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# Velocity Growth Pattern of Skinfold Thicknesses in Term Symmetric and Asymmetric Small for Gestational Age Infants

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## ABSTRACT

The pattern of velocity growth of triceps, sub-scapular, biceps, mid-axillary and anterior thigh skinfold thickness (SFT) was studied amongst full-term, small for gestational age (SGA); 100 symmetric SGA and 100 asymmetric SGA infants. One hundred appropriate for gestational age (AGA) infants served as controls. All babies were measured at 1, 3, 6, 9 & 12 months in Growth Clinic/Laboratory of Advanced Pediatrics Center, PGIMER, Chandigarh. Ponderal Index (PI) was used to categorize SGA babies into symmetric SGA (PI≥2.2g/cm$^3$) and asymmetric SGA (PI<2.2 g/cm$^3$). Mean (SD) growth velocities for each skinfold thickness at every age was computed using Tanner's 1951 method. Intra-group (symmetric vs. asymmetric), inter-group (SGA vs. AGA) and gender differences were quantified using Mann-Whitney-U test. Growth velocity amongst both male and female symmetric and asymmetric SGA as well as AGA infants showed sharp increase between 1-3 months whereafter, it declined. The higher rate of growth for all skinfold thicknesses recorded amongst symmetric and asymmetric SGA infants of the two sexes as compared to their AGA counterparts confirm a tendency of SGA babies to accumulate more fat than the latter during infancy. Relatively, greater rate of sub-cutaneous tissue accumulation for different skinfolds in symmetric SGA than the asymmetric ones suggests that symmetric infants may become overweight/obese, beyond infancy.

**Key Words:** AGA, Growth velocity, Infancy, Mixed-Longitudinal, SGA, Skinfold thickness, Sub-cutaneous fat

## INTRODUCTION

Growth velocity is a valid measure of determining current potential of a child to grow within two consecutive time intervals hence, also of immense importance to Pediatricians, Nutritionists, Auxologists and Public Health practitioners who are responsible for ensuring proper growth, nutrition and overall health of children. In view of this, it becomes imperative to have insight into the velocity growth dynamics of different body parameters of children growing under variety of environmental, socio-economic, nutritional and other conditions and constraints. Inspection of growth velocity related data revealed that children who grow rapidly during initial years of life tend to become overweight/ obese later on. However, such information mostly pertains to those children who had normal gestation and birth weight.

Small for Gestational age (SGA) refers to a neonate with birth weight below 10th percentile of gestational age and sex of the reference standards (Bakketeig 1998). SGA infants are classified into symmetrical and asymmetrical types depending on severity and timing of insult (Gruenwald 1974, Villar & Belizan 1982). Inhibiting factors which operate early in pregnancy (first trimester) result in birth of a symmetrically growth retarded baby whereas, a late pregnancy insult results into birth of an asymmetric SGA infant (Black et al 2013, Clayton et al 2007). Symmetric and asymmetric SGA infants have different implications for postnatal growth and survival (Kaur et al 2017). Epidemiologic studies reveal that children born as SGA accumulate more of sub-cutaneous fat and develop obesity later (Crume et al 2014, Gallo et al 2016, Hong & Chung 2018). While, some studies have suggested that SGA infants remain lighter and have less body fat (Kuhle et al 2017, Kramer et al 2014). However, there is no information on the pattern of velocity growth of SGA infants in terms of skinfold thicknesses which are universally used to assess extent of adiposity for clinical and research purposes. Utility of skinfold measurements to estimate body fat stores in adolescents, children and neonates (Frisancho et al 1971, Miller & Hassanein 1971) is well recognized. Non-availability of velocity related information on auxological pattern of sub-cutaneous fat measured anthropometrically in terms of skinfold thicknesses amongst full-term symmetric and asymmetric SGA infants of Indian origin has prompted us to undertake this serial study.

## MATERIALS & METHODS

Two hundred SGA babies born at full-term (Symmetric SGA: male 50, female 50; Asymmetric SGA: male 50, female 50) and 100 (male 50, female 50) appropriate for gestational age (AGA) in the labor room of Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh, India comprised sample for this mixed-longitudinal study. Infants having birth weight within $10^{th}$ to $90^{th}$ percentile of intrauterine growth curves (Lubchenco et al 1963) were considered as AGA, while those weighing less than $10^{th}$ percentile at birth as SGA. Using Ponderal Index (PI) SGA babies were classified as symmetric SGA (PI $\geq$ 2.2 g/cm$^3$) and asymmetric SGA (PI < 2.2 g/cm$^3$) (Miller & Hassanein 1971). The study protocol was approved by the 'Department Review Board' as well as the 'Institutional Ethics Committee' of PGIMER, Chandigarh. Enrolment of babies in the study was made after obtaining informed written consent of at least one of the parents of every child. Other necessary information regarding immunization, dietary intake and other relevant health related details of the sample subjects have already been published elsewhere (Kaur et al 2012, Kaur et al 2017).

Triceps, sub-scapular, biceps, mid-axillary and anterior thigh skinfold thicknesses were measured for every child using Harpenden's Skinfold Caliper (Make: Holtain Limited, Crymych, UK, Least count: 0.2mm) using standardized techniques (Tanner and Whitehouse 1975, Lohmann 1988). Intra/inter observer error for each skinfold thickness was ±0.2mm. Intraclass correlation coefficient and Cronbach's alpha was applied to see the reliability of inter and intra observer error for 10% of data, which was found to be $\geq$ .7 (that meant there were no measurement errors). Every child was measured at 1 month (±3 days), 3, 6, 9 and at 12 months (±15 days) using mixed-longitudinal design of studying human growth. Each measurement was taken by the trained anthropometrist (HK) in Growth Clinic as well as Growth Laboratory of the Child Growth & Anthropology Unit, Department of Pediatrics, PGIMER, Chandigarh, India on pre-appointed date and time. Babies who did not report for follow-up on the prescribed date were examined in their homes.

### Statistical Analysis

Mean and standard deviation (SD) were computed for different skinfold thicknesses of male and female symmetric SGA, asymmetric SGA and AGA babies at each age level as per statistical method given by Tanner (1951), which is highly efficacious in computing distance and velocity related information from mixed-longitudinally gathered data on growing children. Mann-Whitney U test was used to evaluate magnitude of intra-group (symmetric vs. asymmetric), inter-group (SGA vs. AGA) and gender differences for velocity growth attainments. A p-value less than 0.05 was considered as statistically significant.

## RESULTS

The symmetric SGA, asymmetric SGA and AGA male and female babies enrolled were born to the parents representing upper middle to upper high socio-economic strata (Aggarwal et al 2005) and belonged to north-western regions of India, of whom 48.6% belonged to the state of Punjab, 18.3% to Haryana, 13.7% to Himachal Pradesh, 9.8% to Uttar Pradesh, 4.6% to the Union Territory of Chandigarh, 2.7% to Uttaranchal, and 2.3% from the state of Rajasthan.

Breast feeding amongst all SGA and AGA babies was initiated within 24 hours of birth. By 3 months, 72% of SGA and 87% of AGA babies were exclusively breast fed and its proportion declined to 32.5% and 46% in SGA and AGA respectively, by 6 months. Though bottle feeding was discouraged yet, 37% of the mothers continued with it at some of the age levels. Semi solid food items were introduced around 5 months of age in majority of the subjects. However, mothers of 3 babies did not give semi solid food items until one year of age, despite repeated advice.

The mean (SD) computed for triceps, sub-scapular, biceps, mid-axillary and anterior thigh SFTs growth velocity among symmetric SGA, asymmetric SGA and AGA infants are shown in Tables 1, 2 & Figures 1 to 5.

## DISCUSSION

The changes that occur in any growing child can only be revealed if growth is seen as a varying continuum. “Growth velocity” refers to the varying rate of growth with age and is considered useful to detect abnormal changes and evaluate individuals in terms of changes in growth velocity and its response to therapy (Gibson 2005).

Owing to a high degree of variability associated with different measures of skinfold thicknesses of growing children it becomes, difficult to characterize their pattern of velocity growth. Growth velocity in general, measured maximum for all the measures of sub-cutaneous fat i.e. triceps, sub-scapular, biceps, mid-axillary and anterior thigh skinfold thicknesses between 1 to 3 months followed by a smoother fall between 3 to 6 months amongst both SGA & AGA infants. However, steepness of this fall was recorded to be maximum for mid-axillary (lateral-thoracic) skinfold thickness (Fig 4) followed by sub-scapular skinfold thickness (Fig 2), revealing that deceleration of fat is relatively higher in truncal as compared to peripheral (i.e. appendicular) region. Whereafter, our all study subjects continued to deplete fat as is evident from negative values recorded for all the skinfolds (Figs 1-5). This shows that after birth, infants irrespective of their being born either as SGA or AGA in general, have tendency to lose fat from 2 months onwards until the end of the first year of life. However, magnitude of this decrease remained variable for different skinfold thicknesses.

The velocity growth curves of symmetric SGA infants in general, ran above those plotted for asymmetric SGA infants between 1-6 months after that, these traversed below in respect of triceps and biceps skinfold thickness (Fig 1 & 3). However, the magnitude of this differential never became statistically significant (Table 2). Growth velocity for sub-scapular skinfold thickness in symmetric SGA male infants remained higher than their asymmetric peers throughout first year of life (Fig 2). While, female symmetric SGA infants did so between 1-3 months. Greater velocity for mid-axillary skinfold thickness was observed amongst symmetric SGA male (3-6 & 9-12 months) and female (1-3 & 6-9 months) infants as compared to asymmetric ones. The rate of growth for anterior-thigh skinfold thickness was found to be more amongst asymmetric SGA male and female infants as compared to symmetric SGA infants barring 3-6 months in male infants and 1-3 months in female babies amongst whom the curves plotted for symmetric SGA infants ran above those of the asymmetric SGA infants (Fig 5). The magnitude of intra-group (symmetric SGA vs. asymmetric SGA) difference became statistically significant ($p \leq 0.01$) amongst male SGA infants favoring asymmetric ones (Table 2).

Comparison of different skinfold thicknesses measured amongst two types of SGA with AGA infants of the same sex does not reveal any clear trend. At some age intervals two types of SGA infant depict higher rate of growth for skinfold thicknesses while, at other age intervals AGA infants showed higher attainments. The continuously altered pattern of fat accumulation in SGA infants reported by Ratnasingham et al (2017) corroborates our findings. A phenomenon of catch-up growth in fat noticed amongst SGA babies born thinner who, rapidly caught up with AGA peers also support our findings (Yoshikama et al 2010). These authors reported that triceps, biceps and subscapular skinfolds in SGA infants being thinner at birth caught up to AGA infants within 1 month, which supported existence of rapid postnatal catch-up fat phenomenon in SGA infants. Modi et al (2006) reported that SGA infants had less adipose tissue than AGA infants at birth; by 6 weeks of age, adipose tissue distribution did not differ between AGA and SGA infants. However, the tendency of our symmetric SGA babies to accumulate more fat than their asymmetric SGA counterparts may have postnatal health related consequences hence, needs to be viewed from standpoint of the "fetal origin of adult disease hypothesis" proposed by Barker (1995, 2006). High prevalence of hypertension, cardiovascular and cerebrovascular disease and non-insulin dependent diabetes mellitus (Type II) among SGA infants during adulthood reported by earlier researchers (Hales & Barker 1992, Phipps et al 1993) calls for long term follow-up of two sub-types of SGA infants in the context of Indian circumstances.

**Conflict of Interest:** None

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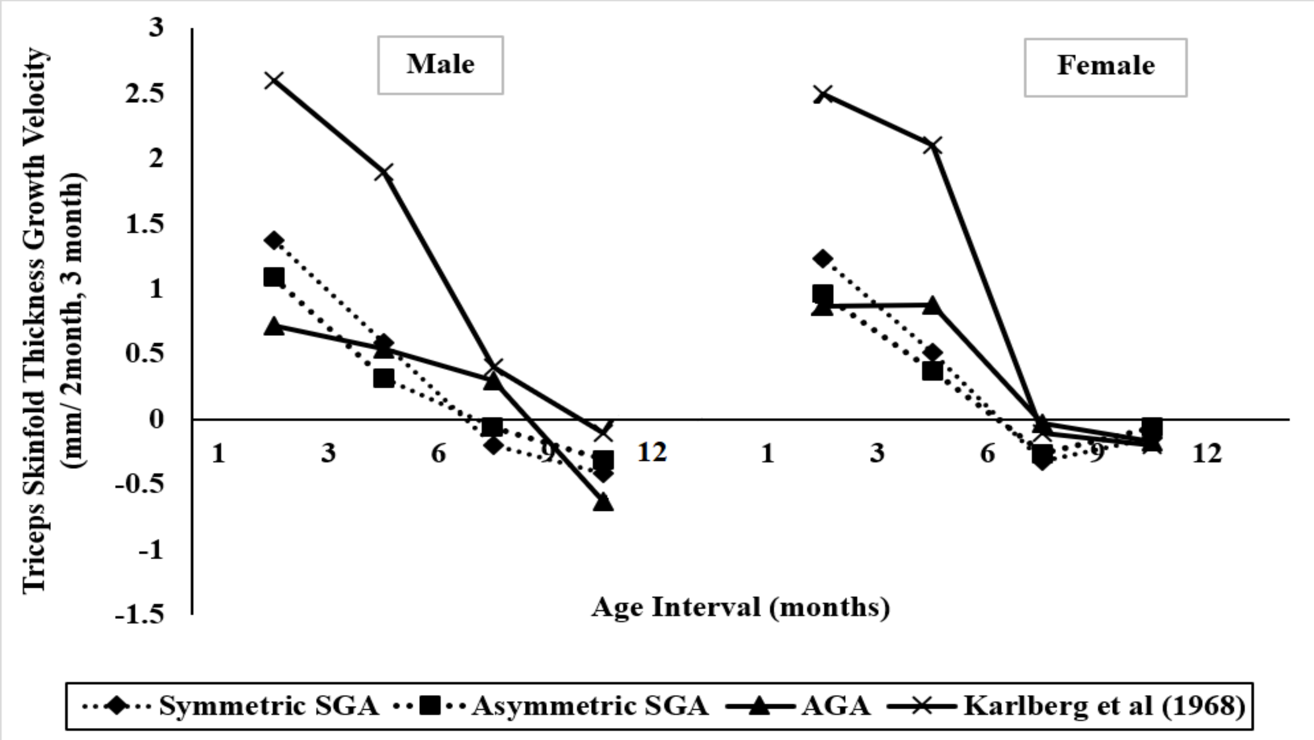
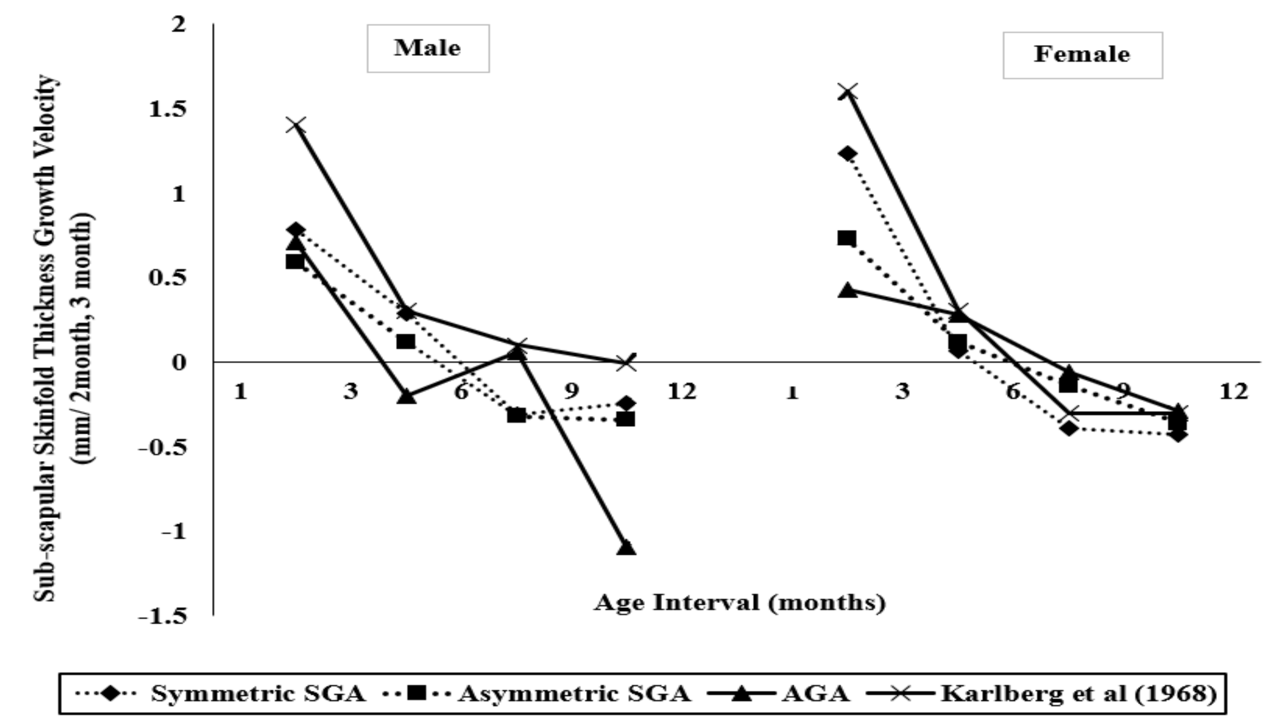
**Fig 1: Comparison of Triceps Skinfold Thickness Growth Velocity˜ of Male & Female Symmetric SGA, Asymmetric SGA, AGA and Normal Infants**



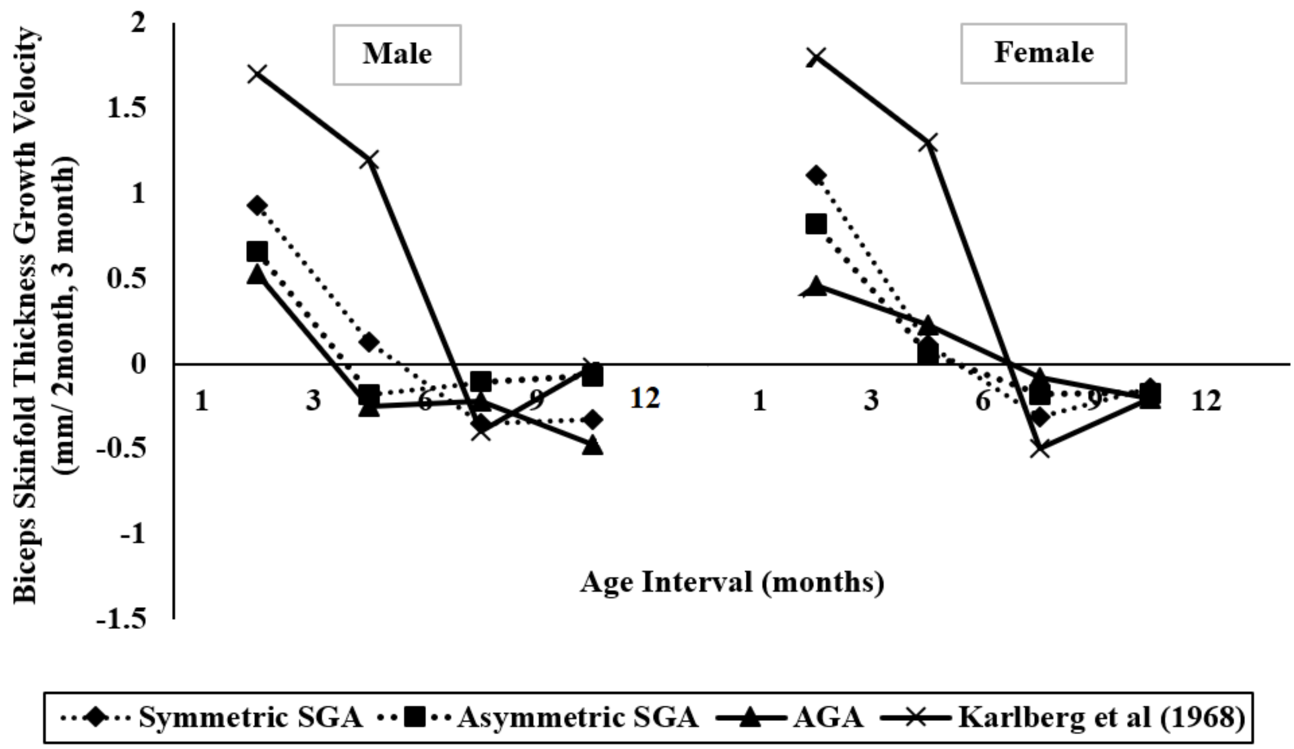

˜ Velocity: 1 to 3 month (mm/ 2 month), 3 to 6, 6 to 9 & 9 to 12 (mm/ 3 month)

**Fig 2: Comparison of Sub-Scapular Skinfold Thickness Growth Velocity˜ of Male & Female Symmetric SGA, Asymmetric SGA, AGA and Normal Infants**



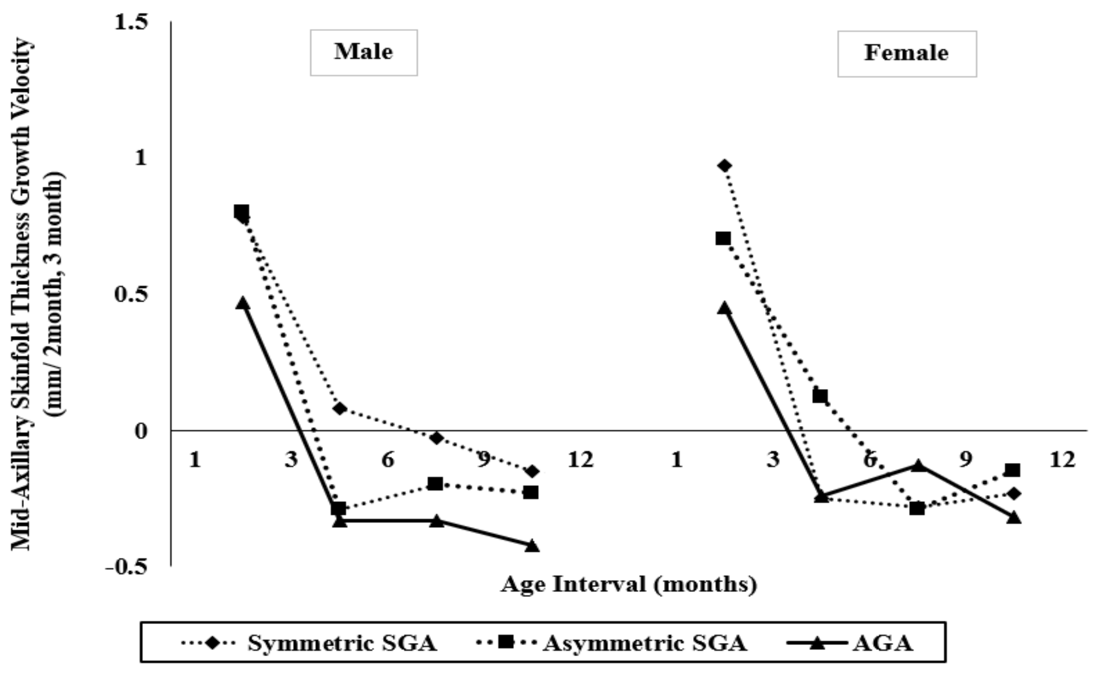

˜ Velocity: 1 to 3 month (mm/ 2 month), 3 to 6, 6 to 9 & 9 to 12 (mm/ 3 month)

**Fig 3: Comparison of Biceps Skinfold Thickness Growth Velocity˝ of Male & Female Symmetric SGA, Asymmetric SGA, AGA and Normal Infants**



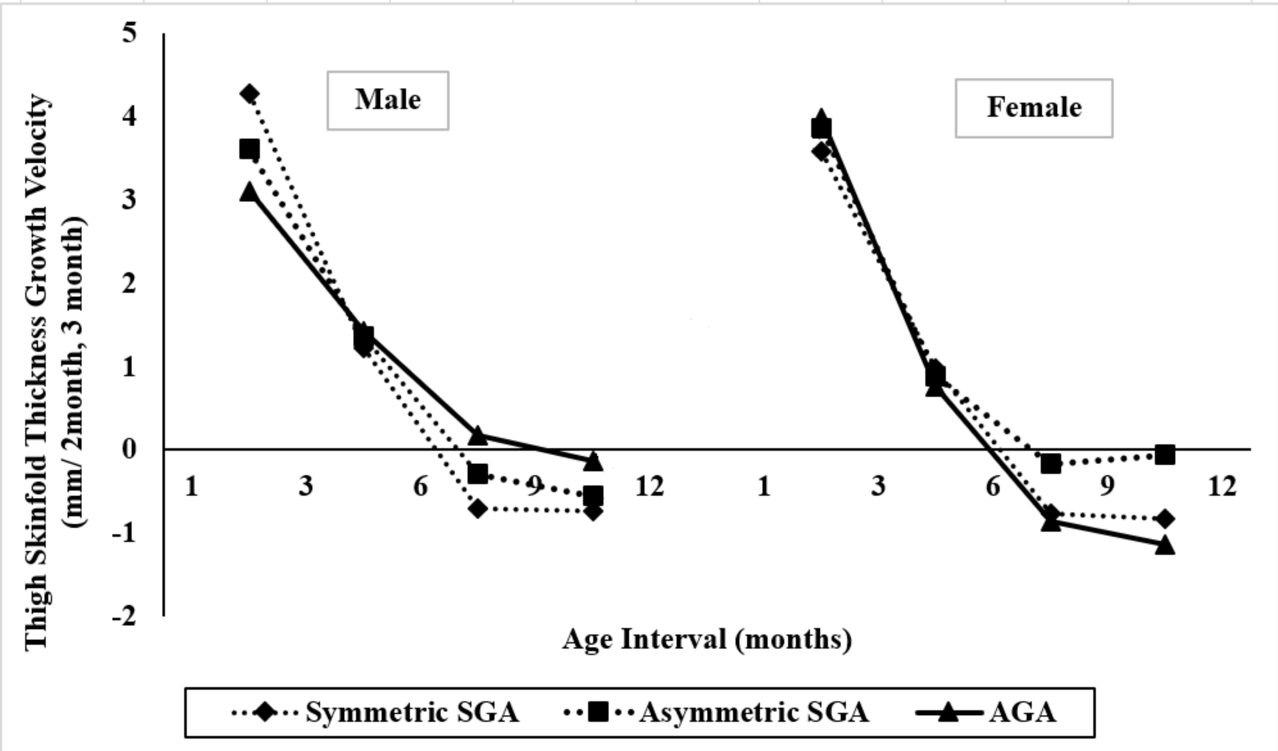

˝ Velocity: 1 to 3 month (mm/ 2 month), 3 to 6, 6 to 9 & 9 to 12 (mm/ 3 month)

**Fig 4: Comparison of Mid-axillary Skinfold Thickness Growth Velocity˝ of Male & Female Symmetric SGA, Asymmetric SGA and AGA Infants**




˝ Velocity: 1 to 3 month (mm/ 2 month), 3 to 6, 6 to 9 & 9 to 12 (mm/ 3 month)

**Fig 5: Comparison of Thigh (anterior) Skinfold Thickness Growth Velocity˝ of Male & Female Symmetric SGA, Asymmetric SGA and AGA Infants**




˝ Velocity: 1 to 3 month (mm/ 2 month), 3 to 6, 6 to 9 & 9 to 12 (mm/ 3 month)

**Table 1: Mean (SD) and Gender Differences for Skinfold Thickness Growth Velocity˝ of Male & Female Symmetric SGA, Asymmetric SGA and AGA Infants**

| Age Interval (mo) | Triceps SFT | | | Biceps SFT | | |
|---|---|---|---|---|---|---|
| | Sym.SGA | Asym. SGA | AGA | Sym. SGA | Asym. SGA | AGA |
| | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** |
| **Male** | | | | | | |
| 1-3 | 1.37 (1.56) | 1.09 (1.32) | 0.74 (1.59) | 0.93 (0.95) | 0.66 (1.00) | 0.53 (1.33) |
| 3-6 | 0.59 (0.88) | 0.32 (1.00) | 0.54 (1.59) | 0.13 (0.97) | -0.18 (0.91) | -0.25 (1.60) |
| 6-9 | -0.20 (0.73) | -0.06 (0.95) | 0.30 (1.02) | -0.35 (1.07) | -0.11 (1.06) | -0.22 (1.23) |
| 9-12 | -0.41 (0.97) | -0.31 (0.84) | -0.63 (1.12) | -0.33 (0.67) | -0.07 (1.02) | -0.47 (0.83) |
| **Female** | | | | | | |
| 1-3 | 1.23 (1.68) | 0.96 (0.87) | 0.87 (1.03) | 1.11 (1.22) | 0.82 (0.75) | 0.46 (0.86) |
| 3-6 | 0.51 (1.22) | 0.37 (0.74) | 0.88 (1.19) | 0.11 (1.15) | 0.06 (0.95) | 0.23 (1.15) |
| 6-9 | -0.32 (1.17) | -0.26 (0.95) | -0.03 (1.19) | -0.31 (1.09) | -0.18 (0.91) | -0.08 (1.19) |
| 9-12 | -0.14 (0.88) | -0.06 (0.66) | -0.17 (0.87) | -0.14 (0.96) | -0.17 (0.67) | 0.20 (0.46) |
| **Gender Differences (t-values)** | | | | | | |
| 1-3 | 0.347 | 0.000 | 1.259 | 0.497 | 1.138 | 0.734 |
| 3-6 | 0.203 | 0.797 | 1.098 | 0.775 | 1.457 | 1.290 |
| 6-9 | 0.186 | 1.921 | 1.116 | 0.261 | 1.702 | 1.135 |
| 9-12 | 0.674 | 0.298 | 1.864 | 0.221 | 0.088 | 1.948* |

| Age Interval (mo) | Sub-scapular SFT | | | Mid-axillary SFT | | |
|---|---|---|---|---|---|---|
| | Sym. SGA | Asym. SGA | AGA | Sym. SGA | Asym. SGA | AGA |
| | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** |
| **Male** | | | | | | |
| 1-3 | 0.78 (0.96) | 0.59 (1.09) | 0.71 (1.10) | 0.78 (0.92) | 0.80 (0.88) | 0.47 (0.84) |
| 3-6 | 0.29 (0.83) | 0.12 (0.75) | -0.20 (1.36) | 0.08 (0.84) | -0.29 (1.03) | -0.33 (0.93) |
| 6-9 | -0.31 (0.76) | -0.32 (0.82) | 0.06 (1.08) | -0.33 (0.99) | -0.20 (0.84) | -0.33 (0.74) |
| 9-12 | -0.24 (0.67) | -0.34 (0.82) | -1.09 (1.35) | -0.15 (0.42) | -0.23 (0.53) | -0.42 (0.85) |
| **Female** | | | | | | |
| 1-3 | 1.23 (1.68) | 0.73 (0.83) | 0.43 (0.93) | 0.97 (1.16) | 0.70 (0.60) | 0.45 (1.09) |
| 3-6 | 0.07 (1.14) | 0.12 (0.77) | 0.28 (1.07) | -0.25 (0.92) | 0.12 (0.67) | -0.24 (0.86) |
| 6-9 | -0.39 (0.73) | -0.14 (0.77) | -0.06 (0.85) | -0.28 (0.54) | -0.29 (0.63) | -0.13 (0.89) |
| 9-12 | -0.43 (0.77) | -0.36 (0.54) | -0.29 (0.59) | -0.23 (0.75) | -0.15 (0.34) | -0.32 (0.76) |
| **Gender Differences (t-values)** | | | | | | |
| 1-3 | 0.980 | 0.701 | 1.080 | 0.679 | 0.339 | 0.109 |
| 3-6 | 0.722 | 0.052 | 2.106* | 1.800 | 2.060* | 0.373 |
| 6-9 | 0.533 | 0.176 | 0.319 | 0.382 | 0.957 | 1.434 |
| 9-12 | 1.534 | 0.577 | 3.353*** | 0.828 | 0.554 | 1.817 |

| Age Interval (mo) | Thigh (anterior) SFT | | |
|---|---|---|---|
| | Sym. SGA | Asym. SGA | AGA |
| | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** |
| **Male** | | | |
| 1-3 | 3.59 (2.26) | 3.86 (2.26) | 3.99 (1.[illegible]3) |
| 3-6 | 0.98 (1.43) | 0.88 (1.42) | 0.07 (2.[illegible]7) |
| 6-9 | -0.77 (1.29) | -0.17 (1.85) | -0.86 (1.[illegible]6) |
| 9-12 | -0.83 (1.24) | -0.06 (1.32) | -1.14 (2.[illegible]1) |
| **Female** | | | |
| 1-3 | 4.28 (3.08) | 3.61 (1.93) | 3.11 (2.2[illegible]) |
| 3-6 | 1.23 (1.58) | 1.36 (1.21) | 1.42 (1.[illegible]2) |
| 6-9 | -0.71 (1.73) | -0.29 (1.32) | 0.18 (2.1[illegible]) |
| 9-12 | -0.74 (1.44) | -0.55 (1.04) | -0.13 (1.9[illegible]) |
| **Gender Differences (t-values)** | | | |
| 1-3 | 0.892 | 0.653 | 2.499** |
| 3-6 | 0.798 | 1.351 | 2.964** |
| 6-9 | 0.569 | 0.941 | 2.549** |
| 9-12 | 0.125 | 2.200 | 2.389* |

***p≤0.05, **p≤0.01, ***p≤0.001, df= n-2 Sym= Symmetric SGA, Asym= Asymmetric SGA**

˝Velocity: 1 to 3 month (mm/ 2 month), 3 to 6, 6 to 9 & 9 to 12 (mm/ 3 month)

**Table 2: Inter-group (Asymmetric SGA vs AGA, Symmetric SGA vs AGA) & Intra-group (Symmetric SGA vs Asymmetric SGA) Differences for Skinfold Thickness Growth Velocity˝ of Male & Female Symmetric SGA, Asymmetric SGA and AGA Infants**

| Age-Interval (mo) | Triceps SFT | | | Biceps SFT | | | Sub-scapular SFT | | | Mid-axillary SFT | | | Thigh (anterior) SFT | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Sym vs Asym** | **Sym vs AGA** | **Asym Vs AGA** | **Sym vs Asym** | **Sym vs AGA** | **Asym vs AGA** | **Sym vs Asym** | **Sym vs AGA** | **Asym vs AGA** | **Sym vs Asym** | **Sym vs AGA** | **Asym vs AGA** | **Sym vs Asym** | **Sym vs AGA** | **Asym vs AGA** |
| **Male** | | | | | | | | | | | | | | | |
| **1-3** | 0.427 | 2.039* | 1.598 | 1.030 | 1.799 | 0.718 | 0.603 | 0.262 | 0.317 | 0.597 | 1.961 | 2.561** | 0.762 | 1.281 | 0.297 |
| **3-6** | 0.897 | 0.312 | 0.476 | 0.927 | 1.010 | 0.106 | 0.865 | 2.504** | 1.790 | 1.183 | 2.191* | 0.782 | 0.375 | 2.221* | 1.735 |
| **6-9** | 1.286 | 2.377* | 1.257 | 1.809 | 0.479 | 1.129 | 0.430 | 1.354 | 1.267 | 0.650 | 0.685 | 1.339 | 2.439** | 0.230 | 2.684** |
| **9-12** | 0.596 | 1.039 | 1.320 | 0.666 | 1.526 | 2.210* | 0.748 | 3.568*** | 3.010** | 0.567 | 2.516** | 1.922 | 2.887** | 0.967 | 2.847** |
| **Female** | | | | | | | | | | | | | | | |
| **1-3** | 0.351 | 0.713 | 0.463 | 0.572 | 3.095** | 2.872** | 0.926 | 2.077* | 1.497 | 0.804 | 2.097* | 2.318* | 0.323 | 1.680 | 1.381 |
| **3-6** | 0.385 | 0.891 | 1.210 | 0.271 | 0.020 | 0.205 | 0.164 | 0.215 | 0.040 | 2.477** | 0.228 | 2.755** | 0.177 | 0.428 | 0.265 |
| **6-9** | 0.872 | 1.173 | 1.910 | 0.810 | 1.813 | 1.515 | 0.824 | 1.598 | 0.711 | 0.086 | 1.264 | 1.015 | 1.013 | 2.162* | 1.187 |
| **9-12** | 0.376 | 0.220 | 0.481 | 0.588 | 0.040 | 0.653 | 0.291 | 1.007 | 1.243 | 0.757 | 0.465 | 0.186 | 0.722 | 2.107* | 1.773 |

***p≤0.05, **p≤0.01, ***p≤0.001, df= n-2 Sym= Symmetric SGA, Asym= Asymmetric SGA**

˝Velocity: 1 to 3 month (mm/ 2 month), 3 to 6, 6 to 9 & 9 to 12 (mm/ 3 month)