Malaysian Journal of Applied Sciences 2018, **Vol 3(1)**: 51-62

eISSN 0127-9246 (Online)

Malaysian Journal of Applied Sciences

ORIGINAL ARTICLE

Spatial Pattern Recognition of School Performance Based on Anthropometric and Motor Parameters using Multivariate Analysis and Kriging Interpolation Technique

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Received: 13/02/2018, Accepted: 12/06/2018

Abstract

The purpose of this study is to determine spatial pattern recognition of school performance based on children's anthropometric and motor skills component. This study involved 94 primary schools with a total 2237 male students aged 7.30±0.28 years in Pahang, Malaysia. The parameters of anthropometric (weight and height) and motor component included lower muscular power (standing broad jump), flexibility (sit and reach), coordination (hand wall toss) and speed (20 meter run) were selected. Cluster Analysis (CA) and Discriminant Analysis (DA) under Multivariate Method and technique of Kriging Interpolation in Geographic Interpolation Software (GIS) were used. CA revealed two clusters of school performance. There are a total 34 high performance schools (HPS) and 60 low performance schools (LPS). Then, the assigned groups were treated as independent variable (IV) while anthropometric and motor parameters were treated as dependent variable (DV) in DA. Standard mode of DA obtained 95.74% correctness of classification matrix with three discriminated variables (height, standing broad jump and 20 meter run) out of six variables. Meanwhile, forward and backward stepwise mode of DA discriminated only one (standing broad jump) out of six variables with 96.81% of classification correctness. The map output of Kriging interpolation has shown graphically the pattern of discriminated variables that greatly influence school performance. It exposed the ability of children motor skills development in particular region is higher than another region.

Keywords: Cluster analysis; discriminant analysis; kriging interpolation; multivariate analysis; pattern recognition.

Introduction

Motor skills are an integral part of the total development process, especially during the preschool years (Malina et al., 2004). Improper performance of motor fitness and social life during childhood can have a long-term negative impact on the optimal development of children (Faigenbaum et al., 2013; To et al., 2001). Several recent studies have supported the importance of early childhood for motor skill development (Rao et al., 2018; Filatova et al., 2017; Loprinzi et al., 2015; Payne and Isaacs, 2002). The development of children motor skill can be influenced by various factors such as guardians, family members, culture in general and the children's environment (Ramey et al., 1982). Environment factors including families, peers, socio-economic status, culture and community beliefs, technology resources, teachers and schools are also contributing to this development. Based on these factor, school was stand up as important source to improve motor performance starts from early age. The observed differences may be related to activity habits associated with school physical education and lifestyle in the respective communities. Mining of anthropometric and fitness data using multivariate analysis would classify homogenous school performance group, which will create meaningful clusters.

Cluster analysis is one of the multivariate methods widely used among researchers (Xu and Wunsch, 2005) and easy way for classifying groups (Aldenderfer and Blashfield, 1984). Samples in the same cluster have characteristics that are almost identical to each other, and are significantly different from those in other clusters. Mahalanobis et al. (1949) used this method in an anthropometrics survey of the united province. Vasulu and Pal (1989) also apply this method to study the relationship between anthropometric differentiation and cultural diversity among Yanadi communities in various parts of India. Rao et al. (2013) used this technique in the anthropometric data of 10096 children in 54 Uttar Pradesh districts and classified children in 4 groups according to their average height and weight. In this study, geographic clusterization of schools in a state of Malaysia based on anthropometric and motor skills performance of the children was carried out for determining the spatial pattern of school performance. It may help in identifying factors that have significant influence on the growth and development of children motor skills and to design and implement appropriate schools' specific strategies for prevention and control of children health-related.

Materials and Methods

Area of Study

This study had analysed data from a sports development program in Malaysia. It involved 94 primary schools in Pahang, Malaysia. Pahang is divided into 11 administrative districts. Administrative district boundaries are usually coextensive with local government area boundaries but may sometimes differ especially in urbanised areas. The school location is mapped onto Figure 1.

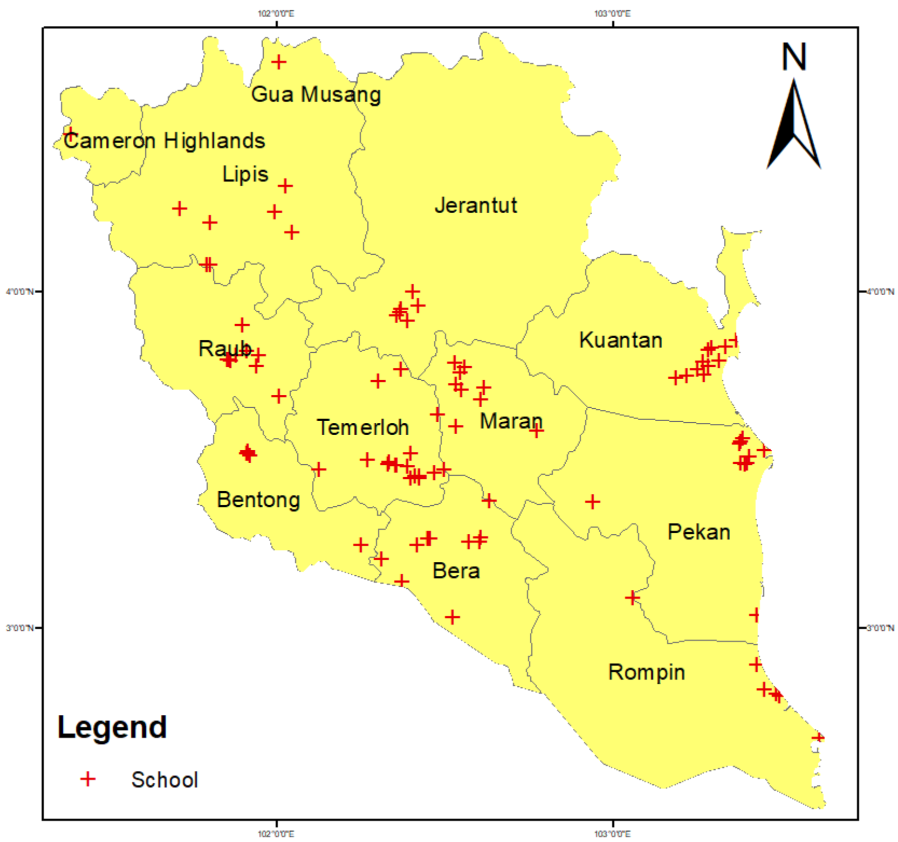

Figure 1. Location of school involved in this study

Participants and Testing Procedure

A total 2237 boys aged 7.30±0.28 years was selected from 93 primary schools in Pahang, Malaysia. They were tested on two anthropometric components (weight and height); and four motor subscales which is power, flexibility, speed and coordination. Procedures for anthropometric measurements and motor fitness tests in this study have been carried out as follows.

Anthropometrics
For basic measurement (height and weight), the equipment used included a stadiometer and a weighing scale. Height characteristics were measured to the nearest 0.1cm, and mass characteristic was measured in kg. Height was measured from fingertip to fingertip while standing with the back to a flat wall and arms stretched with palms facing the investigator. The equipment required consisted of a tape measure on the wall, measured in centimetre (cm).

Standing broad jump (SBJ)
The participant stood behind a line marked on the ground with feet slightly apart. A two-foot take-off and landing was used, with swinging of the arms and bending of the knees to provide forward drive. The participant attempted to jump as far as possible, landing on both feet without falling backwards. Three trials were allowed and the farthest was considered.

Twenty-meter speed test (20MR)
The participants running a single maximum sprint over a set distance, with time recorded. After a standardised warm up, the test was conducted over 20 meters. The starting position should be standardised, starting from a stationary position with a foot behind the starting line, with no

rocking movements. By using stopwatch equipment, the time to run each split distance (20 meter) were measured.

Sit and reach (SAR)
The participants sitting on the floor with legs out straight ahead and feet with shoes off are placed with the soles flat against the sit and reach box. Both knees are held flat against the floor by the investigator, if required. With hands on top of each other and palms facing down, the participant reaches forward along the measuring line as far as possible. The reach is held for at least two seconds while the distance is recorded. The investigator must make sure there are no jerky movements and the fingertips remain level with the legs flat. Readings must be recorded in multiples of 0.5 cm.

Hand Wall Toss (HWT)
A mark is placed a certain distance from the wall (1 meter). The participant stands behind the line and facing the wall. The ball is thrown from one hand in an underarm action against the wall, and attempted to be caught with the opposite hand. The ball is then thrown back against the wall and caught with the initial hand. The test continues for 10 attempts. The number of throws that were caught will be recorded.

Statistical Analysis

Pre-processing data
A matrix set of male group contains 7800 matrices data (6 variables × 2237 participants) were computed in this study. For matrices that have very small amounts of data lost (~ 3%) than the overall data recorded, the nearest neighbouring method can be used (Musa et al., 2016). This method examines the distance between each point and its nearest point. The nearest neighbouring method is the simplest method, where the endpoint of the gap is used as an estimate of all missing values.

Cluster Analysis (CA)
In this study, CA was employed to investigate the grouping of the participant's profile in a sport development program. Cluster analysis (CA) was employed to identify the grouping of the relative performance pattern (Mat-Rasid et al., 2017, Abdullah et al., 2016). CA is a robust method to identify and categorize components or subjects (observations/population) into clusters with greater homogeneity state within the class and greater heterogeneity state among classes with regard to a predetermined selection criterion (Abdullah et al., 2016b). Moreover, Ward's technique utilizing Euclidean distances as a degree of resemblance in HACA has shown to be a very effective technique. The finding is clarified by a dendrogram, giving the clusters and their closeness. However, the Euclidean distance which represents the quotient between the linkages distances alienated by the highest distance. The quotient is commonly multiplied by 100 to standardize the linkage distance signified by the y-axis.

Discriminant Analysis (DA)
DA was applied in this study to determine whether the groups vary with respect to the mean of a variable and to utilize that variable to predict school performance membership. The DA was put into the raw data using the standard, forward stepwise, and backward stepwise methods (Abdullah et al., 2016). These were used to construct DFs to evaluate relative performance variations based on anthropometrics and motor skill component. The relative performances of the school which is high performance school (HPS) and low performance school (LPS) were treated as dependent variables whereas all the assessed components institute as independent variables in DA. Similarly, in the forward stepwise mode, variables are counted in step by step starting with the utmost significant variable until no significant changes were obtained. In the backward stepwise mode, variables are removed step by step beginning with the less significant variable until no significant changes were obtained.

Kriging Interpolation

Kriging is a geostatistical interpolation technique that considers both the distance and the degree of variation between known data points when estimating values in unknown areas. A kriged estimate is a weighted linear combination of the known sample values around the point to be estimated. Kriging procedure generates an estimated surface from a scattered set of points with z-values. Kriging assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface. The Kriging tool fits a mathematical function to a specified number of points, or all points within a specified radius, to determine the output value for each location. The kriging formula formed as a weighted sum of the data as follow

$$\hat{Z}(s_o) = \sum_{i=1}^{N} \lambda_i Z(s_i) \quad (1)$$

Where $Z(s_i)$ the measured value at the ith location is, λ_i is an unknown weight for the measured value at the ith location, s_o is the prediction location and N is the number of measured values. All the analysis was run using ArcMAp 10 software.

Results

Table 1 shows the descriptive statistics of anthropometric and motor parameters among 2237 male students. It shows minimum and maximum scores, mean and standard deviations.

Table 1. Descriptive statistic of boy students of primary school involved in this study.

Variables	Observation	Min	Max	Mean	Standard Deviation
Weight (kg)	2237	15.00	29.00	20.98	3.14
Height (cm)	2237	105.0	132.5	118.4	5.29
SBJ (cm)	2237	67.0	153.0	109.2	17.07
SAR (cm)	2237	15.0	37.0	26.9	4.39
HWT (no.)	2237	1	10	6	2.76
20 M Run (s)	2237	3.54	6.05	4.79	0.48

The median value of each parameter was used in further analysis because they will give almost identical results. The median is the value separating the higher half of a data sample, a population, or a probability distribution, from the lower half. 50 percent of values are above it, and 50 percent below it. When the data is not symmetrical, this is the form of “average” that gives a better idea of any general tendency in the data. Contrarily, the mean value is calculated by adding together all the values, and then dividing them by the total number of values. This approach is fine if the data is symmetrically distributed. But the mean can still be thrown right out by a few extreme values, and if the data is not symmetrical (i.e. skewed) it can be downright misleading. Hence, condicering the median value will give almost identical results in this study.

Grouping of schools based on anthropometrics component and motor fitness

In this study, CA were applied to categorize 94 schools according to their level of performance. CA assigned two cluster of school performance. There are 34 schools were assigned in high potential school (HPS) and 60 schools were assigned in low potential school (LPS) as shown in Figure 2 and Figure 3.

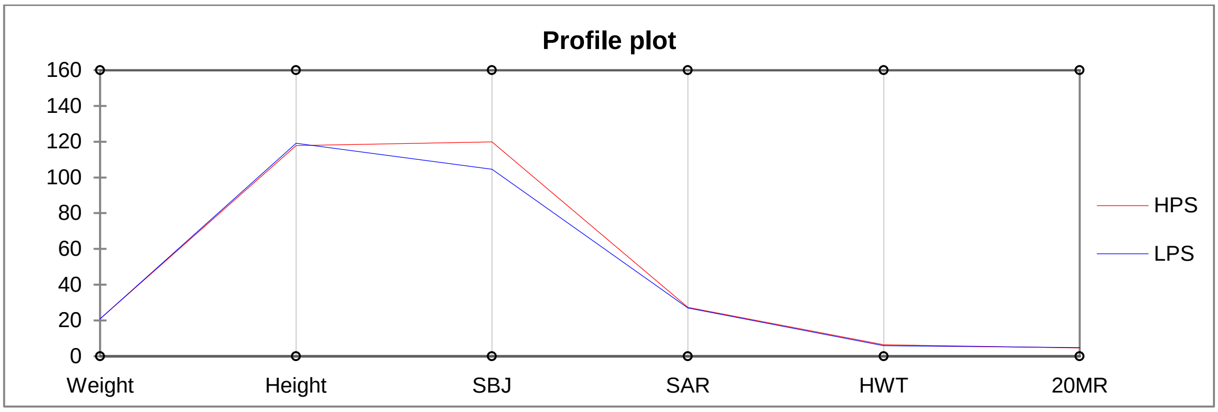

Figure 2. School profile plot of different clusters.

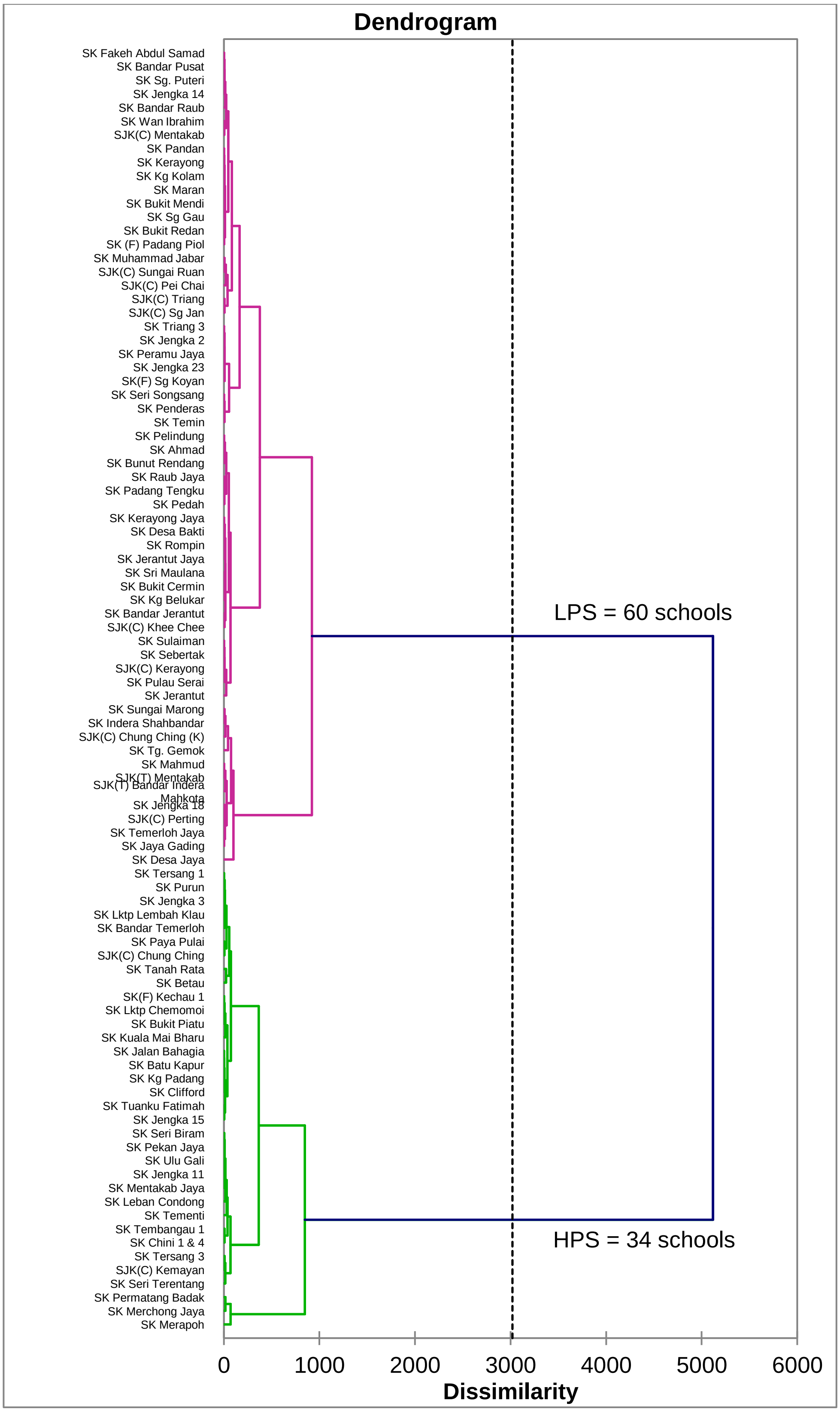

Figure 3. Dendrogram of different clusters of school performance.

DA was applied on the raw data post grouping of the schools into two main clusters/groups defined by CA. Groups of HPS and LPS were treated as dependent variables, while anthropometric and motor parameters were treated as independent variables. DA was carried out via standard, forward stepwise and backward stepwise methods. The accuracy of classification for studied group using standard, forward stepwise and backward stepwise mode DA were 95.74% (3 discriminant variables), 96.81% (1 discriminant variable1) and 96.81% (1 discriminant variable) respectively as shown in Table 2. Using standard mode, the parameters of height, standing broad jump and 20 meters run were found to be significant variables. Meanwhile, both forward and backward mode assigned the only standing broad jump parameter is significant with $p<0.05$.

Table 2. The classification correctness of school performance group

DA mode	from \ to	HPS	LPS	Total	% correct
Standard	3 discriminated variables				
	HPS	31	3	34	91.18%
	LPS	1	59	60	98.33%
	Total	**32**	**62**	**94**	**95.74%**
Forward (Stepwise)	1 discriminate variable				
	HPS	31	3	34	91.18%
	LPS	0	60	60	100.00%
	Total	**31**	**63**	**94**	**96.81%**
Backward (Stepwise)	1 discriminated variables				
	HPS	31	3	34	91.18%
	LPS	0	60	60	100.00%
	Total	**31**	**63**	**94**	**96.81%**

Mapping of Pattern Recognition of School Performance

Based on the previous result of CA and DA, three discriminate variables so-called height, standing broad jump and 20 meters run were selected to be demonstrated using simple kriging interpolation in Geographic Information System (GIS). The data of median value of each parameter with latitude and longitude for each school were key-in into ArcMap 10 Software. The map output from GIS shows the spatial variability of discriminate variables on map clearly (referred in Figure 4). The analysis of spatial variability suggest that the pattern of children's anthropometric and motor component has significant different regarding to the region where the school were located which means the spatial correlation may change under the influence of environment. The pattern shown in standing broad jump parameter clearly showed that the spatial variability in the north east part of Pahang is relatively lower than area in other part.

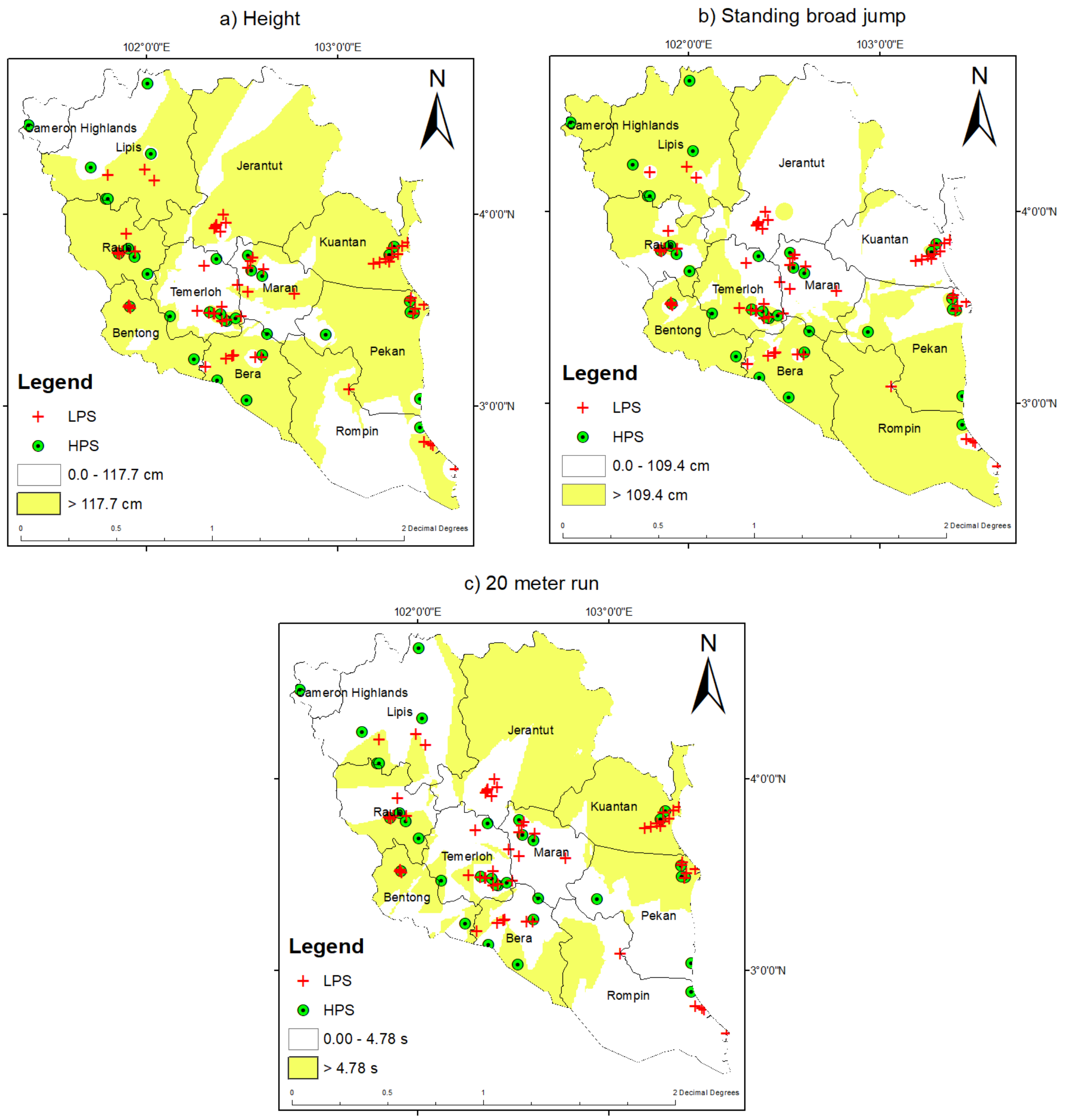

Figure 4. Spatial variability of discriminate variables at $p<0.05$ in Pahang, Malaysia a) height b) standing broad jump and c) 20 meter run.

Discussion

This study has successfully showed the spatial pattern recognition of school performance based on children's anthropometric and motor components. Our findings suggest that motor development of preschool-aged children is associated with the area where the child resides in. Most of the low performance school were found in Jerantut, Maran and Kuantan districts those located in north east of Pahang that can be categorized as urban area with high population density and infrastructure of built environment. The administrative district boundaries are usually coextensive with local government area boundaries; however, it sometimes may differ especially in urbanised areas. Urban development and population growth cause over-exploitation of residential and industrial areas. The limited space, less of interest, decline rate of outdoor activities can be factors of the decline rate in motor performance. Living in areas distinguished by size of the population can be attributed to differences in eating habits, access to sports facilities, and opportunities for physical fitness activities (Kabagambe et al., 2002;

Parks et al., 2003). Such factors indirectly can affect the motor abilities development of children in that area.

Present finding also confirmed schools play a major role in providing physical activities that help children to improve their physical and physiological health. Children in same residence are often involved in the same activities, but they have different daily routines involving physical activity. (DiPietro, 2001). Hence, school physical education must provide a context for regular and structured physical activity. The poorer training on hand use (drawing, playing with games, etc.), hand-eye coordination and others may probably contribute to the relative delay found in the fine motor abilities of the children. Much sensorial information is acquired by playing, when the toys act as tools with which the child develops their fine motor abilities (Hua et al., 2016; Stein et al., 2001). In this early period (during preschool years), the child's permanence in a favourable environment will facilitate a normal development and offer possibilities to a fine potential of exploration and interaction.

Finding in this study also found that an increased level of lower muscular fitness (standing broad jump) was associated with a higher speed ability. Figure 4 obviously showed schools children located in Kuantan, a district and capital of Pahang, Malaysia which is rapidly developing as a developed city has poor muscular strength and speed ability. Supported study has proved neighbourhoods and schools located in urban areas have poor motor abilities compared to rural children because of limited open play areas (Louie and Chan, 2003). Thus urban children have less alternatives to develop their gross motor skills for participating in some activities such as running and chasing. This exercise can give positive effect on children ability in speed.

However, present result is contrary with the previous study that claimed children live in urban area attained higher performance than suburban children (Giagazoglou et al., 2007). A possible explanation for the better performance of children who live in towns could be the increased number of working women. In urban areas, most children were attended day care centres and kindergarten from a very young age. Consequently, the activities that develop fine mobility are likely to be gained faster in day care centres and kindergarten due to daily practice (Felfe and Lalive, 2014; Giagazoglou et al., 2005). Besides, motor development is strongly associated with the stimulation level of the family environment (Ferguson et al., 2013). Children who have been raised in a stimulating home environment may possess a greater number and variety of toys. They may also be encouraged to develop skills, such as fine motor abilities, which will be useful for their later school performance. Haydari et al. (2009) suggested that improving motor skill are associated with the availability of more suitable toys provided.

Conclusion

As a conclusion, there are significant anthropometric, lower muscular strength and speed ability to differentiate school performance in Pahang, Malaysia. Spatial pattern recognition shown in this study supported environment factors such as residence area contributing to this difference. Thus, the assigned school with low performance were suggested to improve activities in physical education lesson so that children motor skill can be developed from school. Otherwise, the awareness among parents and teachers regarding to physical development and motor performance among children must be preferred.

Acknowledgments

The researchers thank the National Sports Institute of Malaysia for providing the research grant for the study (i1017-00005); Terengganu State Sports Council and Research and Development Management Unit, University of Sultan Zainal Abidin (UniSZA). The researchers also have no any conflict of interest to declare.

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How to cite this paper:
Abdullah, M.R., Aziz, I.A., Mat-Rasid, S.M., Juahir, H., Musa, R.M., Maliki, A. B. H. M., Kosni, N.A., Ayob, N., & Zawi, M.K. (2018). Spatial Pattern Recognition of School Performance Based on Anthropometric and Motor Parameters using Multivariate Analysis and Kriging Interpolation Technique *Malaysian Journal of Applied Sciences, 3*(1), 51-62.