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The influence of biological maturation on anthropometric determinants of talent identification among U-14 provincial girl tennis players – A pilot study

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Abstract

The aim of this study was to determine whether biological maturation would significantly influence the anthropometric determinants of talent identification among U-14 provincial girl tennis players. Twenty-six of the top thirty-two provincial female players (mean age = 13.21± 0.72 years) from the Northern Gauteng and the North-West Province participated in the study. Twenty-eight anthropometric measurements were taken according to the protocols of The International Society for the Advancement of Kinanthropometry. Subjects completed a Biological Maturation Identification Questionnaire (BMIQ) on their stage of secondary sexual characteristics development and age of menarche as well as a few questions related to their demographic information, which facilitated the gathering of data on sport participation and South African ranking. The subjects were grouped into early (n = 4), average (n = 11) and late developers (n = 11) according to the BMIQ. The results of the Kruskal-Wallis ANOVA revealed no statistical significant differences between the anthropometric characteristics of the different biological maturation groups although certain trends with regard to differences were noted. Furthermore, results with regard to the ranking of the players showed that the late and average developer groups had the most seeded players. The findings suggest that the average and late developing female tennis players may surpass the early developers in their tennis performance.

Keywords: Kinanthropometry, growth, biological maturation, girls, tennis.

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Introduction

Vaeyens, Lenoir, Williams and Philippaerts (2008) defined talent identification as the process of recognizing current participants with the potential to excel in a particular sport. Several countries (Australia, Belgium, England, New Zealand, Russia, Serbia and Spain) emphasize the importance of talent identification for tennis (Unierzyski, 2010). The importance of identifying talented players is even

more accentuated by national associations and private investors who want as much assurance as possible that a player is truly talented before backing him/her financially (MacCurdy, 2010). In the last stage of the talent identification process during which the most talented tennis players are identified, a variety of tennis specific talent identification determinants (motor abilities, technique, mental features and physical components) are evaluated (Vaeyens *et al.*, 2008; MacCurdy, 2010; Unierzyski, 2010). This evaluation usually takes place at the ages of between 12 to 16 years for girls (Lucacia, 1996; Unierzyski, 2010). One component that is especially important in the tennis talent identification process due to its relationship to success at the elite level is the anthropometric characteristics of the players (Pallulat, 1984; Bloomfield, 1998; Sanchez-Munoz, San & Zabala, 2007; Vaeyens *et al.*, 2008; Unierzyski, 2010).

Consequently, several studies have investigated the anthropometric profile of elite tennis players (Pallulat, 1984; Roetert & Ellenbecker, 1998; De Ridder, Monyeki, Amusa, Toriola, Wekesa & Carter, 2000). In this regard, Roetert and Ellenbecker (1998) for example found that an optimal body fat percentage (12-22%) together with a relatively high muscle mass, are important determinants for success in tennis. Furthermore, Pallulat (1984) reported the ideal somatotype for elite women tennis players to be in the mesomorphic-ectomorph category and that elite, professional women tennis players generally have a muscular and tall body build. These findings were also supported by Sanchez-Munoz *et al.* (2007) who indicated that the top 12 elite junior female players in their study were significantly taller than the lower ranked girls. Bloomfield (1998) also demonstrated that elite women tennis players display long upper and lower limb lengths as well as long upper body lengths. Research with regard to African and South African professional woman tennis players further showed that these players display a mesomorphic-endomorph somatotype and that they are generally muscular but shorter with a more stout body build in comparison to women from other countries and continents (De Ridder *et al.*, 2000; Sports Information and Science Agency: SISA, 2000).

A problem that researchers and sport scientists face is that adolescent (12-16 year old) girl tennis players' anthropometric profile may still undergo changes because of growth and maturation (Unierzyski, 2010). Biological maturation refers to the stage of pubertal development (Malina & Geithner, 2011). It must therefore, be considered in the last stage of the talent identification process (Carlson, 1988; Schulz & Curnow, 1988; Meuller, Benko, Rashner & Schameder, 2000; Unierzyski, 2010). Differences with regard to the biological maturation contribute to a high variability in the body size and composition between young tennis players of the same age group and may lead to the elimination of talented players at a young age during the talent identification process because of their late-maturing state (Unierzyski, 2010). This view is supported by Schulz and Curnow (1988) who indicated that the biological

developmental category in which a child finds him/herself, will determine the sporting performance he/she will achieve at that stage in time. Furthermore, anthropometric determinants, which have a well-known developmental profile, will have a higher chance of being successful talent identification determinants (Bulgakova & Voroncov, 1978; Coetzee, 2000).

The influence of biological maturation on tennis success is complex and research on this aspect is minimal. By ignoring the possible effect of biological maturation on the anthropometric determinants of talent identification during the final talent identification process, a situation could arise where talented players are eliminated and potential future stars are lost (Abernethy & Russel, 1983; Muller, 1990; Tuffnell, 1998; Unierzyski, 2010).

Therefore, this study was primarily designed to determine whether biological maturation would significantly influence the anthropometric determinants of talent identification among U-14 provincial female tennis players. The study is based on the assumption that early developing female tennis player's anthropometric characteristics will be more favourable for successful tennis performance during the current developmental stage and talent identification process.

Methods

The Ethics Committee of the North-West University approved the test protocol that was used in this study. The study formed part of the bigger Tennis Talent Identification Project (TTIP: project number 01M12).

Study design

The design of the study was a quantitative, descriptive, cross-sectional and selected group design. Information was obtained by means of a questionnaire and by taking a series of anthropometric measurements.

Participants

According to MacCurdy (2010) and Monsaas (1985) junior tennis players start preparing themselves to enter top international competitions at the age of 13 years. Furthermore, data from the World Tennis Association (WTA) suggests that the top 20 woman tennis players in the WTA world rankings turned professional at an average age of 15.6 years (WTA Tour, Inc., 2012). Also, the last stage of the talent identification process during which the most talented tennis players are identified, takes place at the ages of between 12 to 16 years for girls. With this information in mind, a group of u-14 girl tennis players were selected as participants of this study. The Northern Gauteng and North-West

Tennis Unions, respectively declared their top sixteen (16) players available for participation in the study. Twenty-six (26) of these players (age = 13.21 ± 0.72 years) volunteered to participate in the study. The study design, purpose and possible risks were explained to the participants and written informed consent was obtained from the participants and their parents before the study was undertaken. Only the players who were injury free at the time of testing, from whom all anthropometric measurements were taken and who answered the whole Biological Maturation Identification and Questionnaire and questions related to their demographic information were included in the study.

Anthropometric measurements

A total of twenty-eight anthropometric measurements were obtained by using the protocol of The International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones, Olds, Stewart & Carter, 2006). All anthropometric measurements were taken twice by Level 2 ISAK certified anthropometrists. The measurements included body mass to the nearest 0.1 kg (with a calibrated BFW 300 Platform scale, Adam Equipment Co. Ltd., UK.); body stature to the nearest 0.1 cm (with a Harpenden portable stadiometer, Holtain Limited, UK.); sitting height to the nearest 0.1 cm (with a measuring box and a Harpenden portable stadiometer, Holtain Limited, UK), eight skinfolds (with Harpenden calipers, Holtain Limited, UK.); seven girths (using Lufkin metal tapes, Cooper Industries, USA.); five breadths (with Holtain Bicondylar Calipers, Holtain Limited, UK.) and five lengths (with Rosscraft Segmometers, Rosscraft Innovations Inc., Canada).

After landmarking each participant, they were directed to one of five stations where the different anthropometric measurements were taken. Arm, mid-thigh and calf girths were corrected for the different skinfolds at these sites, by using the following formula: Corrected girth = Girth – (π x skin fold thickness). According to Martin, Spenst, Drinkwater and Clarys (1990) corrected girths provide better indicators of musculoskeletal size at each site.

Another six body composition measures were indirectly derived, namely: body density, body fat percentage and body fat mass; muscle mass percentage and muscle mass as well as the somatotype. Somatotype was calculated using the formulas of Carter and Heath (1990) and body density, body fat percentage as well as body fat mass were estimated by using the formulas of Slaughter *et al.* (1988) and Lohman *et al.* (2000); Muscle mass percentage and muscle mass were evaluated by using the formulas of Poortmans *et al.* (2005).

Biological Maturation Identification Questionnaire (BMIQ)

All players completed the BMIQ, which was compiled by making use of the illustrations and information on the Tanner stages (Faulkner, 1996). The questionnaire consisted of questions and illustrations concerning the appearance of primary and secondary sexual characteristics (stages of breast and pubic hair development), which the participants had to identify. Duke, Litt and Gross (1980) reported that girls can assess their own breast and pubic hair developmental stage accurately according to Tanner's standard photographs (Kappa coefficients of 0.81 and 0.91). The study by Schmitz *et al.* (2004) found that more than 85% agreement within one stage was obtained for most measures when self-assessments were validated against physician's reports, Tanner ratings and associations with bone density, gender and age. They concluded that self-assessments have predictive and discriminate validity. This conclusion was also confirmed by an older study of Williams, Cheyne, Houtkooper and Lohman (1988) which showed that adolescents can assess their own stage of sexual maturation accurately regardless of their fatness classification or actual sexual stages of maturation.

The girls completed the questionnaire in the presence of a female researcher. The participants also had to indicate their age of menarche (if applicable) by writing down the date as well as the age when their first menstrual period started. In this regard, Malina (1983) reported that teenage girls are able to recall this developmental landmark correctly within a range of 2 to 3 months. Three (3) different researchers categorized the girls independently into early (n = 4), average (n = 11) and late (n = 11) developers according to the results of the BIMQ. The different developmental categories were described as follows:

- Early developers were defined as children who have reached the growth and development normally associated with a certain age, before the average age of puberty (more or less 12 years for girls) (Seifert & Hoffnung, 1987). This group of children normally reaches the age menarcheal age and the peak height velocity growth phase (PHVGP) at least one year before the average age for these developmental stages (Malina & Bouchard, 1991).
- Average developers are described as children who have reached the normal, average age for puberty and show the normal growth and development associated with this age (Seifert & Hoffnung, 1987). This group of children normally reaches the age at menarche and the PHVGP at least one year or less before the average age for these development phases (Malina & Bouchard, 1991).

- Late developers are children who reach puberty after the average age for this development phase. Consequently, they also do not show the growth and development indicators of their peers (Seifert & Hoffnung, 1987). Girls who fall into this group normally reach the age at menarche and the PHVGP at least one year or more after the average age for these development phases (Malina & Bouchard, 1991).

Demographic information

Lastly each of the participants also answered a few questions regarding their sport participation, South African rankings, injury incidence and competing level.

Identification of anthropometric determinants of talent identification

A literature survey identified the most important anthropometric determinants of talent identification for tennis success in girls, after which the effects of biological maturation on these determinants were investigated.

Statistical analysis

The Statistical Consultation Service of the North-West University determined the statistical methods and procedures for the analysis of the research data. The Statistica Data Processing Package (StatSoft Inc., 2011) was used to analyse the data. Firstly, the descriptive statistics of each anthropometric measurement and biological maturation results were calculated. In order to determine whether biological maturation had a statistically significant influence on the anthropometric determinants of talent identification, the Kruskal-Wallis analysis of variance (ANOVA) method was used. Non-parametric statistics were used mainly due to the low number of players that were allocated to each group (Thomas & Nelson, 2001). The level of significance for the Kruskal-Wallis ANOVA was set at $p < 0.05$.

Results

BMIQ results

Table 1 presents the information obtained from the BMIQ and indicates the different biological maturation phases that the participants were classified into.

The data, which were obtained from the BMIQ, showed that the early developers entered their PHVGP at an average age of 11.37 years compared to the average and late developers who experienced the PHVGP at 12.18 and 12.73 years, respectively. For one of the questions the participants had to classify themselves

on a scale from (1), "earlier", (2) "the same time" and (3) "later" when comparing their own PHVGP, age of menarche, breast and pubic hair development to those of their peers ("in terms of peers"). Despite the perception of the early developers that they did not start growing before their peers, the values of 2.0, 2.27 and 2.45 for PHVGP show that each of the groups, experienced growth earlier (early developers), the same time (average developers) and later (late developers) when compared to their peers. The age of menarche was used as the primary indicator for the classification of the girls into the different developmental groups. The results in Table 1 show that the early, average, and late developers experienced menarche at an average age of 11.75, 12.94 and 13.39 years, respectively.

Table 1: Descriptive statistics of the Biological Maturation Identification Questionnaire for the early, average and late developing girl tennis players

Component	Group	Mean	SD	Minimum	Maximum
Year of most growth (age)	Group 1 (n =4)	11.37	0.47	11.00	12.00
	Group 2 (n =11)	12.18	0.4	12.00	13.00
	Group 3 (n =11)	12.73	0.65	12.00	14.00
In terms of peer group?	Group 1 (n =4)	2.00	0.00	2.00	2.00
	Group 2 (n =11)	2.27	0.47	2.00	3.00
	Group 3 (n =11)	2.45	0.52	2.00	3.00
Menarcheal age	Group 1 (n =4)	11.75	0.50	11.00	12.00
	Group 2 (n =11)	12.94	0.52	12.07	14.00
	Group 3 (n =11)	13.39	0.48	13.00	14.02
In terms of peer group?	Group 1 (n =4)	1.25	0.50	1.00	2.00
	Group 2 (n =11)	2.55	0.52	2.00	3.00
	Group 3 (n =11)	2.73	0.47	2.00	3.00
Pubic hair development	Group 1 (n =4)	4.25	0.96	3.00	5.00
	Group 2 (n =11)	3.36	0.81	2.00	4.00
	Group 3 (n =11)	3.00	0.63	2.00	4.00
In terms of peer group?	Group 1 (n =4)	2.25	0.96	1.00	3.00
	Group 2 (n =11)	3.36	0.81	2.00	5.00
	Group 3 (n =11)	3.82	0.75	3.00	5.00
Breast development	Group 1 (n =4)	4.25	0.96	3.00	5.00
	Group 2 (n =11)	2.95	0.57	2.00	4.00
	Group 3 (n =11)	2.27	0.79	1.00	3.00
In terms of peer group?	Group 1 (n =4)	2.50	0.58	2.00	3.00
	Group 2 (n =11)	3.45	0.82	2.00	5.00
	Group 3 (n =11)	4.18	0.87	3.00	5.00

The participants also had to classify their own breast and pubic hair development according to the figures and descriptions in Tanner's five stages (1980) as described by Faulkner (1996), where: stage 1 illustrated the secondary sex characteristics for the pre-puberty phase; stage 2 illustrated the initial development of specific secondary sex characteristics; stages 3 and 4, the further development of secondary sex characteristics and stage 5, the mature development phase.

The early developers obtained an average value of 4.25 for pubic hair classification. The average and late developers reported average pubic hair classification values of 3.36 and 3.0, respectively. Compared to their peers, early developers reached a certain stage of pubic hair development "slightly earlier" (2.25), the average developers "about the same time" (3.36) and the late developers slightly after" (3.82) their peers. The classification of breast development obtained more or less similar results to those of pubic hair development with values of 4.25 (early developers), 2.95 (average developers) and 2.27 (late developers) that were found.

Anthropometric results

The different development groups were categorized according to the BMIQ results after which the ANOVA was performed to identify significant differences in the anthropometric measurements and components between the three categories. Even though the results revealed no statistically significant ($p \geq 0.05$) differences between the three groups, specific tendencies were clearly visible and are discussed later in this article. The descriptive statistics of the anthropometric variables are presented in Table 2.

The data revealed that the average developers (n = 11) showed the highest mean stature and sitting height values, while the early developers (n = 4) were the shortest group with the highest mean body mass values. The early developer group also showed the highest mean muscle mass (kg) and fat percentage as well as higher corresponding endomorphic and mesomorphic values. The early developers also had the highest mean skinfold measurements (in six of the eight) and girth values (in six of the seven measurements).

The average developers had the highest means for limb lengths (in three of the five measurements), while the late developers recorded the highest mean breadth values (in three of the five measurements). The average and late developers were also characterized by lower mean fat and muscle mass as well as higher mean stature values compared to the early developers.

Table 2: Descriptive statistics of the anthropometric talent identification determinants for the girl tennis players at an age of early, average and late development

Variables	Early developers (n = 4)		Average developers (n = 11)		Late developers (n = 11)	
	Mean	**SD**	Mean	SD	**Mean**	**SD**
Age (years)	13.00	1.27	12.96	0.53	13.59	0.68
Body stature (cm)	159.7	5.16	162.56	5.86	159.05	9.10
Body mass (kg)	53.25	7.58	48.45	5.93	48.91	12.23
Sitting height (cm)	74.75	11.25	81.73	1.90	78.70	4.79
Muscle mass (kg)	24.48	5.75	22.9	4.31	21.61	4.80
Muscle mass (%)	45.91	7.31	47.11	5.53	44.93	6.98
Endomorphy	5.27	2.36	3.25	0.45	4.17	1.71
Mesomorphy	4.01	1.10	3.05	0.49	3.60	1.19
Ectomorphy	2.60	1.78	4.13	0.67	3.53	1.62
Fat percentage (%)	25.20	7.96	18.52	2.16	21.75	6.40
Skinfolds (mm)						
Triceps	15.70	6.88	12.25	2.70	13.85	4.85
Biceps	8.96	3.26	7.63	1.98	11.19	8.34
Sub scapular	12.17	6.14	8.00	1.24	10.88	7.25
Abdominal	23.95	13.05	12.99	3.54	16.93	9.38
Ilio-cristal	18.51	8.99	11.40	4.08	12.73	7.31
Supra-spinal	24.27	15.23	10.17	2.13	15.33	9.93
Anterior thigh	26.83	9.41	19.84	4.81	23.75	8.29
Medial calve	14.20	6.34	12.16	3.76	15.44	4.89

Shaded portions indicate highest values among the three development groups

Results with regard to the answers to the demographic questions

A further analysis, in which the sport participation data obtained from the answers to the demographic questions was used, is presented in Table 3. This table contains the South African rankings for the year of measurement and the classification of maturity status for each of the players that were tested.

These results showed that 17 of the tested players were seeded players and that the highest seeded players were categorized as late maturers. The highest seeded player was, however, classified as an early maturer.

Table 2 (cont.): Descriptive statistics of the anthropometric talent identification determinants for the girl tennis players at an age of early, average and late development

Variables	Early developers (n = 4)		Average developers (n = 11)		Late developers (n = 11)	
	Mean	**SD**	Mean	SD	**Mean**	**SD**
Girths (cm)						
Relaxed upper arm	24.46	3.00	22.14	1.91	22.94	2.83
Tensed upper arm	26.46	2.99	23.9	1.91	24.7	2.68
Forearm	23.7	2.51	22.4	1.68	22.7	1.71
Wrist	15.45	1.03	15.25	0.81	14.93	0.75
Thigh	47.33	5.58	43.84	3.38	44.36	4.20
Calf	33.51	3.48	32.18	2.44	31.38	3.20
Ankle	21.45	1.75	25.52	14.81	21.10	1.70
Lengths (cm)						
Acromial-radial	27.52	0.83	29.20	2.24	28.27	1.95
Radial-styloid	23.72	1.59	24.54	1.33	24.56	1.44
Hand	17.75	0.78	18.00	0.99	18.00	0.85
Trochanter-tibial lateral	37.61	1.79	39.02	3.07	35.98	4.08
Tibial lateral	43.12	1.28	45.19	3.16	46.16	2.45
Breadths (cm)						
Humerus	6.22	0.29	6.22	0.31	6.35	0.63
Femur	8.72	0.55	8.74	0.49	8.81	0.44
Bi-acromial	36.77	0.57	35.70	1.82	35.66	2.40
Bi-cristal	26.97	0.47	26.40	2.25	27.28	4.46
Hand	7.61	0.77	7.99	0.58	7.84	0.66

Shaded portions indicate highest values among the three development groups

Discussion

The results of the BMIQ showed that all three of the player groups fell within the normal average range (11 to 13 years) reported for the commencement of the PHVGP (Seifert & Hoffnung, 1987; Gallahue & Ozmun, 1995; Wilmore, Costill & Kenney, 2008). Furthermore, the results also suggest that each of the groups experienced growth and the resulting biological changes earlier, at the same time and later, respectively compared to their peers. Similar results were also found for the average age of menarche between the three development groups with the early developers who reported the lowest average age for menarche (11.75 years) and the late developers the highest average menarcheal age (13.39 years). The average developers reported their age of menarche to be 12.94 years, which is very similar to the values of between 12.7 and 12.9 years reported by other researchers (Ross, Brown & Faulkner, 1977; Charzewski, Lewadndowska,

Pieckaczek, et al., 1998). With regard to the classification of pubic hair and breast development, the highest value (4.25) of the early developers indicated that full maturity with regard to their biological development was almost reached. Again, the average and late developers reported average values for these developmental characteristics that were much lower compared to those of the early developers.

Table 3: Rankings of the early, average and late developing girl tennis players

Maturity status group	SA ranking
Early developers (n = 4)	5
	211
	No ranking
	No ranking
Average developers (n = 11)	87
	105
	125
	147
	151
	No ranking
	No ranking
	No ranking
	No ranking
	No ranking
	No ranking
Late developers (n = 11)	16
	17
	64
	66
	81
	83
	112
	129
	196
	No ranking
	No ranking

SA = South African (as for the U-14 girls category)

The results would, therefore, suggest that players were able to accurately classify and judge their own developmental stage.

The anthropometric results showed that early developers on average displayed the smallest stature, highest average body and muscle mass as well as fat percentage values with higher corresponding endomorphic and mesomorphic values. They were also the group who displayed the highest average skinfold and girth values. Similarly, Coetzee (2000) demonstrated that early developing girls show a shorter stature as adults when compared to the stature of other developing groups. Furthermore, Malina, Bouchard and Bar-Or (2004) indicated that early developers are taller and heavier than average and later developers from about

six years of age but that these differences disappear at the start of the early adulthood phase.

The results on stature do not correspond to those of Malina and Geither (2011), who reported that girls who show a more advanced biological maturation tend to be taller than those who are in a later stage of maturation. However, the same authors found higher endomorphic, mesomorphic and fat percentage values for the early compared to the average and late developing girls in their study, which is similar to the results of this study. The findings of this study are consistent with the conclusions of Malina *et al.* (2004) that early developing girls display higher average bone, muscle and fat measurements at the extremities as well as higher average subcutaneouss fat measurements between the ages of 7 to 17 years than late developers.

Comparatively, the average developers displayed the highest stature and sitting height, muscle mass percentage, ectomorphy and limb length values on average. In view of the late developers' delayed biological maturation it was surprising that they were the group who displayed the highest limb breath values. Due to a lack of research that has investigated the possible influence of biological maturation on the anthropometric variables of young girls, this finding could not be explained by existing literature. A more linear or skinny body build is, however, associated with late development (Coetzee, 2000; Malina & Geithner, 2011), as is also evident in the study through the lower average fat and muscle mass as well as the higher average values of stature in the average and late developers. Research also indicated that late developers usually surpass the muscle and strength values of early developers (Beunen & Malina, 1988; Faulkner, 1996), and generally perform better compared with early developers (Malina & Geithner, 2011), which in turn favors tennis success. From the results of this study it is clear that the early developing girls tend to be shorter, with a more stout body build when compared to the other developmental groups.

Conclusions and Recommendations

The conclusion drawn from this study, despite of the lack of statistically significant differences between the biological maturation groups, is that early maturing girls will perform better in tennis in their respective age groups during the pre-adolescent phase compared to children of other maturity status categories. However, the results also show that this trend might change during puberty when the more ideal physique of the average and late maturing tennis players will enable them to perform better in tennis than their early maturing peers. These facts alone indicate the importance of including the measurement of biological maturation into the final tennis talent identification phase.

Several shortcomings of this study should, however, be considered when interpreting the data. The small group size is the main shortcoming of this study and may be the primary factor contributing to the lack of statistically significant differences between the three groups. In spite of this, the research brought a number of valuable findings to the fore and can therefore be regarded as a pilot study. The design of the study may be used on a larger number of participants, not only to overcome the small group sizes, but also to enable researchers to generalize the overall findings to all U-14 provincial female tennis players in South Africa. A secondary recommendation is that the developmental groups need to be classified more strictly according to the average age for PHVGP, which occurs at the average ages of 11 to 13 years (Seifert & Hoffnung, 1987; Gallahue & Ozmun, 1995; Wilmore *et al.,* 2008), and not according to the differences in the onset of maturational indicators between groups. It would also be advisable to include relative anthropometric measurements such as body mass index, brachial index and crural index into the talent identification protocol. This will also allow researchers to compare the three groups proportionally with regard to growth.

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