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Some Standard Physical Characteristics of Students in Seoul: Modeling Approach

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Abstract Physically handicapped students (PHSs) are a part and parcel of a nation and indeed it is an important factor for socio-economic development. The purpose of this study is to fit some models to some standard physical characteristics (SPCs) of PHSs for male and female who are in primary and secondary schools in Seoul. For this, the data is taken from Seoul Education Statistical Annual. Quasi Newton Method is employed to fit these models using the Statistical software STATISTICA. Moreover, t-test, F-test and cross validity prediction power (CVPP) are used to check the accuracy as well as validation of the model. In this study, it is seen that these SPCs are showing upward pattern in accordance with age. Furthermore, it is found that SPCs of PHSs like height, weight, chest girth and sitting height of male and female students follow third degree polynomial model. These models are well fitted in accordance with t-test, F-test and CVPP. The stabilities of these models are more than 99%.

Keywords Standard Physical Characteristics (SPCs), Physically Handicapped Students (PHSs), Polynomial Model, t-test, F-test, Cross Validity Prediction Power (CVPP)

1. Introduction

Seoul, the capital of Korea, has been a central city of the nation more than 600 years, since being selected as the capital by the Chosun Dynasty in 1394. Physically handicapped students (PHSs) are an important issue for nation's socio-economic development. PHSs stand for locomotor disabled students. Disability is any restriction or lack of an ability to perform an activity in the manner or within the range considered normal for a human being (WHO, 2002). Physical characteristics are personality or features about a person. In the present study, some standard physical characteristics (SPCs) of PHSs in Seoul represents four measurements like height, weight, chest girth and sitting height. And these measurements are assumed as latent indicators of early nutrition and lifetime health status. The sitting height is more important in the design and layout of transport, living and classroom of PHSs. Anthropometry is the study of measurement of the human body in terms of the dimensions of bone, muscle and adipose tissue. Factors which influence human growth and development are heredity, sex, socioeconomic factors, nutrition, hormones and different kinds of pollution etc. Oppositely, anthropometric measurement is one of the way to know the nutritional and health status of human body in any region or any country. The adolescent physical growth spurt, which tends to occur at an earlier age in a better nourished, healthier population (Eveleth and Tanner, 1976). Anthropometric data on the general population is essential in ergonomics to specify the physical dimensions of workspace, equipment, furniture and clothing to fit the user and to avoid a physical mismatch between the dimensions of products and equipment and corresponding user dimensions (Bridger, 1995). As anthropometric dimensions of humans widely vary across the age range, it is crucial to investigate the effect of age on anthropometric characteristics (Pennathur and Dowling, 2003; Hu et al., 2007; Ali and Arslan, 2009 and Dawal et al., 2012). A number of studies is done regarding anthropometric characteristics but modeling approach on these characteristics is more or less rare. For this, an attempt has been made to study these anthropometric measures mathematically. That is why, in this study, polynomial model is considered to study the level and pattern of SPCs such as height, weight, chest girth and sitting height of PHSs. It is mentioned that polynomial model was used in several studies (Islam, 2004, 2005a; 2005b; 2006a; 2006b; 2006c; 2007a and 2011; Islam et al., 2004).

Therefore, the specific objectives of this study are addressed below:

i) to study the level and pattern of height, weight, chest girth and sitting height of PHSs by sex of Seoul,
ii) to fit some models to some SPCs of PHSs by sex of Seoul, and
iii) to check the validity of these fitted models using cross validity prediction power (CVPP).

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2. Data and Data Source

A secondary data on SPCs of PHSs who are in primary and secondary schools of Seoul in 1991 have been taken from the Seoul Education Statistical Annual (Jeon and Kim, 1994) which is shown in Table 1 and that is used as raw materials in the present study for fulfilling the above objectives.

3. Methods and Methodological Issues

3.1. Model Fitting

Using the scattered plots (Fig.1-Fig.8) of SPCs of PHSs by age and sex in Seoul, these seem that the data can be fitted by polynomial models with respect to different ages in year. Therefore, an nth degree polynomial model is considered in case of Seoul and the form of the model is

$$y = a_0 + \sum_{i=1}^{n} a_i x^i + u \;;$$

where, x is the mean value of the age group; y is SPCs of PHSs; a_0 is the constant; a_i is the coefficient of x^i (i =1, 2, 3, ..., n) and u is the disturbance term of the model. Here, a suitable n is found for which the error sum of square is minimum.

Table 1. Standard Physical Characteristics of Physically Handicapped Students of Seoul

Age	Height (cm)		Weight (kg)		Chest girth (cm)		Sitting height (cm)	
	Male	Female	Male	Female	Male	Female	Male	Female
6	119.37	118.31	22.41	22.52	58.51	56.80	66.38	65.66
7	124.79	124.01	25.20	24.52	60.73	59.45	68.88	68.30
8	130.02	129.60	28.28	27.50	63.09	61.66	71.04	70.68
9	135.14	134.37	31.32	30.75	65.19	63.83	73.55	73.02
10	140.38	141.35	35.64	35.58	68.74	67.26	75.70	76.36
11	145.66	147.28	39.99	39.44	71.77	70.24	78.17	79.03
12	152.85	152.48	45.30	44.48	74.48	74.75	81.48	82.63
13	159.54	156.16	50.13	48.76	77.54	77.52	84.82	84.67
14	165.81	157.37	55.60	51.17	81.20	79.23	88.40	85.61
15	169.55	158.95	60.05	53.14	84.84	80.36	91.04	86.47
16	170.88	158.61	61.14	53.73	86.26	81.12	91.89	86.27
17	171.23	158.70	64.18	55.49	88.09	82.10	92.38	86.46

Source: Seoul Education Statistical Annual (Jeon and Kim, 1994)

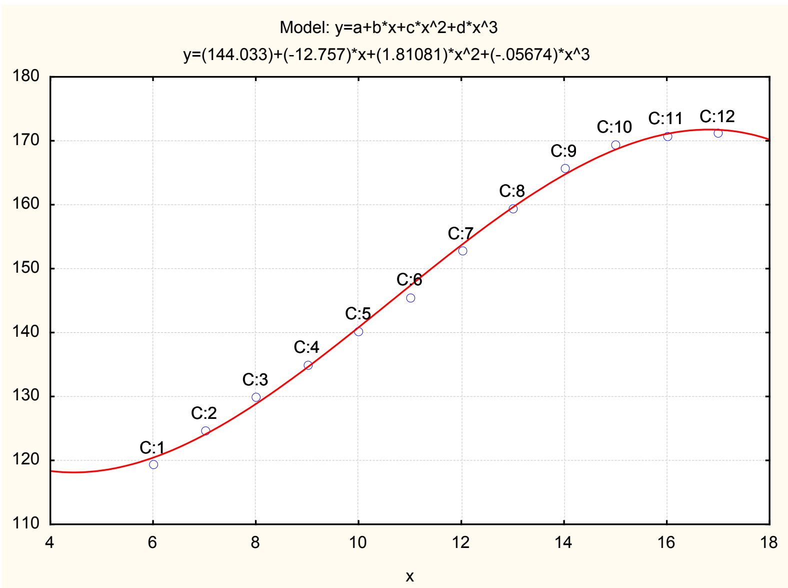

Figure 1. Observed and Fitted Height (cm) of Physically Handicapped Male Students of Seoul. X: Age in Years and Y: Height (cm)

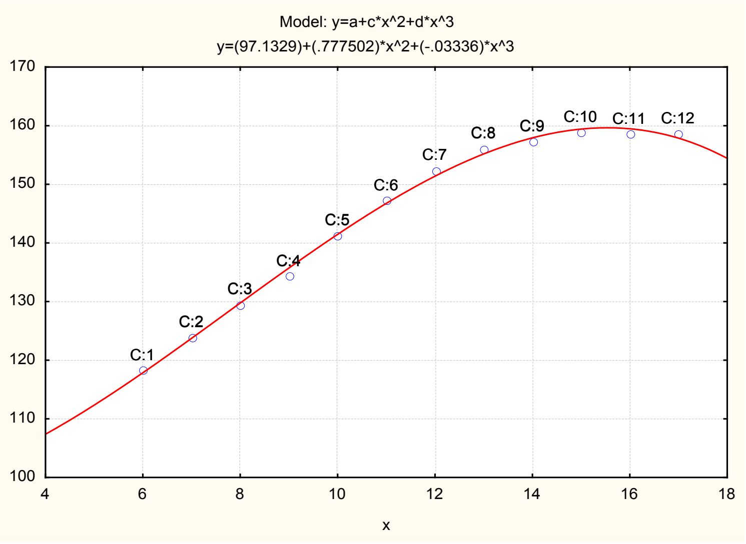

Figure 2. Observed and Fitted Height (cm) of Physically Handicapped Female Students of Seoul. X: Age in Years and Y: Height (cm)

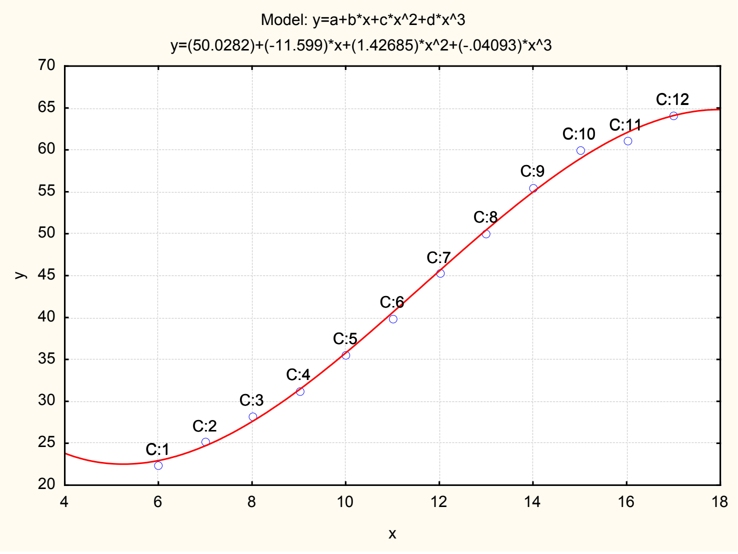

Figure 3. Observed and Fitted Weight (kg) of Physically Handicapped Male Students of Seoul. X: Age in Years and Y: Weight (kg)

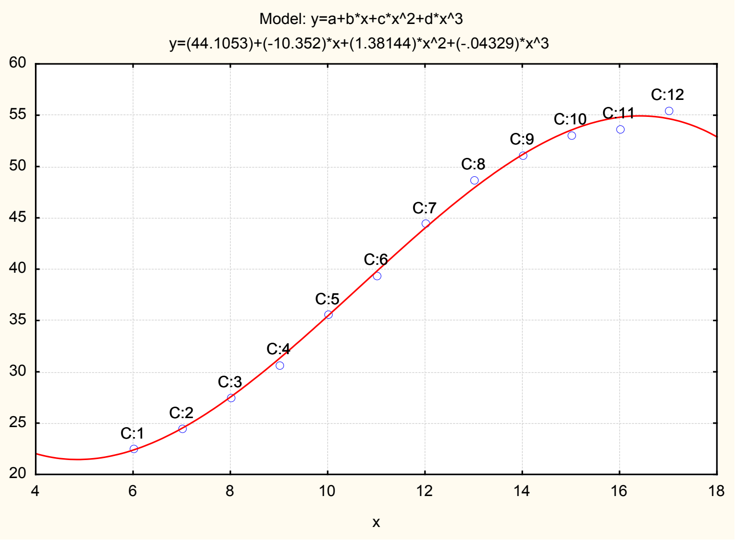

Figure 4. Observed and Fitted Weight (kg) of Physically Handicapped Female Students of Seoul. X: Age in Years and Y: Weight (kg)

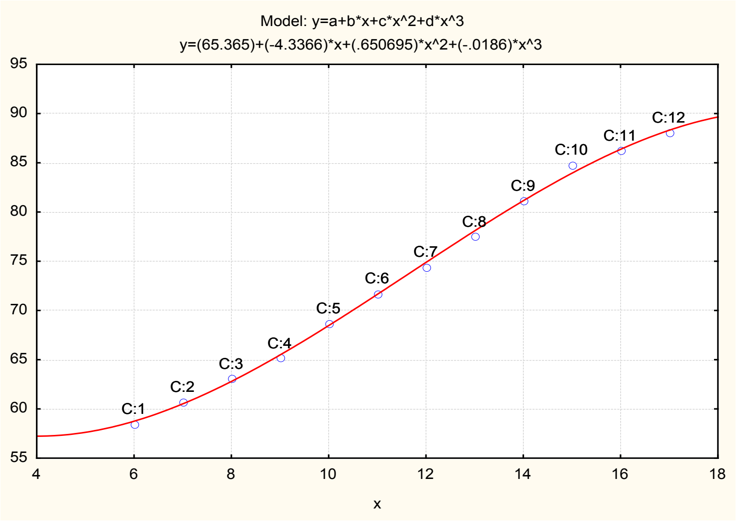

Figure 5. Observed and Fitted Chest girth (cm) of Physically Handicapped Male Students of Seoul. X: Age in Years and Y: Chest Girth (cm)

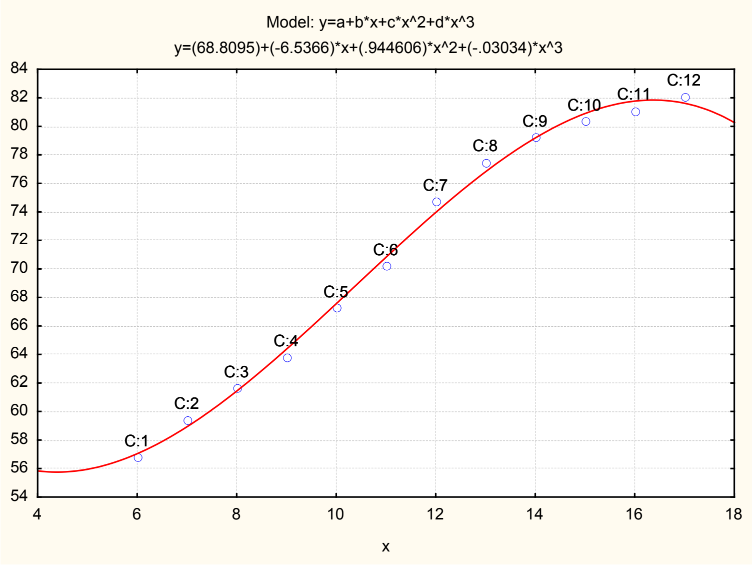

Figure 6. Observed and Fitted Chest girth (cm) of Physically Handicapped Female Students of Seoul. X: Age in Years and Y: Chest Girth (cm)

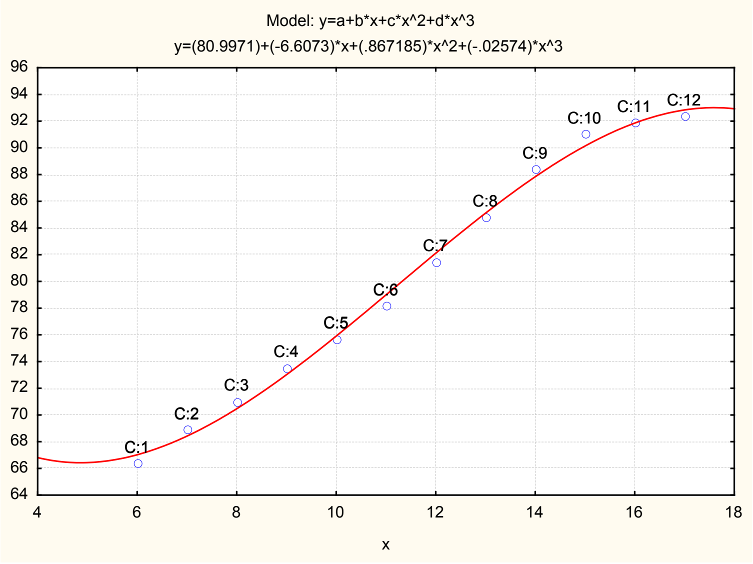

Figure 7. Observed and Fitted Sitting height (cm) of Physically Handicapped Male Students of Seoul. X: Age in Years and Y: Sitting Height (cm)

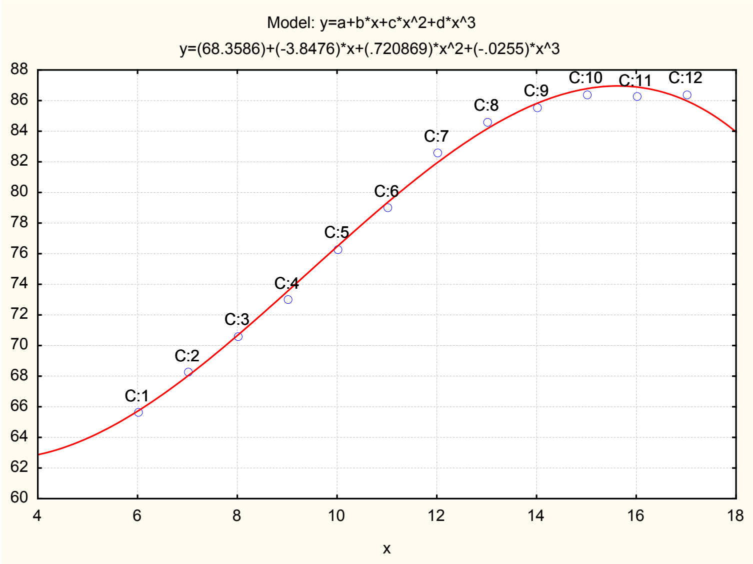

Figure 8. Observed and Fitted Sitting Height (cm) of Physically Handicapped Female Students of Seoul. X: Age in Years and Y: Sitting Height (cm)

The Statistical software STATISTICA was used to fit these models to SPCs of PHSs.

3.2. Model Validation Technique

To check how much these models are stable over population, the cross validity prediction power (CVPP), ρ^2_{cv}, is applied in the case of Seoul. Here

$$\rho^2_{cv} = 1 - \frac{(n-1)(n-2)(n+1)}{n(n-k-1)(n-k-2)}(1-R^2) \text{ (Stevens, 1996)}$$

where, n is the number of cases, k is the number of predictors in the model and the cross validated R is the correlation between observed and predicted values of the dependent variable. The shrinkage coefficient of the model is the positive value of (ρ^2_{cv} - R^2); where ρ^2_{cv} is CVPP and R^2 is the coefficient of determination of the model. 1-shrinkage is the stability of R^2 of the model. The information on model fittings and estimated CVPP has been demonstrated in Table 2. This technique is also used as model validation technique (Islam, 2007b; 2008; 2009; 2010; 2012a; 2012b; 2013; Islam & Hossain, 2013a; 2013b; 2014a; 2014b; Hossain & Islam, 2013; Islam et al., 2013; 2014; Islam & Hoque, 2015).

3.3. F-test

To verify the measure of the overall significance of the model as well as the significance of R^2, the F-test is employed here. The formula for F-test is given below:

$$F = \frac{R^2/(k-1)}{(1-R^2)/(n-k)}$$

where k = the number of parameters is to be estimated, n = the number of cases and $\mathbf{R^2}$ is the coefficient of determination in the model (Gujarati, 1998). These estimates are shown in Table 3.

4. Results and Discussion

The SPCs of PHSs by sex of Seoul is presented in Table 1. The status and physique of PHSs who are in primary and secondary schools in Seoul were studied and observed that the height, weight, chest girth and sitting height of male and female students are showing increasing pattern. Moreover, it was found that these physical characteristics of male students are comparatively high at every age than that of female excepting the height at ages 10 and 11, chest girth at age 12, sitting height at ages 10, 11 and 12.

The polynomial model is constructed for height of physically handicapped male students of Seoul and the fitted equation is as follows:

$$y = 144.0333 - 12.7568x + 1.8108x^2 - 0.0567x^3 \quad (1)$$

t-stat	(10.6816)	(-3.2947)	(5.1551)	(-5.5930)
P-value	(0.0000)	(0.0109)	(0.0008)	(0.0005)

Again, another polynomial model is constructed for height of physically handicapped female students of Seoul and the fitted equation is

$$y = 97.1329 + 0.7775x^2 - 0.0333x^3 \quad (2)$$

t-stat	(84.4302)	(29.5190)	(-23.5393)
P-value	(0.0000)	(0.0000)	(0.0000)

In which the term containing x is excluded from the model because of the insignificant of the parameter.

Another polynomial model is fitted for weight of physically handicapped male students of Seoul and the fitted equation is given below:

$$y = 50.0282 - 11.5988x + 1.4269x^2 - 0.0409x^3 \quad (3)$$

t-stat	(5.6898)	(-4.5941)	(6.2295)	(-6.1875)
P-value	(0.0004)	(0.0017)	(0.0002)	(0.0002)

Moreover, another polynomial model is constructed for weight of physically handicapped female students of Seoul and the fitted equation is as follows:

$$y = 44.1053 – 10.3515x + 1.3814x^2 - 0.0433x^3 \quad (4)$$

t-stat	(5.4711)	(-4.4719)	(6.5783)	(-7.1373)
P-value	(0.0005)	(0.0020)	(0.0001)	(0.0000)

Again, a polynomial model is fitted for chest girth of physically handicapped male students of Seoul and the fitted equation is addressed below

$$y = 65.3650 – 4.3365x + 0.6506x^2 - 0.0186x^3 \quad (5)$$

t-stat	(11.4802)	(-2.6525)	(4.3871)	(-4.3419)
P-value	(0.0000)	(0.0291)	(0.0023)	(0.0024)

Furthermore, another polynomial model is constructed for chest girth of physically handicapped female students of Seoul and the fitted equation is given by

$$y = 68.8095 – 6.5366x + 0.9446x^2 - 0.0303x^3 \quad (6)$$

t-stat	(8.8614)	(-2.9316)	(4.6698)	(-5.1943)
P-value	(0.0000)	(0.0189)	(0.0016)	(0.0008)

And, a polynomial model is fitted for sitting height of physically handicapped male students of Seoul and the fitted equation is

$$y = 80.9971 – 6.6073x + 0.8671x^2 - 0.0257x^3 \quad (7)$$

t-stat	(9.5413)	(-2.7106)	(3.9214)	(-4.0296)
P-value	(0.0000)	(0.0266)	(0.0044)	(0.0037)

Then, polynomial model is fitted for sitting height of physically handicapped female students of Seoul and the fitted equation is

$$y = 68.3586 – 3.8475x + 0.7208x^2 - 0.0255x^3 \quad (8)$$

t-stat	(11.2049)	(-2.1963)	(4.5359)	(-5.5566)
P-value	(0.0000)	(0.0593)	(0.0019)	(0.0005)

The estimated CVPP, ρ_{cv}^2 corresponding to their R^2 are shown in Table 2. The observed and fitted values are depicted in Figure 1 to Figure 8. In this table, all fitted models from equation (1) to equation (8) are highly cross validated and their shrinkage's are very small. Moreover, it is observed that all the parameters of the fitted models are statistically significant with large proportion of variation explained and their proportion of variation are more than 99%. And the stabilities of these models are more than 99%. The stabilities of R^2 of these models are also more than 99%.

The calculated values of F-statistic of the models (1) to (8) are 56517.29 with (3, 8) degrees of freedom (d.f.), 116656.0 with (2, 9) degrees of freedom (d.f.), 12283.45 with (3, 8) degrees of freedom (d.f.), 12552.87 with (3, 8) degrees of freedom (d.f.), 77361.98 with (3, 8) degrees of freedom (d.f.), 39049.34 with (3, 8) degrees of freedom (d.f.), 41464.06 with (3, 8) degrees of freedom (d.f.), 76943.49 with (3, 8) degrees of freedom (d.f.) respectively where as the corresponding tabulated values are only 7.59, 8.02, 7.59, 7.59, 7.59, 7.59, 7.59 and 7.59 at 1% level of significance, respectively. Therefore, from these statistics it is also concluded that all these constructed models are highly statistically significant. Hence, the fits of all these models are well.

Table 2. Information on Model Fittings and Estimated CVPP of the Predicted Equations of SPCs of PHSs of Seoul

Models	n	k	R^2	ρ_{cv}^2	Shrinkage	Variance explained (%)
Equation 1	12	3	0.99756	0.994808	0.00275226	99.756
Equation 2	12	2	0.99730	0.995531	0.00176875	99.730
Equation 3	12	3	0.99834	0.996468	0.00187244	99.834
Equation 4	12	3	0.99790	0.995531	0.00236875	99.790
Equation 5	12	3	0.99855	0.996914	0.00163557	99.855
Equation 6	12	3	0.99658	0.992722	0.00385768	99.658
Equation 7	12	3	0.99608	0.991658	0.00442167	99.608
Equation 8	12	3	0.99703	0.993680	0.00335009	99.703

Table 3. The Calculated and Tabulated F of the Predicted Equations of SPCs of PHSs of Seoul

Models	**n**	**k**	**Cal. F**	**Tab.F (at 1% level)**
Equation 1	12	4	56517.29	7.59 with (3,8) d.f.
Equation 2	12	3	116656.0	8.02 with (2,9) d.f.
Equation 3	12	4	12283.45	7.59 with (3,8) d.f.
Equation 4	12	4	12552.87	7.59 with (3,8) d.f.
Equation 5	12	4	77361.98	7.59 with (3,8) d.f.
Equation 6	12	4	39049.34	7.59 with (3,8) d.f.
Equation 7	12	4	41464.06	7.59 with (3,8) d.f.
Equation 8	12	4	76943.49	7.59 with (3,8) d.f.

5. Conclusions

In this study, it is found that height, weight, chest girth and sitting height of PHSs for male and female are increasing due to increment of age. Also it is investigated that SPCs of PHSs for male and female follow cubic polynomial models with explaining large proportion of variance. The stabilities of these models are more than 99%. Moreover, the stabilities of R^2 of these models are more than 99%. It is found that the overall significance of these models is very high due to F-statistics. It is recommended that Government and Non-Government Organizations should take proper steps for bringing them to normal life and linked them to the development process of the nation.

REFERENCES

[1] Ali, I. & Arslan, N. (2009) Estimated Anthropometric Measurements of Turkish Adults and Effects of Age and Geographical Regions. Int J Ind Ergon, Vol. 39, No. 5, pp: 860–865.

[2] Bridger, R. S. (1995) Introduction to Ergonomics, Singapore, McGraw-Hill.

[3] Dawal, S. Z., Zadry, H. R., Azmi, S. N., Rohim, S. R. & Sartika, S. J. (2012) Anthropometric Database for Learning Environment of High School and University Students. International Journal of Occupational Safety and Ergonomics (JOSE), Vol. 18, No. 4, pp: 461-472.

[4] Eveleth, P. B. & Tanner, J. M. (1976) Worldwide Variation in Human Growth. Cambridge U.K., Cambridge University Press.

[5] Gujarati, D. N. (1998) Basic Econometrics, Third Edition, McGraw Hill, Inc., New York.

[6] Hossain, M. S. & Islam, M. R. (2013) Age Specific Participation Rates of Curacao in 2011: Modeling Approach. American Open Computational and Applied Mathematics Journal, Vol. 1, No. 2, pp: 08 - 21.

[7] Hu, H., Li, Z., Yan, J., Wang, X. & Xiao, H. (2007) Anthropometric Measurement of the Chinese Elderly Living in the Beijing Area. Int J Ind Ergon, Vol. 37, No. 4, pp: 303–311.

[8] Islam, M. R. (2004) Mathematical Modeling of Age Specific Fertility Rates in the Rural Area of Bangladesh, J. of Science, Rajshahi University Studies, Part- B, Vol. 32, pp. 211-227.

[9] Islam, M. R., Islam, M. N. and Rahman, M. M. (2004) Trends and Patterns of Reproductivity Decline in Bangladesh: 1956-1998, Man in India, Vol. 84, No. 1 & 2, pp. 85-97.

[10] Islam, M. R. (2005a) Construction of Abridged Life Tables and Indirect Estimation of Some Mortality Measures of Bangladesh in 2005. Journal of Population, Indonesia, Vol. 11, No. 2, pp: 117-130.

[11] Islam, M. R. (2005b) Mathematical Modeling of Age Specific Marital Fertility Rates in Urban Area of Bangladesh. Pakistan J. of Statistics, Vol. 21, No. 3, pp. 289-295.

[12] Islam, M. R. (2006a) Age Associated with Expectation of Life (e_x) for Female Population of Bangladesh: An Application of Polynomial Model, Indian J. of Social Development, Vol. 6, No. 1, pp. 83-90.

[13] Islam, M. R. (2006b) Modeling ASFRs of Bangladesh: An Application of Polynomial Model, South Asian Anthropologist, Vol. 6, No. 2, pp. 97-100.

[14] Islam, M. R. (2006c) Modeling of Age Structure and ASDRs for Both Sexes of Bangladesh, J. of Social Anthropology, Vol. 3, No. 1, pp. 51-56.

[15] Islam, M. R. (2007a) Construction of Abridged Life Tables and Indirect Estimation of Some Mortality Measures of Bangladesh in 2005. Journal of Population, Indonesia, Vol. 11, No. 2, pp: 117-130.

[16] Islam, M. R. (2007b) Predicting Population for Male of Rural Area in Bangladesh. J. of Statistical Research of Iran, Vol. 4, No. 2, pp: 227-238.

[17] Islam, M. R. (2008) Modeling Age Structure for Female Population in Rural Area of Bangladesh. J. of Interdisciplinary Mathematics, Vol. 11, No. 1, pp: 29-37.

[18] Islam, M.R. (2009) Mathematical Modeling of Age Specific Marital Fertility Rates of Bangladesh, Research J. of Mathematics and Statistics (RJMS), Vol. 1, No. 1, pp. 19-22.

[19] Islam, M.R. (2010) Modeling Life Expectancy for Aged Male and Female Population of Bangladesh: Regression Model Approach, The Internet J. of Geriatrics and Gerontology, Vol. 5. No. 2.

[20] Islam, M. R. (2011) Modeling of Diabetic Patients Associated with Age: Polynomial Model Approach. International Journal of Statistics and Applications, Vol. 1, No. 1, pp: 1-5.

[21] Islam, M. R. (2012a) Mathematical Modeling of Age and of Income Distribution Associated with Female Marriage Migration in Rajshahi, Bangladesh. Research Journal of Applied Sciences, Engineering and Technology, Vol. 4, No. 17, pp: 3125-3129.

[22] Islam, M. R. (2012b) Modeling and Projecting Population for Muslim of Urban Area in Bangladesh. International Journal of Probability and Statistics, Vol. 1, No. 1, pp: 4-10.

[23] Islam, M. R. & Hossain, M. S. (2013a) Mathematical Modeling of Age Specific Adult Literacy Rates of Rural Area in Bangladesh. American Open Demography Journal, Vol. 1, No. 1, pp: 01-12.

[24] Islam, M. R. and Hossain, M. S. (2013b) Mathematical Modeling of Age Specific Participation Rates in Bangladesh. International Journal of Scientific and Innovative Mathematical Research (IJSIMR), Vol. 1, No. 2, pp: 150-159.

[25] Islam, M. R. (2013) Modeling Age Structure and ASDRs for Human Population of Both Sexes in Bangladesh. International Journal of Anthropology, Vol. 28, No. 1, pp: 47-53.

[26] Islam, M. R., Ali, M. K. & Islam, M. N. (2013) Construction of Life Table and Some Mathematical Models for Male Population of Bangladesh. American Journal of Computational and Applied Mathematics, Vol. 3, No. 6, pp: 269-276.

[27] Islam, M. R. and Hossain, M. S. (2014a) Some Models

Associated with Age Specific Adult Literacy Rates of Urban Area in Bangladesh. *International Journal of Ecosystem, Vol.* 4(2): 66-74.

[28] Islam, M. R. and Hossain, M. S. (2014b) Mathematical Modeling of Age Specific Adult Literacy Rates in Bangladesh, *Advances in Life Sciences, Vol.* 4(3): 106-113.

[29] Islam, M.R., Hossain, M.S. and Faroque, O. (2014) U-Shaped Pattern of Employees' Job Satisfaction: Polynomial Model Approach, International Journal of Ecosystem, Vol. 4(4): 170-175.

[30] Islam, M. R. and Hoque, M.N. (2015) Mathematical Modeling and Projecting Population of Bangladesh by Age and Sex from 2002 to 2031. *Emerging Techniques in Applied Demography*, *Applied Demography* Series 4, Chapter 5: 53-60.

[31] Jeon, H. J. & Kim, J. S. (1994) A Study of the Development Pattern of Physically Handicapped Students in Seoul. Adapted Physical Activity, Springer Japan, Part: IV, pp 161-170.

[32] Pennathur, A. & Dowling, W. (2003) Effect of Age on Functional Anthropometry of Older Mexican American Adults: a Cross-Sectional Study. Int J Ind Ergon, Vol. 32, No. 1, pp: 39–49.

[33] Stevens, J. (1996) Applied Multivariate Statistics for the Social Sciences. Third Edition, Lawrence Erlbaum Associates, Inc., Publishers, New Jersey.

[34] WHO (2002) Towards a Common Language for Functioning, Disability and Health, World Health Organization.