The role of anthropometric, growth and maturity index (AGaMI) influencing youth soccer relative performance

Ahmad Bisyri Husin Musawi Maliki[1], Mohamad Razali Abdullah[1,2], Hafizan Juahir[1], Wan Siti Amalina Wan Muhamad[2], Nur Afiqah Mohamad Nasir[2], Rabiu Muazu Musa[2,3], Siti Musliha Mat-Rasid[1], Aleesha Adnan[2], Norlaila Azura Kosni[2], Farhana Abdullah[2] and Nurul Ain Shahirah Abdullah[2]

[1] East Coast Environmental Research Institute (ESERI), Universiti Sultan Zainal Abidin, 21300, Terengganu, Malaysia.
[2] Faculty of Applied Social Sciences, Universiti Sultan Zainal Abidin, 21300, Terengganu, Malaysia
[3] Innovative Manufacturing, Mechatronics & Sports Lab (iMAMS), Faculty of Manufacturing Engineering, Universiti Malaysia Pahang (Pekan Campus), 26600 Pekan, Pahang, Malaysia.

E-mail: razali896@yahoo.com

Abstract. The main purpose of this study was to develop Anthropometric, Growth and Maturity Index (AGaMI) in soccer and explore its differences to soccer player physical attributes, fitness, motivation and skills. A total 223 adolescent soccer athletes aged 12 to 18 years old were selected as respondent. AGaMI was develop based on anthropometric components (bicep, tricep, subscapular, suprailiac, calf circumference and muac) with growth and maturity component using tanner scale. Meanwhile, relative performance namely physical, fitness, motivation and skills attributes of soccer were measured as dependent variables. The Principal Component Analysis (PCA) and Analysis of Variance (ANOVA) are used to achieve the objective in this study. AGaMI had categorized players into three different groups namely; high (5 players), moderate (88 players) and low (91 players). PCA revealed a moderate to very strong dominant range of 0.69 to 0.90 of factor loading on AGaMI. Further analysis assigned AGaMI groups as treated as independent variables (IV) and physical, fitness, motivation and skills attributes were treated as dependent variables (DV). Finally, ANOVA showed that flexibility, leg power, age, weight, height, sitting height, short and long pass are the most significant parameters statistically differentiate by the groups of AGaMI ($p<0.05$). As a summary, body fat mass, growth and maturity are an essential component differentiating the output of the soccer players relative performance. In future, information of the AGaMI model are useful to the coach and players for identifying the suitable biological and physiological demand reflects more comprehensive means of youth soccer relative performance. This study further highlights the importance of assessing AGaMI when identifying soccer relative performance.

1. Introduction

Anthropometric is a basic research method of somatometric that involves the size of body composition and body part. It is a measurement of the body composition which determines the size of the composition of the body to be tested [1]. The total of the body fat measurement fundamentally in skinfold test has

seven sites to be measured namely, biceps, triceps, subscapular, suprailiac, supraspinale, thigh and calf. In the meantime, girth and maturation also contributes to the development of physical characteristic especially in adolescent soccer players. Determination of the optimum physical characteristics integration of the body size, growth and maturation in the early stage of the talent identification and development on the game of soccer are vital.

On the other hand, multilateral factors of anthropometric, physical fitness, soccer specific skill and psychology recently been investigated in predicting soccer players potential [2-4]. Applying multilateral of factors will help coaches, instructors as well as players to focus on the most dominants factors predicting to the soccer player performance. Meanwhile, some of the studies focusing on the variation of the level of the participation in soccer in regard to identify the profiling and distinction of the specific soccer related performance and fitness level [5-7]. It is proven to be variation among soccer players in terms of the position, level of age, level of participation and most of it influence by the physical characteristics, growth and maturation, and also psychosocial of the players. However, most of the studies only consider limit to the anthropometric, physical fitness, physiological, psychological and technical factors [2-7]. In contrast, the variation of the lifestyle by the players influence the body size, somatotype, body fat, growth and maturation. It is fewer study focusing on the variation of the body fat level in contrast to the soccer player performance. Thus, this study aims to develop Anthropometric, Growth and Maturity Index (AGaMI) in soccer and explore its differences to the soccer player physical characteristics, physical fitness, psychological and soccer specific skill attributes.

2. Materials and Method
All the procedures of the current studies such as, anthropometrics, battery test, soccer specific battery test and psychometric related to soccer was undertaken by the following procedures:

2.1 Participants
A random sampling technique were employed to the current study consist of youth soccer players in Malaysia soccer academies by combining ex post facto design. A total of 184 youth soccer players (mean age = 15.2 ± 1.6 years) were voluntary participate in this study which is randomly drawn from soccer academies. Prior of the data collections, all the procedure and protocol were officially approved by the Human Research Ethics Committee of the University (UniSZA/02/1/2016/Jil. 207). Furthermore, aims of the study were informed to all participants and their guidance and were told to signed if they voluntary agreed to be participant of the study.

2.2 Anthropometrics, growth and maturation (AGaMI)
Anthropometric tests were done to measured weight, standing stature, sitting height, and four locales of body fat. Weight is evaluated utilizing a standard electronic advanced scale to the closest of 0.1 kg, in the interim standing stature was measure to the closest 0.5 cm. Meanwhile, chronological age is measured in the month beginning from the date of every player being perceived until the date of test. Moreover, sitting height were measured from the highest point of the head to the base of the sitting and recorded to the closest of 0.5 cm. Level of muscle versus fat is measured through skinfold calliper utilizing four measuring locales to be specific, trisep, biceps, subscapular and suprailiac to the closest of 0.1 mm as indicated by the suggestion from past examinations [6-9]. Furthermore, the body size or girth is measured on two sections of the body in particular, calf circumcision (cc) and middle upper arm perimeter (muac) by non-elastic tape. All procedures were recorded twice and the mean score is recorded for facilitate further analysis. Then again, maturation was measured by applying Tanner scale stages of development as prescribed by prior studies and adopting into current study [3- 4].

2.3 Soccer battery test
Muscle strength assessments are measured in the suggested way for physical fitness assessment. There are seven parameters to be recorded in physical fitness test performance namely, vertical jump, variability of sit up, agility, sit and reach, 5 m, 10 m and 20 m speed. The tape scale is used to measure the range of the flexibility and the long reach of sit and reach and distances of the leg power were measure by using vertical jump. A sit and reach test are undergone to measure the flexibility of the lower

back and the hamstring muscles. The player must start in a ready position with both legs are straight. The range is premeditated to the extent that the finger reaches the maximum of the measuring line. Vertical jump tests are doing to measure the distances differences of the starting height and maximum height while jumping. While calculating the height of the jump, the time is also recorded for the process of the jumping routine. The purpose of this test is to measure the horizontal explosive power of the leg muscles [10]. Stopwatch and timing gate were used to compute and recorded the timing of the sit-ups test agility tests. Variability of sit up test is performed to measure the strength and durability of abdominals and hip muscles. The sit up maximum routine of set undertaken for recorded. Meanwhile, agility is the capability of the players to quickly change the body position into the given direction in the minimum requirement time. The timing gate is essential and proven to be valid to record the fastest time from the start line to the finish line as recommended by the previous study [11].

2.4 Soccer technical skills
Soccer specific skill tests were executed to acquire technical skill characteristics by applying from the previous studies namely F-MARC test accompanying to measure skill test namely dribbling with and without ball, ball control using three different part of body, short pass, long pass, shooting with foot and score using head. Time and speed are taken and evaluated during the test process [3].

2.5 Psychometric (Motivation)
Task and Ego Orientation in Sports (TEOSQ) have been implementing in this study. It contains 13 items that assessed the ability of players weather they are task or ego oriented towards the soccer game. The form was translated into Bahasa Melayu using the back-translation method and it was confirmed and added extraordinary reliability in sports. Spectrum for task and ego orientation shows appropriate internal reliability with alpha 0.82 (ego) and 0.71 (task) reliability coefficients respectively [12]. This instrument contains six items that assess the ego components (such as "I can do better than my friends") and seven items assess the task components (such as "I work hard"). Feedback is shown on 5 points of Likert scale where 1=strongly disagrees and 5=strongly agree.

2.6 Data Analysis
A total of 4784 matrices data comprised all 184 observations of players and 26 parameters was calculated to be analyzed. Prior of the main analysis, box plots and Kolmogorov-Smirnov were computed to check the missing, error, typing error and normality of the data. As a result, it is described that the data is clear. Although some of the parameters are not normally distributed, main analysis were computed as recommendation by the prior researches stated that it is normal to have unnormal data to be distributed in human performance because of the individuality variation [6,8,10,11].

To achieve the objective of this study, principal component analysis (PCA) method was conducted a to scrutinize the data. Through the investigation, it can help the researcher to examine the domain components interrelated to the soccer performance. From this current study, seven factors were categorized as an independent component. Nevertheless, only dominant factors will be interpreted after computing varimax rotation [12]. Furthermore, all the expectations of the PCA were calculated prior of the analysis such as sampling adequacy and sphericity test [6,8,10,11]. End of the PCA, an index of anthropometric, growth and maturation (AGAM) will be develop into different categorical of group. It will highlight the range of each groups. Additionally, researcher also applying analysis of variance (ANOVA) in regard to scrutinize group differences of anthropometric, growth and maturation (AGAM) toward soccer performance.

3. Results and Discussion
The output of this study will project in two-fold, 1) examine the domain components interrelated to the soccer performance and 2) scrutinize group differences of anthropometric, growth and maturation (AGAM) toward soccer performance predictors. Prior of the main analysis, PCA were computed to determine the appropriate components with eigenvalue greater than 1 (eigenvalue>1.0). It can be observed from Figure 1 that PCA identified two components as the most essential due to the higher

eigenvalues (>1). Further analysis performed with varimax rotation by applying two new latent factors in the manner of the appropriate interpretation.
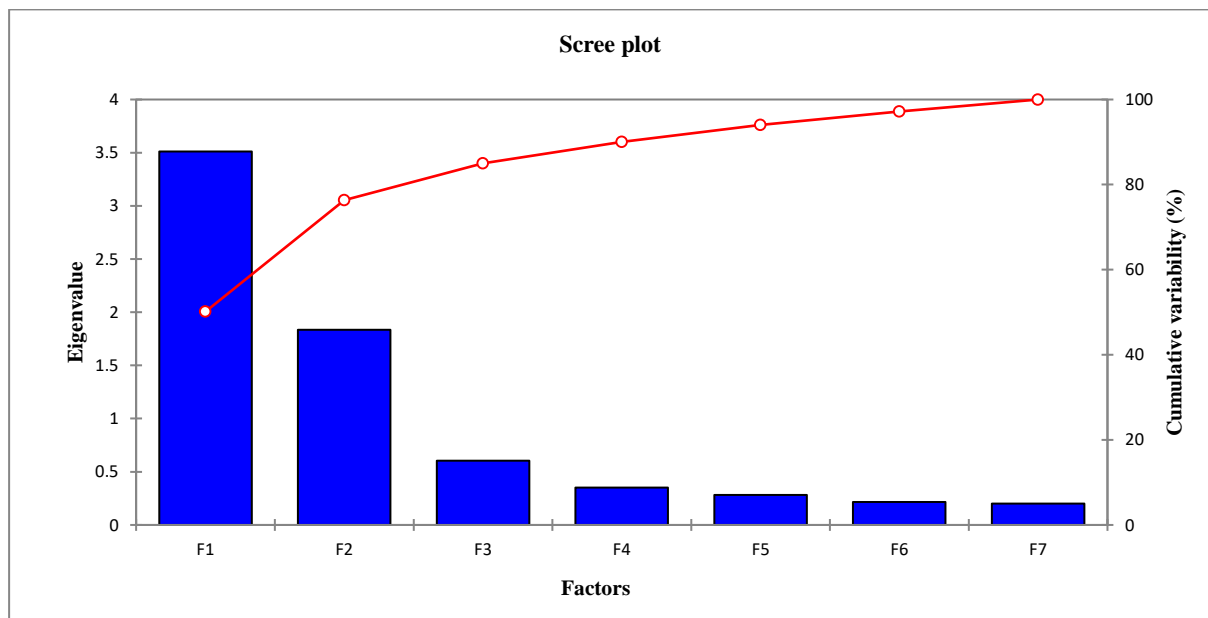

Figure 1: Scree plot of descriptive eigenvalue.

PCA pattern after varimax rotation was disclosed in Table 1. It can be seen the influence of the variance for PCA1 (42.7 %) and PCA2 (33.7 %) with the cumulative of variance is 76.4 %. There are four principal components from first factors (PCA1) satisfied the factor loading threshold (factor loading threshold >0.65) namely bicep, triceps, subscapular, and suprailiac which is reflecting the domain of the body fat. This finding suggesting the important of the body fat needed to be monitor as it have associated with the soccer players performance. According to the previous studies, performance of the soccer (sprint times) players were strongly correlated with the changes in percentage of body fat [13]. Furthermore, percentage of body fat content of elite professional soccer players significantly reduced during the pre-season and seasoning period and increased during the off-season. Thus, physiological operating demanding specific level of body fat, though extra percentages of adipose tissue acts as an additional load in which the body weight must be lifted repeatedly against gravity [14]. Finding of the current study highlighted the important of the domain factor of the percentage of the body fat needed to be monitored as it shown the domain in the first factors which biceps and triceps shows very strong loading, suprailiac part show strong loading and subscapular show moderate loading (see Figure 2).

Meanwhile, second factors explained the domain components from growth and maturation namely muac, cc and maturation. This finding suggesting the domain factors of biological growth and maturity of soccer player. It can be observed that calf circumference (31.9 %) shows the most contributor compared to maturity (28.4 %) and middle upper arm circumference respectively (27.4) (see Figure 2). Finding of the study is in concordance with the previous study stated that biological growth and maturity status contributes positively, although to a small degree, to the dissimilarity in soccer performance [15]. Variation of the anthropometric, growth and maturation by soccer performance were further discuss.

Table 1: Factor loading pattern after Varimax rotation (factor loading set at >0.65).

Components	PCA1	PCA2
Bicep		0.9007
Tricep		0.9092
Subscapular		0.6963
Suprailiac		0.8501
Muac		0.8039
CC		0.8666
Maturation		0.8119
Eigenvalue	3.5105	1.8354
Variability (%)	42.6542	33.7164
Cumulative %	42.6542	76.3705
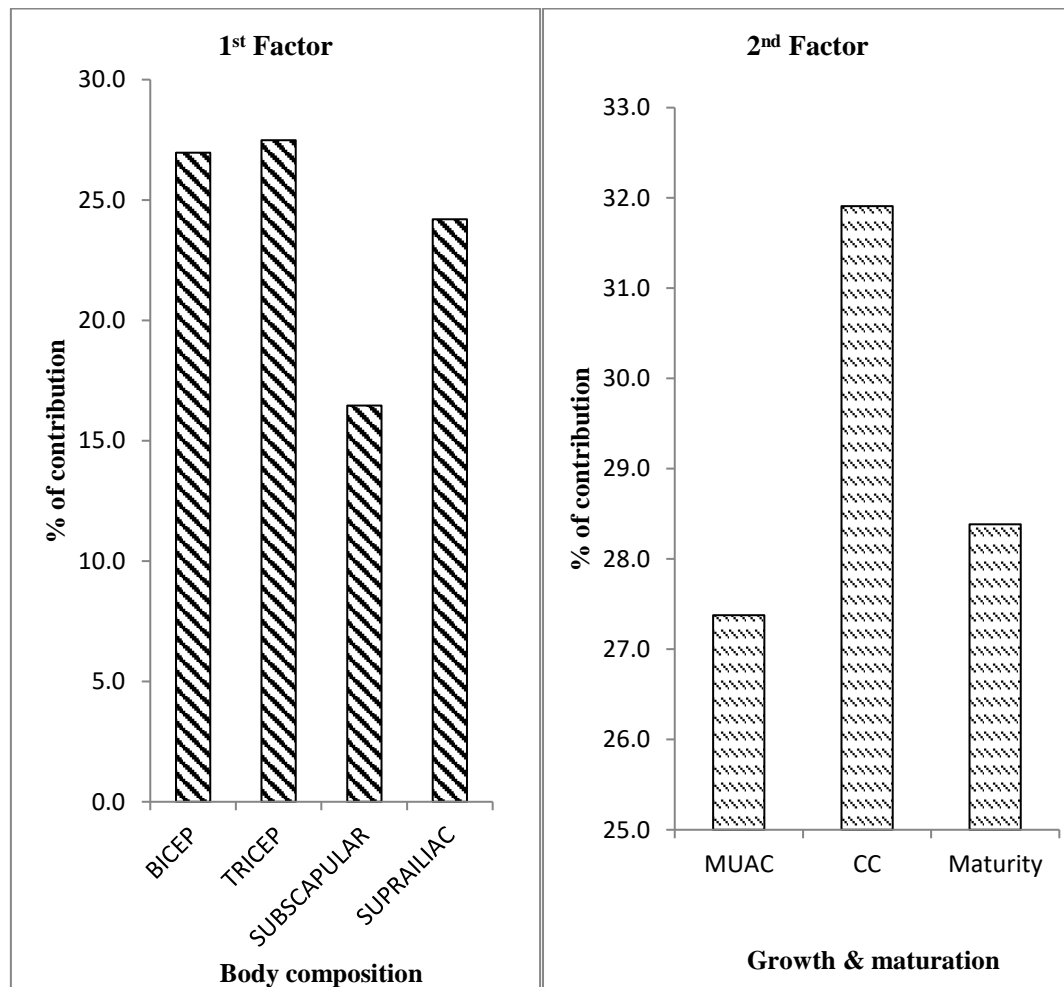
Figure 2. Contribution of The Variables (%) After Varimax Rotation On 1st Factor and 2nd Factor.
*Note: MUAC = middle upper arm circumference; CC = calf circumference.

Furthermore, further analysis was calculated by evolving an index of the anthropometric, growth and maturation index (AGaMI) by applying output of the PCA. Index of the anthropometric, growth and maturation are based on the most dominant components consequential to yield three different categorical sets of anthropometric, growth and maturation namely low, moderate and high AGaMI as shown on Table 2. As shown in Table 2, frequency and cumulative frequency of the players in each group are presented. Based on an index described 5 players consist on high AGaMI group, 88 players on moderate and 91 players on low AGaMI group. Based on the result of AGaMI, each group were further analyzed by seeking the variation on the soccer performance.

Table 2. Index Status of Anthropometric, growth and maturation index (AGaMI).

Status	Frequency	Cumulative Frequency	%	AGaMI
-131.98	91	91	49.46%	Low
-5.34	88	179	47.83%	Moderate
121.31	5	184	2.72%	High

Output of an index were further analyzed by applying ANOVA to determine the differences between groups on soccer performances. Descriptive statistics of mean for functional capacities, chronological age, body size, goal orientation and soccer specific skills for players in three groups of AGaMI are summarized in Table 3. High AGaMI players are significantly lacking of flexibility, leg power, short and long pass, and have equivalently on biological and body size (age, height, weight and sitting height) than other groups ($p<0.05$), but the groups do not differ in muscle strength, agility, speed, aerobic capacity, goal orientation, ball control and shooting ($p>0.05$). Discrepancy of the AGaMI groups based on the significant parameters are summarized in Figure 3.

Table 3. Age, body size, functional capacities, sport-specific skills and goal orientation of youth soccer players classified as high, moderate and low in anthropometric, growth and maturation index and results of ANOVAs.

|	Moderate	High	Low	Pr > F	Significant
Sit & Reach (cm)	14.58	13.70	12.20	0.0076	YES
Vertical jump (cm)	66.24	59.60	61.60	0.021	YES
Variability Sit Up (reps)	6.05	6.60	5.90	0.1762	NO
Agility (s)	2.39	2.39	2.35	0.5396	NO
5 m speed	0.81	0.78	0.78	0.3819	NO
10 m speed	1.51	1.49	1.54	0.63	NO
20 m speed	2.83	2.80	2.88	0.4567	NO
VO_2max (ml/kg/min)	48.75	45.18	47.52	0.3747	NO
Chronological age (month)	15.59	15.05	14.74	0.0015	YES
Weight (kg)	60.39	70.12	52.00	< 0.0001	YES
Height (cm)	168.20	166.70	163.87	0.0016	YES
Sitting Height (cm)	88.70	90.06	84.91	< 0.0001	YES
Task	60.31	60.80	59.34	0.685	NO
Ego	32.35	39.00	32.95	0.4262	NO
Ball Control (point)	7.43	6.40	7.11	0.4105	NO
Long Pass (point)	4.31	4.00	3.26	0.037	YES
Short Pass (point)	10.61	8.40	9.20	0.026	YES
Shooting Right top corner (point)	3.44	3.60	3.58	0.9491	NO
Shooting Left top corner (point)	3.05	4.20	3.76	0.2155	NO
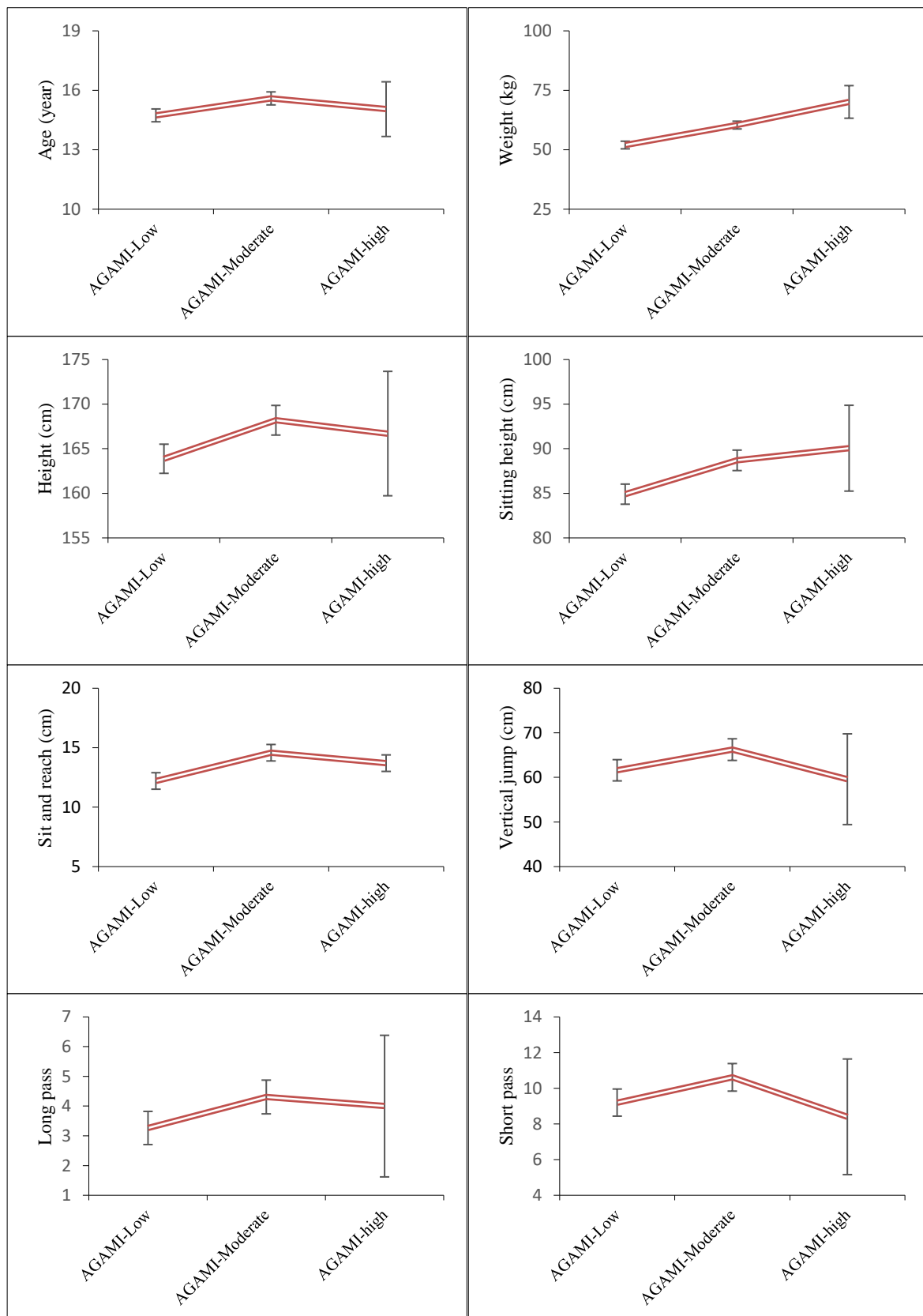
Figure 3: Differences of the most significant variables between AGaMI groups.

Variation in anthropometric, growth and maturity index associated with soccer relative performances in moderate groups of AGaMI was similar in general, between groups advanced in body size, functional capacity and specific soccer attributes than those on low and high groups of AGaMI. Correspondingly, finding of the current study reckon that moderate group of AGaMI advanced their pier groups on the flexibility, vertical jump, short and long pass test. This current finding is similar with previous study stated that body size was significantly vary in maturity status [15] and this discrepancy will lead to the significant differ on the specific soccer performance such as lower leg explosive power test [16]. In contrast to other tests, majority of the assessment of youth soccer players did not differ between groups. It leads to the 11 tested parameters suggesting that there is an equivalent performance between groups that not influence by the variation of the anthropometric, growth and maturation.

Noted that the current study is limited to youth soccer players in Malaysia and an inquisitiveness of potential attention is the anthropometric, growth and maturity status of the players relative to the general population of Malaysia youth. The moderate group of AGaMI tended to be, on average, greater muscle flexibility, more explosive leg power, greater point on short and long pass and taller and aged than low and high of AGaMI. In contrast, the high group of AGaMI tended to be, on average, proportionally taller in sitting height and heavier than other groups. Interestingly, variation of the AGaMI did not affected on the most functional capacity, goal orientation, ball control and shooting test.

4. Conclusion

Model of adaptations to AGaMI include the underlying physical characteristic variations and their explicit indicators. Deliberation of the tested parameters did not consist of perceptual cognitive, tactical, and biomechanical and all these data were not encompassed as it is mostly laboratory-based and not fit for the current study design. Current study summarizes multilaterally the role of AGaMI affecting the variation of the youth soccer performances. This study highlights the soccer players characteristics on the physical characteristic disparities effect. Information of this characteristics on the physical disparities will lead to the effectiveness on the training regime fit with the demand of the soccer game respectively. Specifically, finding of the study suggesting that coaches and instructor need to characterize their player based on the physiological and physical attributes since it proven to influence soccer player performances.

Acknowledgments

References

[1]   Tóth T, Michalíková M, Bednarčíková L, Živčák J, and Kneppo P 2014 Somatotypes in sport *acta mechanica et automatic* **8** 27-32.

[2]   Lund S, Söderström T 2017 To See or Not to See: Talent Identification in the Swedish Football Association *Sociology of Sport Journal* 1.

[3]   Keller B S, Raynor A J, Bruce L, and Iredale F 2016 Technical attributes of Australian youth soccer players: Implications for talent identification *International journal of Sports Science & Coaching* **11** 819-24.

[4]   Wilson R S, James R S, David G, Hermann E, Morgan O J, Niehaus, A C, ... and Smith M D 2016 Multivariate analyses of individual variation in soccer skill as a tool for talent identification and development: utilising evolutionary theory in sports science *Journal of sports sciences* **34** 2074-86.

[5]   Gil S M, Zabala-Lili J, Bidaurrazaga-Letona I, Aduna B, Lekue J A, Santos-Concejero J, and Granados C 2014 Talent identification and selection process of outfield players and goalkeepers in a professional soccer club *Journal of sports sciences* **32** 1931-9.

[6]   Abdullah M R, Maliki A B H M, Musa R M, Kosni N A, Juahir H, and Mohamed S B 2017 Identification and Comparative Analysis of Essential Performance Indicators in Two Levels of Soccer Expertise *International Journal on Advanced Science, Engineering and Information Technology* **7** 305-14.

[7]   Abdullah M R, Musa R M, Maliki A B H M, Kosni N A, and Aziz M A 2016 The Application of Principle Components Analysis to Identify Essential Performance Parameters in Outfield Soccer Players *Research Journal of Applied Sciences* **11** 1199-205.

[8]   Abdullah M R, Eswaramoorthi V, Musa R M, Maliki A B H M, Kosni N A, and Haque M 2016 The Effectiveness of Aerobic Exercises at difference Intensities of Managing Blood Pressure in Essential Hypertensive Information Technology Officers *Journal of Young Pharmacists* **8** 483-6.

[9]   Gipit Charles M A, Abdullah M R, Musa R M, Kosni N A, and Maliki A B H M 2017 The Effectiveness of Traditional Games intervention program in the Improvement of Form One School-Age Children's Motor Skills Related Performance Components *Journal of Physical Education and Sport* **7** 925–30.

[10]   Johnston K, Wattie N, Schorer J, and Baker J 2018 Talent Identification in Sport: A Systematic Review *Sports Medicine* **48** 97–109.

[11]   Woods C T, Raynor A J, Bruce L, McDonald Z, and Robertson S 2016 The application of a multi-dimensional assessment approach to talent identification in Australian football *Journal of sports sciences* **34** 1340-5.

[12]   Hirose N, Seki T 2016 Two-year changes in anthropometric and motor ability values as talent identification indexes in youth soccer players *Journal of science and medicine in sport* **19** 158-62.

[13]   Ostojic S M 2003 Seasonal alterations in body composition and sprint performance of elite soccer players *Journal of Exercise physiology online* **6** 24-7.

[14]   Rico-Sanz J 1998 Body composition and nutritional assessments in soccer *Int J Sport Nutr* **8** 113-23.

[15]   Malina R M, Cumming S P, Kontos A P, Eisenmann J C, Ribeiro B, and Aroso J 2005 Maturity-associated variation in sport-specific skills of youth soccer players aged 13–15 years *Journal of sports sciences* **25** 515-22.

[16]   Figueiredo A J, Gonçalves C E, Coelho E Silva M J, and Malina R M 2009 Youth soccer players, 11–14 years: maturity, size, function, skill and goal orientation *Annals of human biology* **36** 60-73.