Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/17475
DOI URL: http://dx.doi.org/10.21474/IJAR01/17475

RESEARCH ARTICLE

PERFORMANCE POTENTIALS ON SOMATOTYPE COMPONENTSOF THE BANGLADESHI ADOLESCENT MALEATHLETES

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Manuscript Info

Manuscript History
Received: 27 June 2023
Final Accepted: 31 July 2023
Published: August 2023

Key words:-
Performance Potentials, Somatotype Components, Adolescent Male Athletes, Stepwise Ridge Regression, Cross Validity Predictive Power and Model Building

Abstract

The purpose of the present study was to investigate the somatotype 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 somatotype components were calculated. Forward stepwise Ridge regression was applied to find out the most important determinants of PP. Satisfying all the test and validity conditions, it was found that endomorphy and mesomorphy variables were the most important determinants of PP of the Bangladeshi adolescent male athletes. The proposed equation can be applied for enhancing the PP of the athletes by the sport authorities in Bangladesh.

Introduction:-

The technique of somatotyping is used to appraise shape and composition of body. The somatotype is defined as the quantification of the present shape and composition of the human body. It is expressed in a three-number ratings, representing endomorphy, mesomorphy and ectomorphy components, always in the same order. The relative fatness is termed as endomorphy, the relative musculo-skeletal robustness is called mesomorphy, and the relative linearity or slenderness of a physique is known as ectomorphy. For example, a3-5-2 rating is recorded in this manner and is read as three-five-two, which give the magnitude of each of the three components. Ratings on each component of 0.5-2.5 are considered low, 3.0-5.0 are moderate, 5.5-7.0 are high, and 7.5 and above are very high (Carter and Heath, 1990). The rating is applicable to both genders from childhood to old age, which is phenotypical and based on the concept of geometrical size-dissociation (Carter, 1996; Ross et al, 1999).Cureton (1954) tested 55 middle aged athletic champions and compared them with 400 middle aged and normal young men. He showed that the former were more mesomorphic and more linear in skeletal build.Porter (1958), following the Sheldon's technique, compared the somatotypes of 50 explorers and 88 normal school boys. Explorers were significantly less endomorphic and more ectomorphic than the control group but there was little difference in mesomorphy. He explained that the challenge of physical efforts and discomfort appealed particularly to the type of person whose physique was relatively high in ectomorphy and low in endomorphy.Parnell (1958) showed that sprinters tended to be endomorphic-mesomorph, while distance runners, long jumpers and high jumpers were more ectomorphic in build.Tanner’s (1964) findings on track and field competitions of the athletes are supposed to be outstanding till date. He studied 137 athletes in Olympics and Common Wealth Games. There were marked differences in somatotype distribution between competitions in different events. The throwers had somatotype around 3-6-2 or 3.5-

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6-2. The track athletes and jumpers, on the other hand, had somatotype mostly ranging between 2-5-3 and 2-3-5. The average somatotype of the sprinters was 2.5-5.5-3, of the 400 m runners 2.5-4.5-4 of the 1500 m.Carter (1970) found that San-Diego state and high school runners showed high rating of endomorphy, low mesomorphy and slightly higher ectomorphy than Olympic runners. Furthermore, Olympic runners were found to be smaller and lighter than San-Diego runners. Somatotype was found to be selective factor in distance running.Carter et al. (1982) somatotyped the track and field athletes of Montreal Olympic Games. They reported the somatotype of male track and field athletes as 1.7 -5.0- 2.9. They were found as ecto-mesomorphs.Sodhi et al. (1996) conducted a study on track and field athletes of Nepal (n=237). Marathoners were lightest and shortest with 54.2 Kg weight and 167.3 cm height. Discus, hammer and shot put throwers were heaviest (70.41 Kg) and 110 m hurdlers were tallest with 177.4 cm. Athletes of Nepal were found to be lighter, shorter, more endomorphic and less mesomorphic as compared with Olympians (De. Garay 1974).Kaul et al. (1997) reviewed somatotype studies on sports persons of India. He discussed patterns of somatotype changes according to various sports events at different levels of competitions.Kaur (2000) investigated 260 trainers of team and individual game in relation to somatotype. It was observed that the mean somatotype of athletes were 2.02-4.2-2.95.Somatotypes of Indian and Olympic male athletes were reviewed by Kaur et al. (2002). Results of which indicated that track sports were out of the desired circle of somatotype components. Lai (2005) studied the somatotype of male sprinters, middle distance runners and long distance runners of Himachal Pradesh University. He found that sprinters, middle distance runners and long distance runners had somatotyping rating 1.72-3.29-3.17, 1.63-3.10-3.39, and 1.55-3.04-3.54, respectively. Sprinters were in significant differences in all components of somatotyping from long distance runners. However, they did not differ significantly in all components of somatotyping from the middle distance runners, whereas,long-distance runners did not differ significantly in all three components of somatotyping frommiddle distance runners.Singh et al. (2008) found out the differences among the somatotypes of various groups of inter university male throwers and long distance runners. The throwers were found heavier and taller as compared to long distance runners. The endomorphy and mesomorphy components have been noticed maximum in throwers (shot-put throwers followed by discus and javelin throwers) followed by runners. The inter-university athletes were found more endomorphic and less mesomorphic, as compare to the elite Indian athletes and Olympic level athletes.

Tønnessen et al. (2015) used mixed model with random intercept on 100 adolescent track and field athletes in a study of performance development. They found that relative annual performance gradually increases after age of 12 and gradually declines approaching 18 years of age.Blume and Wolfarth (2019) investigated potential performance-related predictors in 96 young athletes. They found that regulation of training and modification of intensities were the required predictors.

Reviewing the literatures, it is revealed that somatotype components are very important predictor 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. Furthermore, all the research works mentioned above are of some descriptive findings or based on simple test of hypothesis. 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 through the improvement of its determinants. Thus, the objective of the present studyis to find out the determinants of PP through model building strategy.

Data and Methodology:-

To meet the objective of the study a nationally representing sample is a must. Unfortunately, no such work is done here in Bangladesh by the Government or research oriented NGOs. Since, secondary data is unavailable, primary data is essential here. Facing the hard reality and difficulties along with the huge personal financial involvement, a nationally representative sampling is eventually done by the researcher. Since, no sampling frame of the adolescent athletes was available; aMulti-Stage Random Sampling was conducted. The administrative Divisions, Districts, and Upazilas were regarded as the 1st, 2ndand 3rdstage sampling units, respectively, and the educational institutions (High Schools) were considered4thstage or primary sampling units for the purpose.

A questionnaire was prepared in which all the relevant variables were included. After completing the painstaking sampling all the information were inputted into the computer and then by using sophisticated statistical softwares like Minitab, SPSS, STATISTICA, etc. were used to get the appropriate outputs.

To get rid of the noisy errors, 4253H, TwiceResistant Smoothing technique was applied to the raw data. Then the analyses were done. For the test of consistency, results of descriptive statistics along with their standard errors and biases from Bootstrap Sampling might be compared.

The anthropometric somatotype:
It is to be noted that all the anthropometric measurements were taken by using recommended and appropriate instrumentsand methods (ISAK, 2019). Now it is needed to compute the somatotype components from the obtained anthropometric measurements of the athletes. For calculating the somatotype components, the following equations were used(Carter, 1996):

$$Endomorphy = -0.7182 + 0.1451 * X - 0.00068 * X^2 + 0.0000014 * X^3$$

$$Mesomorphy = (0.858 * HB + 0.601 * FB + 0.188 * CAG + 0.161 * CCG) - (0.131 * H) + 4.5$$

$$Ectomorphy = \begin{cases} 0.732 * HWR - 28.58 & ; if\ HWR \geq 40.75 \\ 0.463 * HWR - 17.63 & ; if\ 38.25 < HWR < 40.75 \\ 0.1\ (or\ recorded\ as\ 0.5) & ; if\ HWR \leq 38.25 \end{cases}$$

Where, $X = (Triceps\ SF + Subscapular\ SF + Supraspinale\ SF) * (170.18/H)$

$SF = Skinfold, H = Height, W = Weight, HWR = H/(W)^{1/3}$

$HB = Humerus\ Breadth, FB = Femur\ Breadth$

$CAG = Corrected\ Arm\ Girth = Flexed\ Arm\ Girth - Triceps\ SF/10$

$CCG = Corrected\ Calf\ Girth = Maximal\ Calf\ Girth - Calf\ SF/10$

Model Building:
For the purpose of model building the dependent variable is taken to be the Performance Potentials (PP) of the athletes, which is an ordinal variable with the values 1-18 (1 being the school level 3rd to 18 being the international level 1st). The levels of competitions in ascending orders are: school, upazila, district, division, national, and international.

To build model, we must check the normality and linearity assumptions of the dependent variable. Accordingly, we can select the linear or non-linear model to fit. The noisy-irregular pattern can be removed by using smoothing method. The well-known and most popular valid method is 4253H, Twice Resistant Smoothing method (Velleman, 1980; Velleman and Hoaglin, 1981). The most popular method for screening the most important determinants is Forward Stepwise regression method (Montgomery et al., 2013). If the explanatory variables are inter-correlated, then Forward Stepwise Ridge Regression might be useful (Khalaf, 2022). To validate the fittings, normality of the residuals, plot of predicted vs. observed values of dependent variables, adj.R^2 and cross-validity predictive power ρ_{cv}^2 might be applied (Ali and Ohtsuki, 2001; Rahman et al., 2004).

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. 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$0.491 kg in weight, 4.56$\pm$0.047 mm in triceps skinfold, 6.62$\pm$0.099 mm in subscapular skinfold, 5.83$\pm$0.137 mm in supraspinale skinfold, 5.15$\pm$0.067 in medial-calf skinfold, 24.88$\pm$0.073 cm in arm girth, 29.95± 0.063 cm in calf girth, 6.55± 0.012 cm in humerus breadth and 9.27± 0.018 cm in femur breadth. Bangladeshi adolescent male athletes were 2.24 cm taller and 1.99 kg heavier than Indian Bengalee adolescent athletes(Konor, 2010).Also, Bangladesh adolescent male athletes were about 1 cm taller and 6 kg heavier than Indian non-tribal Bengalee adolescent athletes. Arm girth, calf girth, humerus breadth and femur breadth of our studied athletes were 3 cm higher, 0.5 cm lower, 0.5 cm higher and 1 cm higher, respectively, than Indian non-tribal Bengalee adolescents (Sinha, 2013). Our athletes were almost similar in height and calf girth but about 5 kg heavier than BurdwaniBengaleeathletes(Dasgupta, 2007).

Please Insert Table 1 about here

For somatotype components, Table-2 shows that biases of the estimates in all the cases are very negligible. Hence, it can be said that samplingwasbiased-free. Endomorphy, mesomorphy, and ectomorphycomponentsare of means1.5, 3.6, and 4.0, respectively, which can be written as 1.5-3.6-4.0i.e., theBangladeshi adolescent male athletes are mesomorphic-ectomorph.Sil (2012) in a study on Indian Rajbansi community boys of Coochbehar found endomorphy, mesomorphy and ectomorphy components as 1. 9, 3.2 and 4.4, respectively, which implies that our athletes were higher in mesomorphic components, but lower in both endomorphic and ectomorphiccomponents.Sidhu et al. (1989) studied the physique of athletes specializing in long, middle and short distances. They found that long, middle and short distance runners had somatotyping rating 1.5-3.5-3.91, 1.52-3.68-3.56 and 1.61-3.62-3.65 respectively. The findings regarding the somatotype components in this study are therefore very much similar with those of Sidhu et al. (1989). The difference lies is in the point that this study calculated the overall components instead of event-wise components, as the main focus of the study is to build appropriate model. The Mean$\pm$SE of endomorphy, mesomorphy, and ectomorphy were 1.56$\pm$0.015, 3.47$\pm$0.020, and 3.97$\pm$0.033, 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 somatotype components implied insignificant sampling fluctuations. So, our results indicated highly robustness in the somatotype estimate.

Please Insert Table 2 about here

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.

Please Insert Figure 1 about here

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-3shows that PP is highly significantly correlated with somatotype variables. Therefore, a regression model of PP can be fit on somatotype variables for the improvement of PP of the athletes. Furthermore, all the somatotype variables, except endomorphy and mesomorphy, 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 somatotype 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 StepwiseRidge Regression can be supposed to be the most appropriate here.

Please Insert Table 3 Figure2 about here

Forward Ridge Regression Model of PP on somatotype components of the Athletes:

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

(p = 0.000) (p = 0.000)

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

The above equation includes 2 out of the 3 components (variables), endomorphy and mesomorphy of somatotype (and excludes only the ectomorphy component). The fitted model of PP shows that both the regression coefficients are positive and highly significant. It implies that if the effect of mesomorphy component can be kept fixed then the value of PP will be increased by 0.435 units by an increment of 1 unit of end`omorphy component. Under the similar condition, PP will be increased by 41%of 1 unit if mesomorphy component will be increased by 1 unit. The values of adj. R^2 and ρ^2_{cv} are very close to each other, therefore, the fitted model is highly cross-valid. Since, more than 74% of the variation in response is explained by the predictors, hence, we can also say that fitting of the model of PP on somatotype 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 moderatelygood fit of the model.

Please Insert Figure3 about here

For the discussion of our fitted model, the reference is quite rare. Therefore, the further discussion is kept limited.

Conclusion:-

Primary data on Performance Potentials (PP) and anthropometric variables were measured accordingly. On average, the Bangladeshi adolescent male athletes were 163.86±0.402 cm in height, 51.12±0.491 kg in weight, 4.56±0.047 mm in triceps skinfold, 6.62±0.099 mm in subscapular skinfold, 5.83±0.137 mm in supraspinale skinfold, 5.15±0.067 in medial-calf skinfold, 24.88±0.073 cm in arm girth, 29.95±0.063 cm in calf girth, 6.55±0.012 cm in humerus breadth and 9.27±0.018 cm in femur breadth. The Mean±SEofendomorphy, mesomorphy, and ectomorphy were 1.56±0.015, 3.47±0.020, and 3.97±0.033, 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 Bootstrapsamples. The low length of confidence interval (CI) of average somatotype components implied insignificant sampling fluctuations. So, our results indicated highly robustness in the somatotype estimate.

The stepwise Ridge regression suggested that only two somatotype components are enough to explain the performance potentials (PP) of the adolescent male athletes of Bangladesh, and the valid equation is

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

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) Maximum = 181.2 (178.6)	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)
	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)

	S.D.	9.979 (5.090)	---	-0.024 (-0.015)	0.539 (0.384)	8.946 (4.433)	11.009 (5.898)
Minimum = 27.0 (37.2) 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)
Triceps Skinfold (in mm)	Mean	4.56 (4.48)	0.047 (0.022)	0.000 (0.000)	0.047 (0.021)	4.47 (4.44)	4.66 (4.52)
	S.D.	0.964 (0.438)	---	-0.004 (-0.001)	0.060 (0.024)	0.852 (0.394)	1.085 (0.486)
Minimum = 2.3 (3.3) Maximum = 10.1 (7.1)	Skewness	1.346 (0.534)	0.120 (0.120)	-0.060 (-0.052)	0.303 (0.416)	0.663 (-0.159)	1.868 (1.346)
	Kurtosis	4.337 (2.962)	0.239 (0.239)	-0.382 (-0.355)	1.592 (2.046)	1.087 (-0.145)	7.131 (6.613)
Subscapular Skinfold (in mm)	Mean	6.62 (6.49)	0.099 (0.050)	-0.002 (-0.001)	0.097 (0.050)	6.42 (6.39)	6.82 (6.58)
	S.D.	2.005 (1.021)	---	-0.006 (-0.002)	0.106 (0.059)	1.803 (0.919)	2.227 (1.144)
Minimum = 2.8 (3.9) Maximum = 17.4 (13.0)	Skewness	1.079 (0.679)	0.120 (0.120)	-0.040 (-0.071)	0.246 (0.482)	0.565 (-0.114)	1.527 (1.610)
	Kurtosis	2.756 (3.472)	0.239 (0.239)	-0.240 (-0.540)	1.214 (2.646)	0.525 (-0.595)	5.081 (8.052)
Supraspinale Skinfold (in mm)	Mean	5.83 (5.50)	0.137 (0.060)	-0.001 (-0.001)	0.138 (0.060)	5.57 (5.38)	6.13 (5.62)
	S.D.	2.796 (1.220)	---	-0.012 (-0.004)	0.192 (0.072)	2.445 (1.090)	3.190 (1.364)
Minimum = 2.2 (2.9) Maximum = 24.0 (13.2)	Skewness	1.861 (0.962)	0.120 (0.120)	-0.075 (-0.065)	0.340 (0.430)	1.225 (0.236)	2.489 (1.746)
	Kurtosis	5.965 (3.627)	0.239 (0.239)	-0.605 (-0.484)	2.493 (2.504)	1.769 (-0.180)	10.578 (7.876)
Medial-calf Skinfold (in mm)	Mean	5.15 (5.02)	0.067 (0.030)	-0.001 (0.000)	0.067 (0.030)	5.02 (4.96)	5.30 (5.08)
	S.D.	1.358 (0.599)	---	-0.006 (-0.002)	0.087 (0.034)	1.198 (0.540)	1.538 (0.668)
Minimum = 2.6 (3.4) Maximum = 13.2 (8.7)	Skewness	1.614 (0.710)	0.120 (0.120)	-0.061 (-0.057)	0.288 (0.424)	0.980 (0.011)	2.132 (1.502)
	Kurtosis	4.849 (3.127)	0.239 (0.239)	-0.411 (-0.417)	1.762 (2.271)	1.416 (-0.276)	8.108 (7.171)
Arm Girth (cm)	Mean	24.88 (24.88)	0.073 (0.032)	-0.001 (-0.001)	0.072 (0.032)	24.73 (24.81)	25.02 (24.94)
	S.D.	1.483 (0.659)	---	-0.006 (-0.001)	0.100 (0.031)	1.284 (0.601)	1.677 (0.724)
Minimum = 18.3 (22.3) Maximum = 33.4 (27.8)	Skewness	0.504 (-0.252)	0.120 (0.120)	-0.063 (-0.007)	0.561 (0.246)	-0.661 (-0.690)	1.489 (0.246)
	Kurtosis	6.043 (1.422)	0.239 (0.239)	-0.417 (-0.073)	1.987 (0.670)	1.215 (0.210)	9.169 (2.776)
Calf Girth (in cm)	Mean	29.95 (29.91)	0.063 (0.024)	-0.002 (0.000)	0.064 (0.024)	29.83 (29.86)	30.08 (29.96)
	S.D.	1.290 (0.484)	---	-0.010 (-0.001)	0.121 (0.027)	1.055 (0.434)	1.515 (0.540)
Minimum = 25.3	Skewness	1.927 (-0.456)	0.120 (0.120)	-0.181 (0.043)	0.734 (0.417)	0.127 (-1.272)	2.980 (0.264)

(27.0) Maximum = 39.0 (31.7)	Kurtosis	13.373 (3.231)	0.239 (0.239)	-1.243 (-0.390)	3.907 (1.976)	3.848 (0.061)	18.468 (6.727)
Humerus Breadth (in cm)	Mean	6.55 (6.55)	0.012 (0.006)	0.001 (0.000)	0.013 (0.006)	6.53 (6.54)	6.58 (6.57)
	S.D.	0.248 (0.128)	---	-0.000 (-0.000)	0.010 (0.007)	0.229 (0.116)	0.269 (0.141)
Minimum = 5.7 (5.9) Maximum = 7.4 (7.1)	Skewness	-0.337 (-0.605)	0.120 (0.120)	0.005 (0.016)	0.158 (0.308)	-0.642 (-1.168)	-0.011 (0.021)
	Kurtosis	0.917 (2.633)	0.239 (0.239)	-0.030 (-0.113)	0.298 (1.059)	0.326 (0.698)	1.486 (4.799)
Femur Breadth (in cm)	Mean	9.27 (9.26)	0.018 (0.008)	0.001 (0.000)	0.018 (0.008)	9.23 (9.25)	9.30 (9.28)
	S.D.	0.358 (0.161)	---	-0.001 (-0.001)	0.018 (0.007)	0.324 (0.149)	0.395 (0.174)
Minimum = 7.9 (8.8) Maximum = 10.9 (10.0)	Skewness	0.472 (-0.033)	0.120 (0.120)	-0.013 (-0.011)	0.290 (0.221)	-0.128 (-0.446)	1.032 (0.390)
	Kurtosis	2.379 (0.996)	0.239 (0.239)	-0.146 (-0.037)	0.773 (0.696)	0.615 (-0.087)	3.750 (2.461)

Table 2:- Descriptive statistics of the calculated somatotype components of the athletes.

Somatotype Component n = 414	Descriptive Statistic	Estimate	S.E.	Re-sampling Estimate (Based on 1,000 Bootstrap Samples)			
				Bias	S.E.	95% C.I.	
						Lower	Upper
Endomorphy	Mean	1.556	0.015	-0.000	0.015	1.526	1.585
	S.D.	0.309	---	-0.001	0.015	0.281	0.339
Minimum = 0.86 Maximum = 3.25	Skewness	0.559	0.120	-0.033	0.311	0.044	1.177
	Kurtosis	1.751	0.239	-0.211	1.477	-0.403	4.569
Mesomorphy	Mean	3.471	0.020	0.000	0.020	3.432	3.509
	S.D.	0.404	---	-0.000	0.013	0.379	0.431
Minimum = 2.03 Maximum = 4.53	Skewness	-0.147	0.120	0.001	0.115	-0.397	0.063
	Kurtosis	-0.167	0.239	-0.019	0.263	-0.603	0.421
Ectomorphy	Mean	3.968	0.033	-0.000	0.034	3.900	4.035
	S.D.	0.670	---	-0.000	0.029	0.615	0.728
Minimum = 0.93 Maximum = 5.92	Skewness	-0.312	0.120	0.013	0.194	-0.709	0.036
	Kurtosis	0.964	0.239	-0.076	0.651	-0.073	2.244

Table 3:- Correlation matrix of PP and Somatotype variables of the Athletes.

	PP	**Endomorphy**	**Mesomorphy**	**Ectomorphy**
PP	1.000			

Endomorphy	0.222	1.000		
	(p=0.000)	---		
Mesomorphy	0.132	0.039	1.000	
	(p=0.007)	(p=0.426)	---	
Ectomorphy	-0.391	-0.659	-0.553	1.000
	(p=0.000)	(p=0.000)	(p=0.000)	---

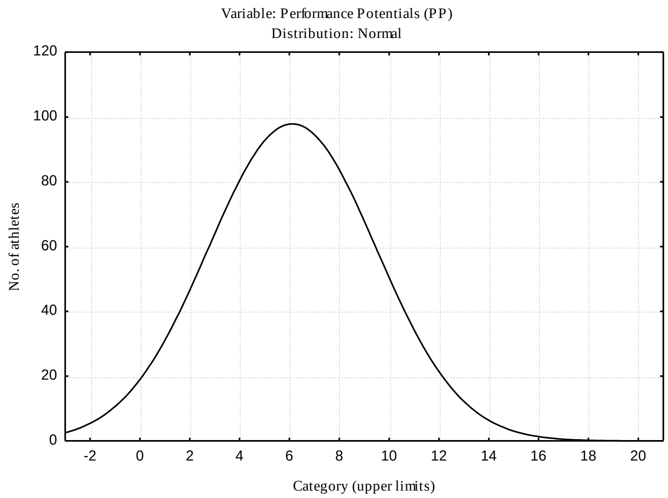

Figure 1:- Shape of the distribution of the Performance Potentials (PP) of the athletes.

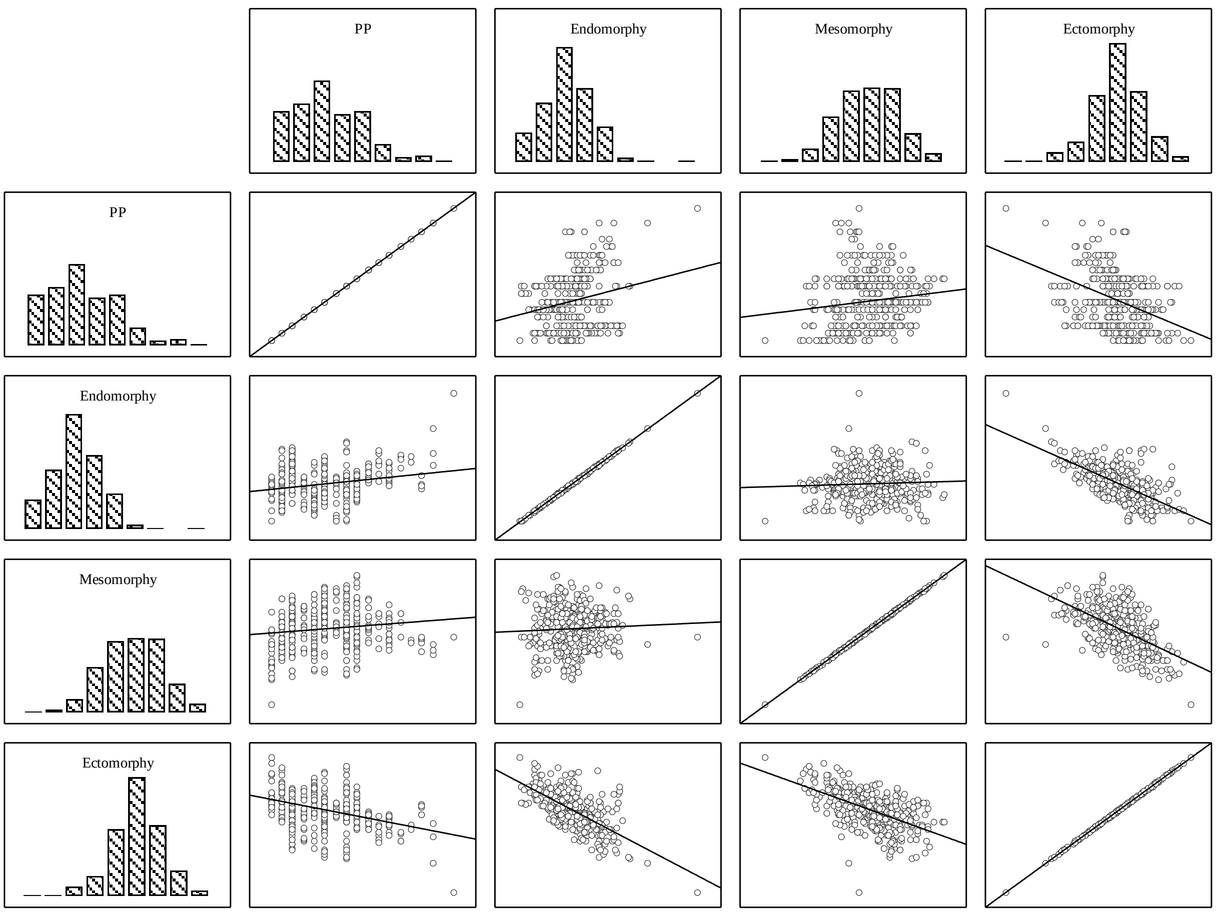

Figure 2:- Scatterplot matrix of PP and somatotype variables of the athletes.

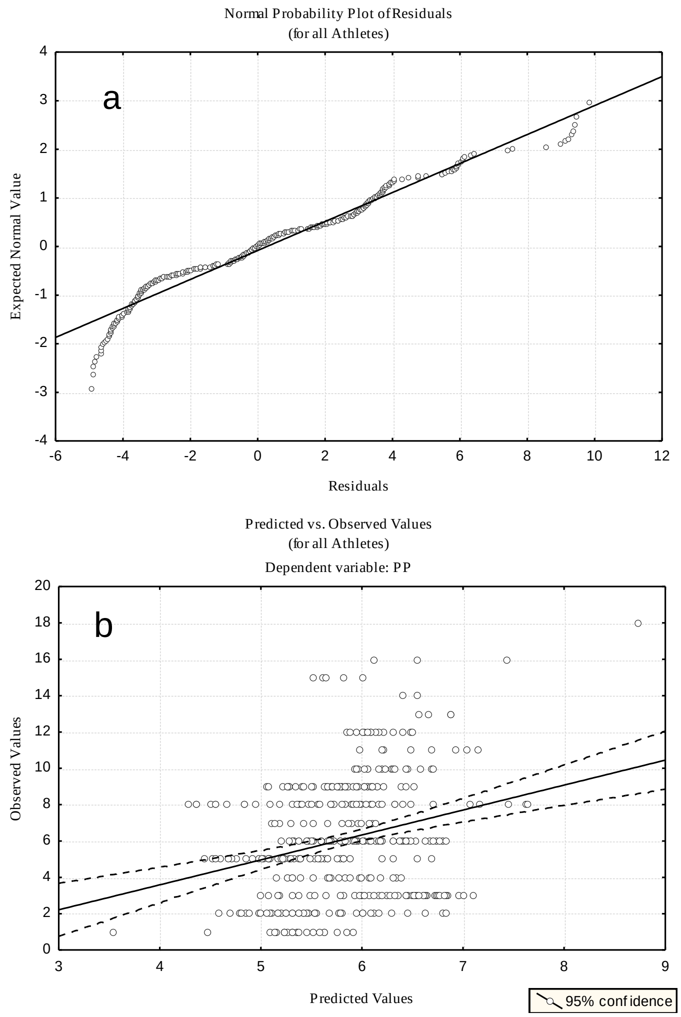

Figure 3:- a) Normal probability plot of residuals; b) Scatterplot of observed and predicted values of PP.

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