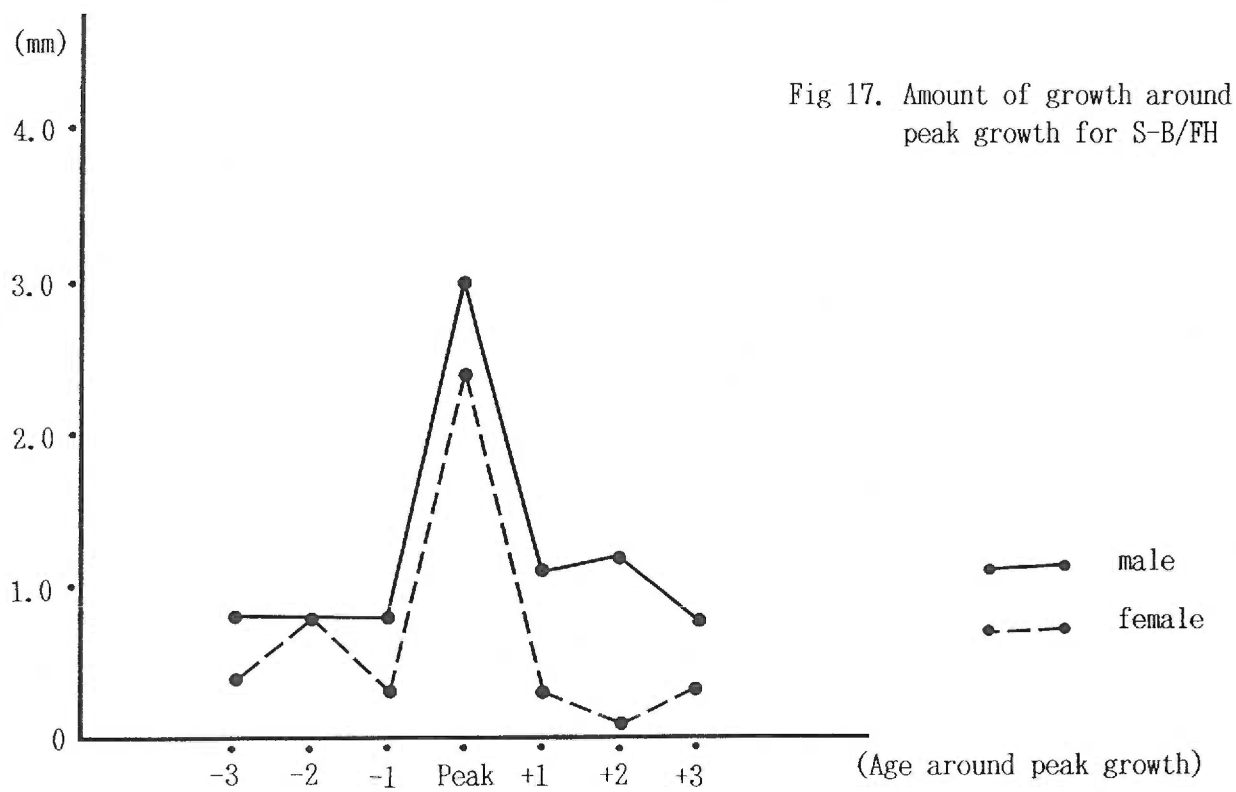


Fig 17. Amount of growth around peak growth for S-B/FH

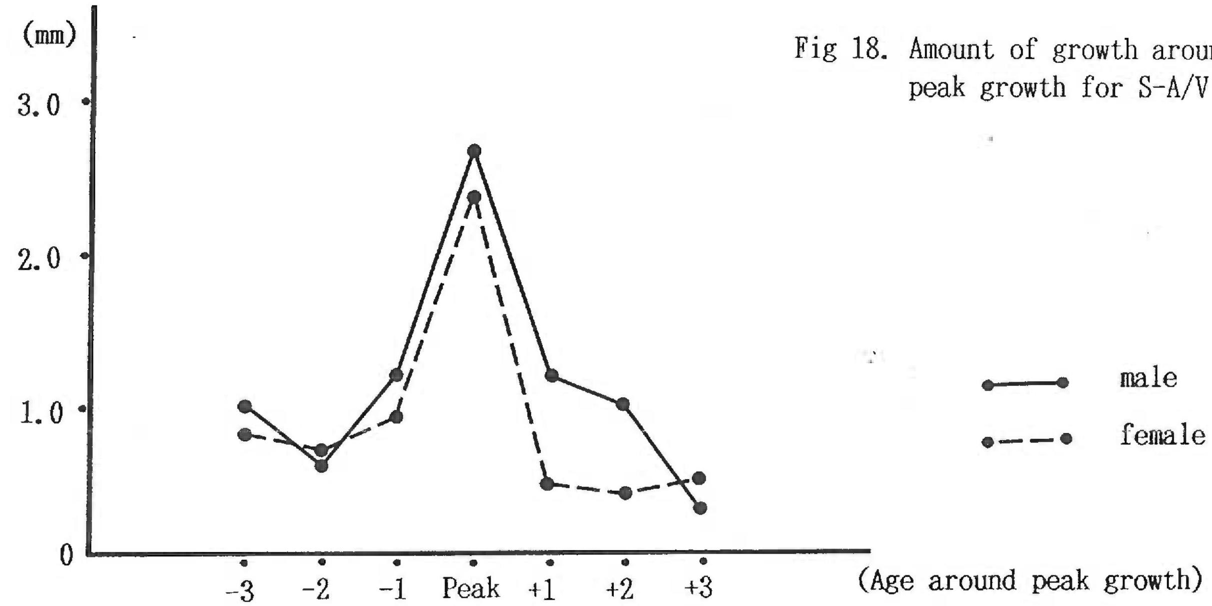


Fig 18. Amount of growth around peak growth for S-A/V

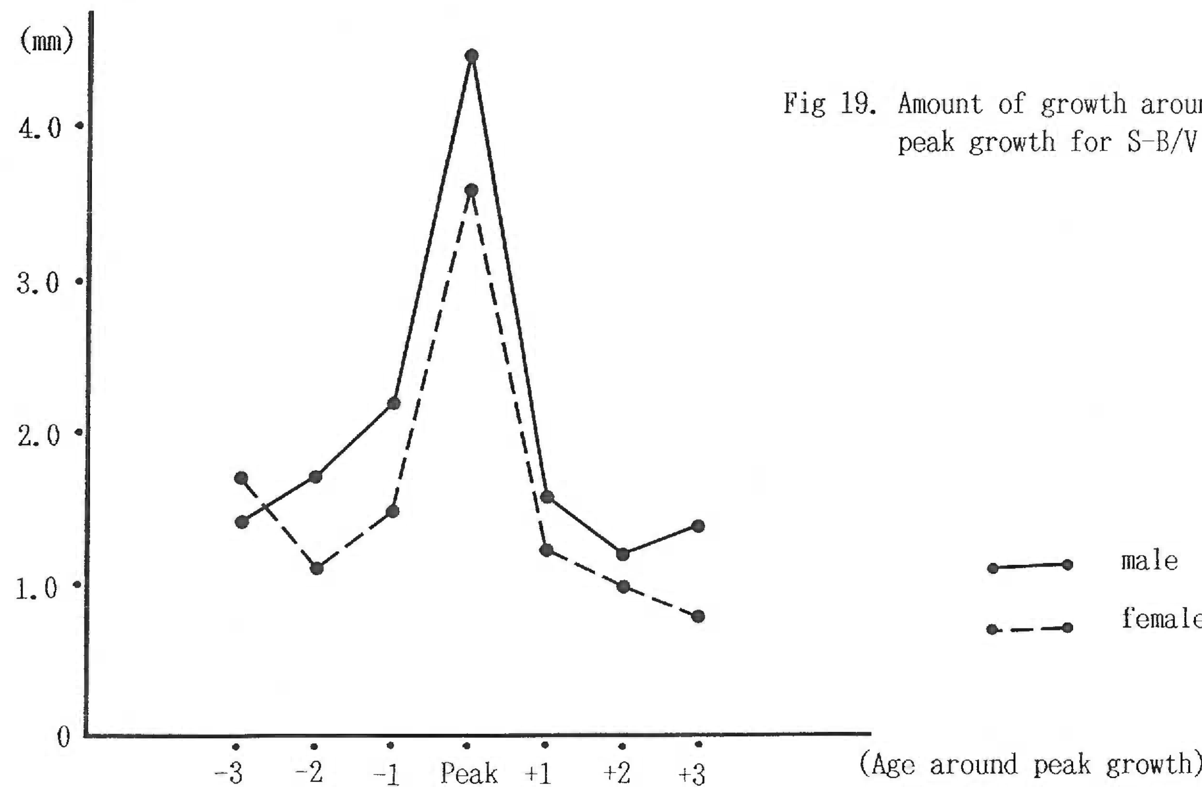


Fig 19. Amount of growth around peak growth for S-B/V

Table 1. Occlusions of the subjects

Variable	Male		Female	
	Number	Percentile	Number	Percentile
Normal	13	65	10	50
ClI crowding	5	25	8	40
ClI spacing	2	10	-	-
ClI crossbite	-	-	1	5
ClI sissorsbite	-	-	1	5

Table 2. Means and standard deviations of the 6 measurements in male (mm)

Age	S-A		S-A/FH		S-A/V	
	Mean	SD	Mean	SD	Mean	SD
8	79.4	3.5	66.1	4.1	43.4	5.7
9	80.9	3.7	67.4	3.8	44.2	5.9
10	81.7	3.4	67.8	3.7	45.2	5.8
11	83.4	3.9	69.2	3.6	46.1	6.0
12	84.8	4.2	70.0	3.7	47.5	6.2
13	86.5	4.3	71.0	3.9	49.1	6.3
14	88.0	4.5	71.8	4.1	50.5	6.2
15	90.2	4.8	73.8	4.5	51.7	6.3
16	91.3	4.6	74.3	4.5	52.7	6.4
17	92.3	4.4	74.9	4.5	53.6	6.5
18	94.6	4.3	75.8	4.6	56.3	6.2

Age	S-B		S-B/FH		S-B/V	
	Mean	SD	Mean	SD	Mean	SD
8	97.1	4.1	57.6	5.5	77.9	6.2
9	99.8	5.0	59.1	5.0	80.0	6.6
10	101.0	3.7	59.7	5.1	81.2	5.6
11	103.4	5.0	61.4	4.5	83.1	6.8
12	105.6	5.7	62.1	4.6	84.9	6.6
13	107.7	5.5	63.2	4.9	87.0	7.0
14	110.4	6.1	64.0	5.0	89.8	7.2
15	113.7	6.2	66.0	5.1	92.4	6.9
16	116.4	5.8	67.0	5.5	94.9	7.3
17	118.4	5.4	68.3	5.9	95.4	9.1
18	120.2	6.2	68.3	6.9	96.7	11.1

Table 3. Means and standard deviations of the 6 measurements in female (mm)

Age	S-A		S-A/FH		S-A/V	
	Mean	SD	Mean	SD	Mean	SD
8	76.8	3.2	64.6	2.9	41.2	5.0
9	77.6	3.4	64.6	3.6	42.7	5.1
10	78.9	3.6	65.5	3.9	43.7	5.0
11	80.6	3.7	66.4	3.8	45.3	5.1
12	81.8	4.0	67.5	4.0	45.9	5.2
13	83.2	4.0	68.3	4.0	47.2	5.3
14	84.2	3.7	68.8	3.8	48.2	5.5
15	84.3	3.8	68.7	4.0	48.6	5.5
16	84.6	3.8	68.7	4.0	49.1	4.9
17	84.8	3.9	69.5	3.5	48.5	5.3
18	84.7	4.2	68.4	3.9	49.7	5.7

Age	S-B		S-B/FH		S-B/V	
	Mean	SD	Mean	SD	Mean	SD
8	94.6	3.4	58.1	4.4	74.4	5.7
9	95.9	3.5	57.9	5.7	76.1	5.6
10	97.6	4.0	58.7	6.1	77.6	6.1
11	99.9	4.0	59.5	6.2	79.9	6.3
12	101.9	4.6	60.5	6.4	81.7	6.7
13	104.7	4.5	61.4	6.7	84.3	7.0
14	106.3	4.3	61.8	6.6	86.0	7.0
15	107.1	4.4	62.0	6.8	86.9	7.0
16	108.1	4.3	61.8	6.5	88.4	6.3
17	108.5	4.5	63.2	5.4	87.9	7.0
18	108.6	4.8	61.3	6.5	89.2	7.2

Table 4. Means and standard deviations of annual growth for 6 measurements in male (mm)

Age	S-A		S-A/FH		S-A/V	
	Mean	SD	Mean	SD	Mean	SD
8-9	1.5	0.6	0.8	0.7	1.6	1.1
9-10	1.4	0.7	0.8	0.6	1.2	0.9
10-11	1.3	0.3	1.0	0.8	0.9	0.7
11-12	1.4	0.7	1.0	0.8	1.0	0.8
12-13	1.7	0.8	1.0	0.6	1.6	1.2
13-14	1.3	0.8	0.8	0.7	1.4	0.8
14-15	2.4	0.7	1.6	0.9	1.7	0.9
15-16	1.0	1.0	0.8	1.1	0.6	0.9
16-17	1.0	0.7	0.5	0.6	0.8	1.0
17-18	0.5	0.5	0.2	0.8	0.6	0.7

Age	S-B		S-B/FH		S-B/V	
	Mean	SD	Mean	SD	Mean	SD
8-9	2.3	1.6	1.0	1.5	2.2	1.6
9-10	2.0	1.1	0.8	1.3	1.9	1.0
10-11	1.9	0.8	1.1	1.0	1.5	0.8
11-12	1.9	1.1	1.4	1.2	1.5	1.3
12-13	2.3	0.8	1.0	0.9	2.1	0.9
13-14	2.7	1.3	0.9	1.0	2.8	1.5
14-15	3.5	0.8	1.5	1.5	3.2	1.0
15-16	2.5	1.5	1.5	1.3	1.9	1.8
16-17	2.0	1.4	1.3	1.3	1.6	1.2
17-18	0.7	0.4	0.3	1.1	0.6	0.9

Table 5. Means and standard deviations of annual growth for 6 measurements in female (mm)

Age	S-A		S-A/FH		S-A/V	
	Mean	SD	Mean	SD	Mean	SD
8-9	1.2	0.8	0.7	0.9	1.2	1.0
9-10	1.3	0.6	0.8	0.8	1.0	0.8
10-11	1.6	0.6	0.9	0.7	1.6	0.8
11-12	1.2	0.8	1.0	0.8	0.6	0.8
12-13	1.3	0.6	0.8	0.4	1.3	0.7
13-14	1.0	0.8	0.5	0.8	0.9	0.9
14-15	0.2	0.5	-0.1	0.5	0.4	0.7
15-16	0.1	0.4	0.1	0.6	0.1	0.8
16-17	0.3	0.5	0.2	0.6	0.2	0.7
17-18	0.1	0.2	-0.1	0.4	0.2	0.7

Age	S-B		S-B/FH		S-B/V	
	Mean	SD	Mean	SD	Mean	SD
8-9	1.8	0.6	0.8	0.8	1.6	1.1
9-10	1.8	1.0	0.8	1.0	1.6	1.3
10-11	2.3	0.9	0.8	1.4	2.3	1.0
11-12	2.0	1.1	0.9	0.9	1.8	1.0
12-13	2.7	0.9	0.9	0.8	2.6	1.0
13-14	1.7	1.0	0.4	1.1	1.7	1.2
14-15	0.8	0.6	0.3	0.9	0.9	0.8
15-16	0.8	0.5	0.1	0.9	0.9	0.8
16-17	0.4	0.4	0.2	0.7	0.3	0.6
17-18	0.1	0.4	-0.2	0.6	0.3	0.6

Table 6. Means and standard deviations of A-B difference parallel to FH plane (mm)

Age	Male		Female	
	Mean	SD	Mean	SD
8	8.5	2.8	6.5	2.9
9	8.3	2.9	6.7	3.4
10	8.1	3.0	6.8	3.4
11	7.9	2.7	7.0	3.6
12	8.0	2.8	7.0	3.9
13	7.8	2.8	6.9	4.1
14	7.8	2.8	7.0	4.2
15	7.7	2.8	6.7	4.3
16	7.3	3.3	6.9	4.1
17	6.6	3.8	6.2	3.9
18	7.4	3.9	7.2	4.5

Table 7. Numbers and percentiles of the subjects that had the peak growth

Variable	Male		Female	
	Number	Percentile	Number	Percentile
S-A	13	65	11	55
S-A/FH	14	70	14	70
S-A/V	15	75	13	65
S-B	12	60	11	55
S-B/FH	13	65	8	40
S-B/V	12	60	13	65

Table 8. Mean ages and ranges of the peak adolescent growth (year)

Variable	Male		Female	
	Mean	Range	Mean	Range
S-A	13.7	11.5-15.5	12.2	10.5-13.5
S-A/FH	14.6	13.5-16.5	11.9	9.5-13.5
S-A/V	13.4	12.5-15.5	12.0	9.5-14.5
S-B	14.2	11.5-15.5	12.2	9.5-13.5
S-B/FH	14.4	11.5-16.5	12.1	10.5-14.5
S-B/V	14.3	11.5-15.5	12.0	9.5-13.5

Table 9. Means and standard deviations of maximum growth and annual growth around peak adolecent growth in male (mm)

Age around peak growth	S-A		S-A/FH		S-A/V	
	Mean	SD	Mean	SD	Mean	SD
-3	1.2	0.8	0.9	0.8	1.0	0.9
-2	1.3	0.8	0.9	0.7	0.6	0.7
-1	1.4	0.6	0.8	0.5	1.2	0.8
Peak	3.0	0.7	2.3	0.6	2.7	0.6
+1	1.0	0.9	0.7	0.8	1.2	0.8
+2	1.1	0.7	0.4	0.6	1.0	1.0
+3	0.5	1.1	0.5	0.6	0.3	0.6

Age around peak growth	S-B		S-B/FH		S-B/V	
	Mean	SD	Mean	SD	Mean	SD
-3	1.6	0.7	0.8	1.1	1.4	1.1
-2	1.9	1.0	0.8	0.8	1.7	1.1
-1	2.4	1.0	0.8	1.0	2.2	1.3
Peak	4.7	0.7	3.0	0.7	4.5	0.8
+1	2.1	0.9	1.1	0.8	1.6	1.3
+2	2.0	0.9	1.2	1.1	1.2	0.9
+3	1.0	1.0	0.8	1.4	1.4	1.3

Table 10. Means and standard deviations of maximum growth and annual growth around peak adolecent growth in female (mm)

Age around peak growth	S-A		S-A/FH		S-A/V	
	Mean	SD	Mean	SD	Mean	SD
-3	1.0	0.5	0.6	0.6	0.8	0.5
-2	1.3	0.6	0.8	0.7	0.7	0.8
-1	1.1	0.6	0.6	0.6	0.9	0.7
Peak	2.2	0.3	1.8	0.5	2.4	0.6
+1	1.1	0.7	0.4	0.8	0.5	0.7
+2	0.1	0.7	0.1	0.9	0.4	0.9
+3	0.2	0.6	0.3	0.6	0.5	1.0

Age around peak growth	S-B		S-B/FH		S-B/V	
	Mean	SD	Mean	SD	Mean	SD
-3	2.0	1.1	0.4	1.2	1.7	1.3
-2	1.8	1.3	0.8	0.8	1.1	1.0
-1	1.8	1.0	0.3	1.3	1.5	1.0
Peak	3.6	0.3	2.4	0.3	3.6	0.7
+1	1.4	1.1	0.3	0.9	1.2	1.0
+2	1.1	0.9	0.1	1.1	1.0	1.0
+3	0.7	0.4	0.3	1.0	0.8	0.8

Table 11. Growth directions in male (degree)

Variable	8 - 18 year		8 year - Peak		Peak - 18 year	
	Mean	Range	Mean	Range	Mean	Range
S-A	52.1	38-78	53.8	41-75	37.8	-78-85
S-B	61.3	48-81	48.8	-74-77	55.4	37-85

Table 12. Growth directions in female (degree)

Variable	8 - 18 year		8 year - Peak		Peak - 18 year	
	Mean	Range	Mean	Range	Mean	Range
S-A	55.9	30-78	55.5	15-85	65.2	37-80
S-B	59.6	-81-79	54.4	-15-84	69.6	58-81

Table 13. Statistical differences between sexes for 6 measurements (T-tests)

Age	S-A	S-A/FH	S-A/V	S-B	S-B/FH	S-B/V
8	*	NS	NS	NS	NS	NS
9	*	*	NS	*	NS	NS
10	*	NS	NS	*	NS	NS
11	*	NS	NS	*	NS	NS
12	*	NS	NS	NS	NS	NS
13	*	NS	NS	NS	NS	NS
14	*	*	NS	*	NS	NS
15	**	**	NS	**	NS	*
16	**	**	NS	**	*	**
17	**	**	*	**	*	**
18	**	**	**	**	**	*

NS : no significant difference * : $p<0.05$ ** : $p<0.01$

Table 14. Summary of ANOVA between ages for annual growth of S-A in male

Source	SS	df	MS	F
Total	123.0	159		
Between Subjects	7.5	19		
Within Subjects	115.5	140		
Treatments	27.4	7	3.91	5.92**
Error	88.1	133	0.66	

** : p<0.01

Table 15. Summary of ANOVA between ages for annual growth of S-A/FH in male

Source	SS	df	MS	F
Total	106.7	159		
Between Subjects	9.0	19		
Within Subjects	97.7	140		
Treatments	14.0	7	2.00	3.17**
Error	83.7	133	0.63	

** : p<0.01

Table 16. Summary of ANOVA between ages for annual growth of S-A/V in male

Source	SS	df	MS	F
Total	150.9	159		
Between Subjects	9.6	19		
Within Subjects	141.3	140		
Treatments	22.5	7	3.21	3.61**
Error	118.8	133	0.89	

** : p<0.01

Table 17. Summary of ANOVA between ages for annual growth of S-B in male

Source	SS	df	MS	F
Total	236.8	159		
Between Subjects	10.9	19		
Within Subjects	225.9	140		
Treatments	41.4	7	5.91	4.28**
Error	184.5	133	1.38	

** : $p<0.01$

Table 18. Summary of ANOVA between ages for annual growth of S-B/FH in male

Source	SS	df	MS	F
Total	217.4	159		
Between Subjects	28.8	19		
Within Subjects	188.6	140		
Treatments	9.9	7	1.41	1.05^{NS}
Error	178.7	133	1.34	

NS : No significant difference

Table 19. Summary of ANOVA between ages for annual growth of S-B/V in male

Source	SS	df	MS	F
Total	279.5	159		
Between Subjects	20.9	19		
Within Subjects	258.6	140		
Treatments	54.0	7	7.71	5.04**
Error	204.6	133	1.53	

** : $p<0.01$

Table 20. Summary of ANOVA between ages for annual growth of S-A in female

Source	SS	df	MS	F
Total	105.5	159		
Between Subjects	0.5	19		
Within Subjects	105.0	140		
Treatments	49.3	7	7.04	16.76**
Error	55.7	133	0.42	

** : $p<0.01$

Table 21. Summary of ANOVA between ages for annual growth of S-A/FH in female

Source	SS	df	MS	F
Total	90.9	159		
Between Subjects	6.2	19		
Within Subjects	84.7	140		
Treatments	25.3	7	3.61	8.02**
Error	59.4	133	0.45	

** : $p<0.01$

Table 22. Summary of ANOVA between ages for annual growth of S-A/V in female

Source	SS	df	MS	F
Total	132.2	159		
Between Subjects	3.2	19		
Within Subjects	129.0	140		
Treatments	39.5	7	5.64	8.42**
Error	89.5	133	0.67	

** : $p<0.01$

Table 23. Summary of ANOVA between ages for annual growth of S-B in female

Source	SS	df	MS	F
Total	194.5	159		
Between Subjects	10.5	19		
Within Subjects	184.0	140		
Treatments	92.0	7	13.14	19.04**
Error	92.0	133	0.69	

** : p<0.01

Table 24. Summary of ANOVA between ages for annual growth of S-B/FH in female

Source	SS	df	MS	F
Total	160.2	159		
Between Subjects	11.3	19		
Within Subjects	148.9	140		
Treatments	15.3	7	2.19	2.19*
Error	133.6	133	1.00	

* : p<0.05

Table 25. Summary of ANOVA between ages for annual growth of S-B/V in female

Source	SS	df	MS	F
Total	229.1	159		
Between Subjects	18.3	19		
Within Subjects	210.8	140		
Treatments	81.6	7	11.66	12.02**
Error	129.2	133	0.97	

** : p<0.01

Table 26. Statistical differences between ages for annual growth of S-A in male (Scheffé tests)

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17
9-10		NS	NS	NS	NS	**	*	**
10-11			NS	**	NS	**	NS	NS
11-12				*	NS	**	NS	*
12-13					*	**	**	**
13-14						**	NS	*
14-15							**	**
15-16								NS
16-17								

NS : no significant difference * : $p<0.05$ ** : $p<0.01$

Table 27. Statistical differences between ages for annual growth of S-A in female (Scheffé tests)

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17
9-10		*	NS	NS	*	**	**	**
10-11			**	*	**	**	**	**
11-12				NS	NS	**	**	**
12-13					**	**	**	**
13-14						**	**	**
14-15							NS	NS
15-16								NS
16-17								

NS : no significant difference * : $p<0.05$ ** : $p<0.01$

Table 28. Statistical differences between ages for annual growth of S-A/FH in male (Scheffé tests)

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17
9-10		NS	NS	NS	NS	**	NS	NS
10-11			NS	NS	NS	**	NS	**
11-12				NS	NS	**	NS	**
12-13					NS	**	NS	**
13-14						**	NS	NS
14-15							**	**
15-16								NS
16-17								

NS : no significant difference   * : p<0.05   ** : p<0.01

Table 29. Statistical differences between ages for annual growth of S-A/FH in female (Scheffé tests)

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17
9-10		NS	NS	NS	NS	**	**	**
10-11			NS	NS	**	**	**	**
11-12				NS	**	**	**	**
12-13					NS	**	**	**
13-14						**	**	*
14-15							NS	*
15-16								NS
16-17								

NS : no significant difference   * : p<0.05   ** : p<0.01

Table 30. Statistical differences between ages for annual growth of S-A/V in male (Scheffé tests)

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17
9-10		NS	NS	*	NS	*	**	NS
10-11			NS	**	**	**	NS	NS
11-12				**	*	**	NS	NS
12-13					NS	NS	**	**
13-14						NS	**	**
14-15							**	**
15-16								NS
16-17								

NS : no significant difference * : p<0.05 ** : p<0.01

Table 31. Statistical differences between ages for annual growth of S-A/V in female (Scheffé tests)

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17
9-10		**	*	NS	NS	**	**	**
10-11			**	NS	**	**	**	**
11-12				**	NS	NS	**	*
12-13					*	**	**	**
13-14						**	**	**
14-15							*	NS
15-16								NS
16-17								

NS : no significant difference * : p<0.05 ** : p<0.01

Table 32. Statistical differences between ages for annual growth of S-B in male (Scheffé tests)

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17
9-10		NS	NS	NS	**	**	NS	NS
10-11			NS	NS	**	**	NS	NS
11-12				NS	**	**	*	NS
12-13					NS	**	NS	NS
13-14						**	NS	*
14-15							**	**
15-16								NS
16-17								

NS : no significant difference * : $p<0.05$ ** : $p<0.01$

Table 33. Statistical differences between ages for annual growth of S-B in female (Scheffé tests)

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17
9-10		**	NS	**	NS	**	**	**
10-11			NS	*	**	**	**	**
11-12				**	NS	**	**	**
12-13					**	**	**	**
13-14						**	**	**
14-15							NS	NS
15-16								NS
16-17								

NS : no significant difference * : $p<0.05$ ** : $p<0.01$

Statistical differences between ages for annual growth of S-B/FH in male (Scheffé tests)

No significant difference in ANOVA

Table 34. Statistical differences between ages for annual growth of S-B/FH in female (Scheffé tests)

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17
9-10		NS	NS	NS	NS	*	**	**
10-11			NS	NS	NS	NS	**	**
11-12				NS	*	**	**	**
12-13					*	**	**	**
13-14						NS	NS	NS
14-15							NS	NS
15-16								NS
16-17								

NS : no significant difference   * : $p<0.05$ ** : $p<0.01$

Table 35. Statistical differences between ages for annual growth of S-B/V in male (Scheffé tests)

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17
9-10		NS	NS	NS	**	**	NS	NS
10-11			NS	*	**	**	NS	NS
11-12				*	**	**	NS	NS
12-13					**	**	NS	NS
13-14						NS	**	**
14-15							**	**
15-16								NS
16-17								

NS : no significant difference * : p<0.05 ** : p<0.01

Table 36. Statistical differences between ages for annual growth of S-B/V in female (Scheffé tests)

	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17
9-10		**	NS	**	NS	**	**	**
10-11			*	NS	**	**	**	**
11-12				**	NS	**	**	**
12-13					**	**	**	**
13-14						**	**	**
14-15							NS	**
15-16								**
16-17								

NS : no significant difference * : p<0.05 ** : p<0.01

Table 37. Summary of ANOVA between ages for measurements of A-B/FH in male

Source	SS	df	MS	F
Total	1233.8	152		
Between Subjects	991.7	16		
Within Subjects	242.1	136		
Treatments	29.4	8	3.68	2.22^{NS}
Error	212.7	128	1.66	

NS : No significant difference

Table 38. Summary of ANOVA between ages for measurements of A-B/FH in female

Source	SS	df	MS	F
Total	1878.6	161		
Between Subjects	1776.0	17		
Within Subjects	102.6	144		
Treatments	4.5	8	0.56	0.77^{NS}
Error	98.1	136	0.72	

NS : No significant difference