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RESEARCH ARTICLE

BODY INDICES AND RATIO-TYPE DETERMINANTS OF PERFORMANCE POTENTIALS OF THE BANGLADESHI ADOLESCENT MALEATHLETES

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Abstract

The purpose of the present study was to investigate the different indices and ratio-type determinants of the performance potentials (PP) of the Bangladeshi adolescent male athletes. Primary data of size 414 were collected using multi-stage random sampling on PP and different anthropometric variables, and then several indices and ratio variables were calculated. Forward stepwise Ridge regression was applied to find out the most important determinants of PP of the Bangladeshi adolescent male athletes. Satisfying all the test and validity conditions, it was found that BMI (Body Mass Index) was the most important determinant among the considered indices and ratio variables. Other determinants of PP were RI (Rohrer's Index), SHIB (Sitting-Height Index of Build) and WsHtR (Waist to Height Ratio). The proposed equation can be applied for enhancing the PP of the athletes by the sport authorities in Bangladesh.

Introduction:-

Sport, nowadays, is regarded as a selective system by virtue of its competitive nature (Dawkins, 1990). One of the first selected characteristics is the physique. Accordingly, recruiting morphologically suitable athletes is common in most sports (Norton and Olds, 2001; Sedeaud et al., 2012). Some studies revealed a link between morphology and success in track and field (O'Connor et al., 2007; Pere et al., 1954).

Body proportions refer to the relationship in size and shape between different parts of the human body, which have been a subject of interest in fields such as art, anthropology, and sports science by playing a key role in our physical abilities, health status, and aesthetic appeal. They can also indicate a person's overall health status, physical fitness, and potential athletic abilities. These ratios or proportions are often referred to in various contexts by different terms. The term 'anthropometry' is commonly used in scientific and medical contexts, which refers to the systematic measurement of the physical properties of the human body and provides valuable insights into human growth, development, and variations across different populations and age groups primarily dimensional descriptors of body size and shape. For instance, the ratio of the length of the arms to the height of an individual is a type of body proportion**.**These ratios are more than just physical measurements, which provide an understanding of how body parts are structured relative to one another.It is needed to be cleared that body proportions and body composition are two distinct but interconnected concepts in the study of the human body. While body proportions refer to the relative

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sizes of different body parts, body composition is the proportion of fat, muscle, bone, and water in the body. Body composition is typically expressed as percentages of fat mass and lean body mass. It is a crucial factor influencing health, physical performance, and appearance. On the other hand, body proportions provide insights into the distribution of body parts and their relationship with one another, which can also affect performance and aesthetics. It's essential to note that while body composition can be modified through diet and exercise, body proportions are largely determined by genetics and cannot be significantly altered. Body proportions are significant for several reasons. In the realm of health, certain body proportions, such as waist-to-hip ratio and waist-to-height ratio, are associated with the risk of metabolic conditions like diabetes and cardiovascular diseases. These proportions can be used as predictive markers for health risks and to guide interventions. From a performance standpoint, specific body proportions can confer advantages in certain sports. For example, long limbs relative to body height can benefit athletes in sports that require reach, like swimming and basketball. Conversely, shorter limbs and a longer torso can provide leverage benefits in sports like weightlifting(Schinke, 2023).

Body proportionsare primarily determined by genetic factors, which dictate the growth rates of different bodyparts. However, environmental factors, such as nutrition and overall health during growth periods, can also influence these proportions. Metabolism does not directly affect body proportions. However, it can influence body composition, which in turn may impact the appearance of body proportions. For instance, a high metabolism could lead to lower body fat levels, making underlying muscle and bone structure more prominent. Thus, the body indices and ratios are supposed to be very important predictors of athletes' performance potentials. But it has never been heard or seen that such type of research were conducted in Bangladesh or on Bangladeshi athletes. Body Mass Index (BMI) is one of the energy indicators, definitely the most popular index relating weight and height, which allows the comparison of athletes. Rohrer's Index (RI) and Sitting-Height Index of Build (SHIB) are also energy indicators, based on weight and height. There are some other body indices and ratios, like Cormic Index (CI), Ape Index (ApeI), Waist to Height Ratio (WsHtR) and Waist to Hip Ratio (WsHpR). It cannot be denied that BMI was used by many researchers to study the characteristics of the athletes, but the remaining indices and ratios were not at all found to get included in such studies. Moreover, they studied mainly the descriptive statistics, correlation etc., but advanced studies like model building of performance potentials were not done. Therefore, an attempt is needed to be taken to build model for Performance Potentials (PP) of the athletes, particularly the adolescent male athletes, of Bangladesh so that their PP would be improved knowing the impact of body indices and ratios on it. Thus, the objective of the present study is to find out the determinants of PP through model building strategy.

Data and Methodology:-

Different anthropometric measurements from a sample of size 414 covering 25 Upazilas of 11 Districts under 4 Divisions of Bangladesh was collected through multi-stage random sampling. Performance potentials were measured according to Mawlaet al. (2023). For the test of consistency, results of descriptive statistics along with their standard errors and biases from Bootstrap Samplingmight be compared.

Body Indices and Ratios:

Measuring body indices and ratios require systematic approaches and accurate tools. Typically, anthropometric measures such as height, limb lengths, and circumferences of various body parts were taken. These were then used to calculate indices and ratios. To measure these accurately, a few tools are commonly used. These include anthropometric tape for measuring circumferences, weighing scale for measuring body mass, and stadiometer for measuring height. It's crucial to follow standardized techniques for measurement to ensure accuracy and repeatability. All the related anthropometric measurements were taken by using recommended and appropriate instruments and methods (ISAK, 2019), and then some of the indices and ratios of our interests were calculated as follows:

Body Mass Index, $\mathrm{BMI} = \frac{\mathrm{Weight}}{(\mathrm{Height}\ )^2}\,\mathrm{kg/m^2}$(Nuttall, 2015);

Rohrer's Index (or Corpulence Index), $\mathrm{RI} = \frac{\mathrm{Weight}}{(\mathrm{Height}\ )^3}\,\mathrm{kg/m^3}$(Nahler, 2009);

Sitting-Height Index of Build, $\mathrm{SHIB} = \frac{\mathrm{Weight}}{(\mathrm{SittingHeight}\ )^3}\,\mathrm{kg/m^3}$(Burton, 2018);

Cormic Index, $\mathrm{CI} = \frac{\mathrm{SittingHeight}}{\mathrm{Height}} \times 100$(Adeyemi et al., 2009; Ukwuma, 2009);

Ape Index, $\mathrm{ApeI} = \frac{\mathrm{ArmSpan}}{\mathrm{Height}}$(Cherif et al., 2022);

Waist to Height Ratio, WsHtR = $\frac{\text{WaistGirth}}{\text{Height}}$(Ashwell, 2005);
Waist to Hip Ratio, WsHpR = $\frac{\text{WaistGirth}}{\text{HipGirth}}$(Shackelford, 2016).

Irregular noises of the data were removed by 4253H, Twice Resistant Smoothing method (Velleman, 1980; Velleman and Hoaglin, 1981). After checking normality and linearity assumptions, Forward Stepwise regression method might be applied for determining the predictors of PP of Bangladeshi adolescent male athletes (Montgomery et al., 2013). If the predictors are inter-correlated, then Forward Stepwise Ridge Regression might be useful (Khalaf, 2022). For the post-test normalityplot of residuals, scatterplot of observed and predicted values of PP, adj.R^2 and cross-validity predictive power ρ^2_{cv} were investigated and judged whether the model fitting is significant and valid or not (Ali and Ohtsuki, 2001; Rahman et al., 2004; Mawla et al., 2023). Sophisticated statistical softwareslike Minitab, SPSS, STATISTICA, etc. were used for the purposes.

Results and Discussion:-

Descriptive statistics (location and scale parameters) and shape characteristics of the anthropometric variables together with their results from resistant smoothing (within parentheses) are shown in Table-1. It is seen from the table that all the estimates obtained from the sample (of size 414) are almost similar i.e., biases are very negligible as compared to the estimates obtained from the re-sampling, which are equivalent to estimates obtained from 1,000 Bootstrap sample of size 414. Thus, the sample can be regarded as highly valid, reliable and consistent. On average, height, weight, sitting height, arm span,waist girth, and hip girth of the Bangladeshi adolescent male athletes were163.86$\pm$0.402 cm, 51.12$\pm$0.491 kg, 85.86$\pm$0.221 cm, 168.82$\pm$0.410 cm, 66.83$\pm$0.346 cmand 83.35$\pm$0.304 cm, respectively. A study on Indian male students of 16 year revealed that height,weight, and sitting heightwere165.18±4.65 cm, 50.54±6.24 kg and 86.58$\pm$2.55 cm respectively (Sarkar, 2012), which indicates that on average Bangladeshi male adolescents were shorter but heavier than the Indian male adolescents. School Boys of 14 years of age were of height, weight, and sitting height 161.62$\pm$6.93 cm, 49.13$\pm$10.50 kg and 84.15$\pm$4.00 cm, respectively (Koner, 010) shows that Bangladeshi male adolescents were taller and heavier than Indian male adolescents.Mean height and weight of higher secondary boys in rural India were observed as 165.38 cm and 51.64 kg, respectively (Ghosh, 2012), which was very close to the findings of this study. According to the study of Sinha (2013), 16 years aged non-tribal Bengalee Indian boy of Tripura were of almost same height (163.5$\pm$2.8 cm), but much lighter (46.3$\pm$2.4 kg) as compared to the Bangladeshi adolescent male athletes.BurdwaniBengalee adolescent male athletes were of average height of 163.4$\pm$5.978 cm and weght of 45.8$\pm$7.223 (Dasgupta, 2007), that means our adolescent male athletes were of almost similar in height and 5 kg heavier than them.

Table 1:- Descriptive statistics of the anthropometric variables together with them from resistant smoothing (within parentheses) and their comparison with those obtained from bootstrap sampling.

Anthropometric Measurement n = 414	Descriptive Statistic	Estimate	S.E.	Re-sampling Estimate (Based on 1,000 Bootstrap Samples)			
				Bias	S.E.	95% C.I.	
						Lower	Upper
Height (in cm)	Mean	163.86 (164.46)	0.402 (0.209)	-0.007 (-0.005)	0.413 (0.215)	162.98 (164.02)	164.72 (164.87)
	S.D.	8.177 (4.247)	---	-0.019 (-0.002)	0.362 (0.167)	7.427 (3.921)	8.838 (4.566)
Minimum = 130.8 (149.7)	Skewness	-0.889 (-0.345)	0.120 (0.120)	0.009 (0.003)	0.134 (0.154)	-1.132 (-0.633)	-0.611 (-0.038)
Maximum = 181.2 (178.6)	Kurtosis	1.190 (0.613)	0.239 (0.239)	-0.032 (-0.021)	0.448 (0.313)	0.401 (0.009)	2.146 (1.251)
Weight(in kg)	Mean	51.12 (50.83)	0.491 (0.250)	-0.002 (-0.002)	0.480 (0.252)	50.18 (50.34)	52.05 (51.36)
Minimum = 27.0 (37.2)	S.D.	9.979 (5.090)	---	-0.024 (-0.015)	0.539 (0.384)	8.946 (4.433)	11.009 (5.898)
Maximum = 94.5 (88.4)	Skewness	0.742 (1.045)	0.120 (0.120)	-0.026 (-0.149)	0.243 (0.716)	0.216 (-0.237)	1.149 (2.259)
	Kurtosis	2.673 (7.355)	0.239 (0.239)	-0.112 (-1.249)	0.702 (4.413)	1.131 (-0.134)	3.891 (13.950)

Sitting Height (in cm)	Mean	85.86 (86.24)	0.221 (0.111)	-0.001 (0.001)	0.221 (0.111)	85.42 (86.02)	86.32 (86.46)
	S.D.	4.494 (2.264)	---	-0.013 (-0.002)	0.195 (0.104)	4.108 (2.065)	4.846 (2.476)
Minimum = 68.7 (77.0)	Skewness	-0.910 (-0.734)	0.120 (0.120)	0.004 (-0.003)	0.115 (0.208)	-1.139 (-1.123)	-0.666 (-0.323)
Maximum = 95.3 (94.5)	Kurtosis	1.083 (1.669)	0.239 (0.239)	-0.009 (-0.026)	0.384 (0.569)	0.384 (0.569)	1.904 (2.834)
Arm Span (in cm)	Mean	168.82 (169.41)	0.410 (0.219)	-0.010 (-0.006)	0.424 (0.227)	167.94 (168.96)	169.67 (169.85)
	S.D.	8.335 (4.448)	---	-0.020 (-0.001)	0.355 (0.160)	7.601 (4.140)	9.002 (4.748)
Minimum = 136.3 (154.6)	Skewness	-0.819 (-0.204)	0.120 (0.120)	0.009 (0.002)	0.129 (0.132)	-1.056 (-0.460)	-0.553 (0.037)
Maximum = 188.7 (183.0)	Kurtosis	0.962 (0.191)	0.239 (0.239)	-0.028 (-0.016)	0.403 (0.250)	0.231 (-0.290)	1.850 (0.698)
Waist Girth (in cm)	Mean	66.83 (66.37)	0.346 (0.166)	0.003 (0.001)	0.337 (0.166)	66.21 (66.06)	67.53 (66.72)
	S.D.	7.038 (3.374)	---	-0.012 (-0.008)	0.397 (0.225)	6.270 (2.963)	7.869 (3.890)
Minimum = 50.9 (58.1)	Skewness	1.202 (1.125)	0.120 (0.120)	-0.029 (-0.127)	0.218 (0.631)	0.720 (0.014)	1.566 (2.186)
Maximum = 99.7 (90.6)	Kurtosis	3.265 (6.505)	0.239 (0.239)	-0.147 (-1.084)	0.844 (3.971)	1.512 (-0.078)	4.817 (12.225)
Hip Girth (in cm)	Mean	83.35 (83.19)	0.304 (0.155)	-0.001 (-0.001)	0.298 (0.156)	82.76 (82.90)	83.92 (83.52)
	S.D.	6.185 (3.158)	---	-0.015 (-0.009)	0.328 (0.231)	5.559 (2.759)	6.815 (3.647)
Minimum = 68.0 (74.6)	Skewness	0.669 (0.962)	0.120 (0.120)	-0.024 (-0.138)	0.239 (0.691)	0.159 (-0.273)	1.079 (2.152)
Maximum = 109.9 (106.1)	Kurtosis	2.507 (6.845)	0.239 (0.239)	-0.101 (-1.131)	0.663 (4.149)	1.049 (-0.140)	3.682 (13.235)

Body index and ratio variables were measured accordingly. Table-2 shows that biases of the estimates in all the cases are very negligible. Hence, it can be said that sampling was biased-free. Mean of BMI got the value of 18.76 $\mathrm{kg/m^2}$, that of RI, SHIB, CI, ApeI, WsHtR and WsHpRwas 11.41 $\mathrm{kg/m^3}$, 79.07 $\mathrm{kg/m^3}$, 52.44, 1.030, 0.404 and 0.798, respectively. A study found that BMI of Indian male students of 16 years was 18.49$\pm$1.91 (Sarkar, 2012), which that Bangladeshi male adolescents are of higher BMI than that of Indians. Das (2013) found BMI of the school boys of age 13-14 of West Bengal, India as 18.04$\pm$4.38 i.e., lower than Bangladeshi adolescent male athletes' average BMI.Koner's (2010) study suggested that mean BMI of the studied Bangladeshi male adolescents were almost similar to the BMI (18.72$\pm$3.38) of Indian male adolescents of 14 years. Ghosh (2012) calculated mean BMI of higher secondary boys of rural India as 18.86$\mathrm{kg/m^2}$, which is approximately the same with the mean BMI of Bangladeshi male adolescents.

The very low value of S.E. indicates the consistent results in the population might be addressed. This is in accord with the results of 1000 Bootstrap samples. The low length of confidence interval of average indices and ratios implied insignificant sampling fluctuations. So, our results indicated highly robustness in the index and ratio variables estimates.

Table 2:- Descriptive statistics of the calculated body index and ratio variables of the athletes.

Body Index and Ratio n = 414	Descriptive Statistic	Estimate	S.E.	Re-sampling Estimate (Based on 1,000 Bootstrap Samples)			
				Bias	S.E.	95% C.I.	
						Lower	Upper
Body Mass Index	Mean	18.76	0.063	0.000	0.064	18.64	18.89

(BMI)	S.D.	1.282	---	-0.003	0.090	1.130	1.465
Minimum = 15.5	Skewness	1.146	0.120	-0.107	0.562	0.189	2.103
Maximum = 27.7	Kurtosis	5.757	0.239	-0.918	3.572	-0.054	11.051
Rohrer's Index (RI)	Mean	11.41	0.035	0.000	0.036	11.33	11.48
Minimum = 9.6	S.D.	0.721	---	-0.000	0.039	0.650	0.800
Maximum = 15.5	Skewness	0.768	0.120	-0.039	0.319	0.234	1.379
	Kurtosis	2.524	0.239	-0.278	1.630	0.075	5.457
Sitting-Height Index of	Mean	79.07	0.218	-0.006	0.221	78.62	79.51
Build (SHIB)	S.D.	4.429	---	-0.017	0.279	3.903	4.998
Minimum = 60.5	Skewness	0.589	0.120	-0.047	0.440	-0.289	1.430
Maximum = 104.8	Kurtosis	3.978	0.239	-0.330	1.651	0.766	6.896
Cormic Index (CI)	Mean	52.44	0.036	0.002	0.036	52.38	52.52
Minimum = 50.29	S.D.	0.737	---	-0.001	0.026	0.687	0.788
Maximum = 54.56	Skewness	0.029	0.120	0.004	0.100	-0.154	0.237
	Kurtosis	0.129	0.239	-0.015	0.182	-0.218	0.468
Ape Index (ApeI)	Mean	1.030	0.000	-0.000	0.000	1.030	1.030
Minimum = 1.02	S.D.	0.004	---	-0.000	0.000	0.004	0.004
Maximum = 1.04	Skewness	-0.141	0.120	0.005	0.103	-0.335	0.072
	Kurtosis	-0.276	0.239	-0.010	0.195	-0.655	0.120
Waist to Height Ratio	Mean	0.404	0.001	0.000	0.001	0.402	0.405
(WsHtR)	S.D.	0.017	---	-0.000	0.001	0.016	0.019
Minimum = 0.36	Skewness	0.758	0.120	-0.052	0.381	0.100	1.460
Maximum = 0.51	Kurtosis	2.977	0.239	-0.378	2.017	-0.085	6.475
Waist to Hip Ratio	Mean	0.798	0.001	0.000	0.001	0.796	0.799
(WsHpR)	S.D.	0.017	---	-0.000	0.001	0.016	0.018
Minimum = 0.75	Skewness	0.195	0.120	-0.006	0.120	-0.043	0.425
Maximum = 0.85	Kurtosis	0.264	0.239	-0.012	0.223	-0.179	0.733

Model Building:
The primary necessity for any higher statistical analysis is the normality assumption of the dependent variable. Figure-1 shows that the distribution of PP is approximately normal. Therefore, next attempts can be made.

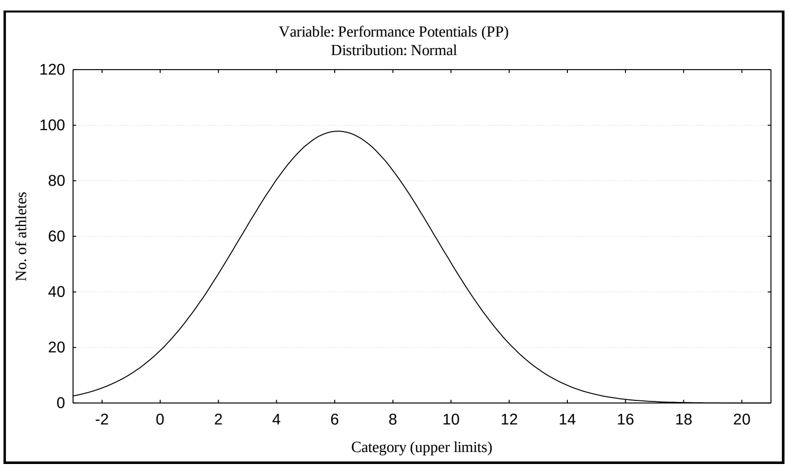

Figure 1:- Shape of the distribution of the Performance Potentials (PP) of the athletes. This figure is reused with the permission of Mawla et al. (2023).

Next step is to study the correlation with the type and significance (as shown in the Table-3). Whenever, correlation exists and is found to be significant the investigation is needed to explore the linearity of the relationship among the variables (as shown in the Figure-2).

Table-3 shows that PP is highly significantly correlated with all the calculated body index and ratio variables, except ApeI. Therefore, a regression model of PP can be fit on BMI, RI, SHIB, CI, WsHtR and WsHpR for the improvement of PP of the athletes. Furthermore, all the body index and ratio variables are also significantly correlated among themselves. It means that a severe multi co-linearity problem is present there. So, we should select a regression technique which can provide us a valid regression model by overcoming the prevailing multi co-linearity problem. Figure 2, scatterplot matrix of PP and body index and ratio variables, presents the type of relationship among the variables. The types of some of the relationship are linear and some other can be regarded as approximately linear. Hence, we must select a technique in which linearity assumption is a must and which is capable of providing a valid regression model by eliminating multi co-linearity problem. We know that stepwise regression is a method, which iteratively examines the statistical significance of each of the predictors in a linear regression model. We also know that forward stepwise regression is a stepwise regression approach that starts from the null model and adds a variable that improves the model the most, one at a time, until the stopping criteria is met. When the independent variables are highly intercorrelated, stable estimates for the regression coefficients cannot be obtained via ordinary least squares (OLS) methods (Hoerl, 1962; Rozeboom, 1979). In the presence of multicollinearity, Ridge regression technique result in estimated coefficients that are biased but have smaller variance than OLS estimators and may, therefore, have a smaller mean square error (Khalaf, 2022). Since, Ridge regression artificially decreases the correlation coefficients so that more stable estimates can be computed, therefore, Forward Stepwise Ridge Regression can be supposed to be the most appropriate here.

Table 3:- Correlation matrix of PP and Body Index and Ratio variables of the Athletes.

	PP	**BMI**	**RI**	**SHIB**	**ApeI**	**CI**	**WsHtR**	**WsHpR**
PP	1.000 ---							
BMI	0.394 (p=0.000)	1.000 ---						
RI	0.388 (p=0.000)	0.926 (p=0.000)	1.000 ---					
SHIB	0.342 (p=0.000)	0.766 (p=0.000)	0.758 (p=0.000)	1.000 ---				
ApeI	-0.029 (p=0.563)	-0.221 (p=0.000)	-0.243 (p=0.000)	0.234 (p=0.000)	1.000 ---			
CI	0.138 (p=0.005)	0.359 (p=0.000)	0.480 (p=0.000)	-0.205 (p=0.000)	-0.694 (p=0.000)	1.000 ---		
WsHtR	0.369 (p=0.000)	0.880 (p=0.000)	0.934 (p=0.000)	0.698 (p=0.000)	-0.245 (p=0.000)	0.467 (p=0.000)	1.000 ---	
WsHpR	0.293 (p=0.000)	0.660 (p=0.000)	0.753 (p=0.000)	0.538 (p=0.000)	-0.187 (p=0.000)	0.416 (p=0.000)	0.893 (p=0.000)	1.000 ---

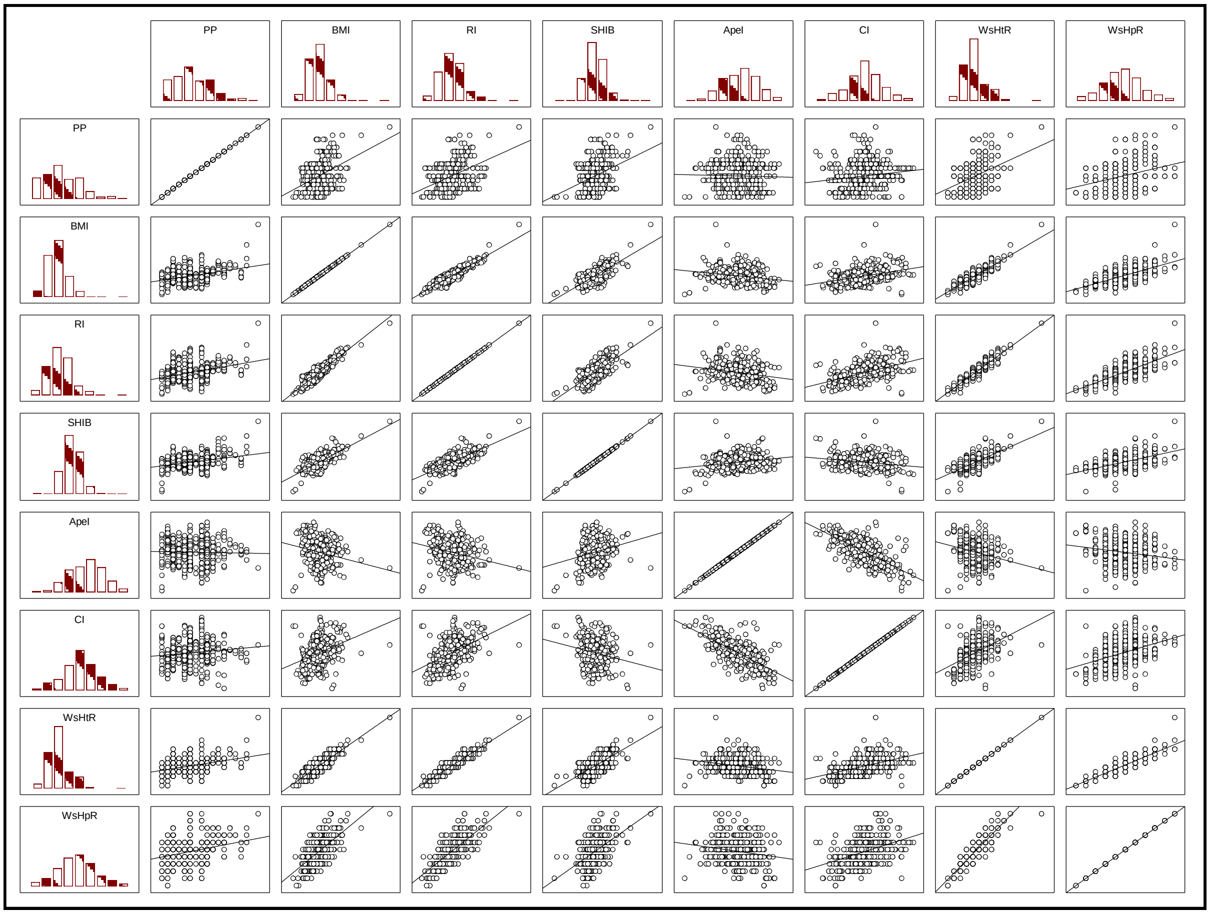

Figure 2:- Scatterplot matrix of PP and Body Index and Ratio variables of the athletes.

Forward Ridge Regression Model of PP on Body Index and Ratio Variables:

$$PP = 0.235 * BMI + 0.226 * RI + 0.206 * SHIB + 0.196 * WsHtR$$
$$(p = 0.000) \quad (p = 0.001) \quad (p = 0.002) \quad (p = 0.003)$$
$$n = 414,\ adj.\ R^2 = 0.7618,\ \rho^2_{cv} = 0.7565,\ F = 332.06\ (p = 0.000).$$

The above equation includes 4 out of the 6 body indices and ratios (variables): BMI, RI, SHIB, and WsHtR (and excludes CI and WsHpR). The fitted model of PP shows that all the regression coefficients are positive and highly significant. It implies that if the effect of remaining 3 indices and ratios can be kept fixed then the value of PP will be increased by 0.235 units by an increment of 1 $kg/m^2$of BMI. Under the similar conditions, PP will be increased by 22.6%, 20.6% and 19.6% of 1 unit if RI, SHIB and WsHtR will be increased by 1 unit, respectively. The values of adj. R^2 and ρ^2_{cv}were very close to each other, therefore, the fitted model is highly cross-valid. Since, more than 76% of the variation in response is explained by the predictors, hence, we can also say that fitting of the model of PP on body index and ratio variables of the athletes is moderately good. Observing the graph, it can be said that residuals are approximately normally distributed (Figure-3a). We see that the predicted and observed values tried to lie as close as possible to the trend line of scattered plot (Figure-3b), which is definitely the indication of a moderately good fit of the model.

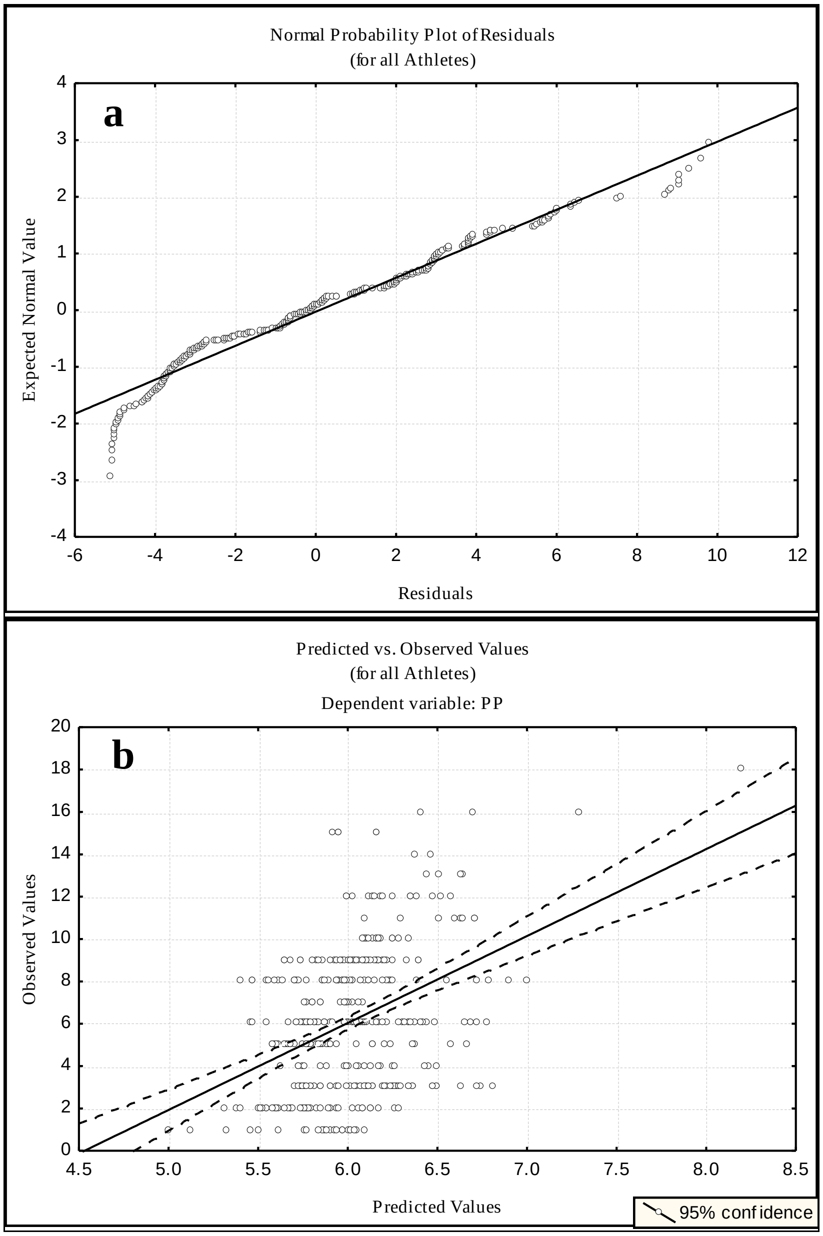

Figure 3:-a) Normal probability plot of residuals; b) Scatterplot of observed and predicted values of PP.

Mawla et al. (2023) proposed the following equation for determining PP on somatotype components. Their proposed equation was:

$$PP = 0.434 * Endomorphy + 0.413 * Mesomorphy$$

($p = 0.000$) ($p = 0.000$)

$n = 414$, adj. $R^2 = 0.7427$, $\rho^2_{cv} = 0.7396$, $F = 598.52$ ($p = 0.000$)

Comparing our fitted equation of Performance potentials with that of Mawla et al (2023), which was based on the somatotype components, we can point out the following: i) from the view point of the values of adj. R^2 and cross-validity predictive power, ρ^2_{cv}, both equationswere almost equally efficient, although proposedequation is somewhat better; ii) number of determinants in this equation is 4, whereas that in Mawla et al. (2023) was only 2, which is the indication of more flexibility of explaining variations of PP here; iii) to calculate the considered indices and ratios, only 5 anthropometric measurements were needed (namely, height, weight, sitting-height, waist girth, and hip girth), whereas for calculating the somatotype components a total of 10 anthropometric measurements were needed (namely, height, weight, humerus breadth, femur breadth, arm girth, calf girth, triceps skinfold, subscapular skinfold, supraspinale skinfold, and medial-calf skinfold), which indicates that this equation involves much fewer labour; iv) the calculation of the indices and ratios were very simple, whereas that of the somatotype components involved highly technical and conditional equations. Therefore, it can be said that this equation, as easy to build and less time might be consumed,is much easier and efficient, and hence suggested or recommended to use.

Conclusion:-

Primary data on Performance Potentials (PP) and anthropometric variables were measured accordingly. On average, the Bangladeshi adolescent male athletes were 163.86$\pm$0.402 cm in height, 51.12$\pm$0.491 kg in weight, 85.86$\pm$0.221 cm in sitting height, 168.82$\pm$0.410 in arm span, 66.83$\pm$0.346 cm in waist girth and 83.35$\pm$0.304 cm in hip girth. The mean$\pm$S.E. of BMI, RI, SHIB, CI, ApeI, WsHtR and WsHpR were 18.76$\pm$0.063$\mathrm{kg/m^2}$, 11.41$\pm$0.035$\mathrm{kg/m^3}$, 79.07$\pm$0.218$\mathrm{kg/m^3}$, 52.44$\pm$0.036, 1.030$\pm$0.000, 0.404$\pm$0.001 and 0.798$\pm$0.001, respectively. The very low value of S.E. indicates the consistent results in the population might be addressed. This is in accord with the results of 1000 Bootstrap samples. The low length of confidence interval (CI) of average body indices and ratios implied insignificant sampling fluctuations. So, our results indicated highly robustness in the calculation of indices and ratios.

The stepwise Ridge regression suggested that four body indices and ratios are enough to explain the performance potentials (PP) of the adolescent male athletes of Bangladesh, and the valid equation is

$$PP = 0.235 * BMI + 0.226 * RI + 0.206 * SHIB + 0.196 * WsHtR$$

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