APPLICATION OF PROFILE ANALYSIS TO REPEATED MEASUREMENTS OF ANTHROPOMETRIC PARAMETERS

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ABSTRACT: Measurements of weight, height and head circumference were taken from one hundred (100) babies for a period of three months at Saint Luke's Hospital, Anua, Uyo, Nigeria. Test results show that there was (i) no group by month interaction, which means that the profiles are parallel, (ii) significant group effect, which means that the three profiles are not equal, but far apart, (iii) significant time (month) effect; i.e. the parameters change over time. Further results show the existence of significant effect of the parameters on a child's growth rate and the existence of significant relationships among the three parameters. Thus, we conclude that the overall growth pattern of a newborn is directly proportional to the growth rate of the anthropometric parameters. Therefore, one of the parameters, say head circumference may serve to assess the condition of a newborn in a situation where measurements of other parameters cannot be taken or are not available.

INTRODUCTION

Pediatricians and family physicians usually use growth charts to keep track of a child's growth rate. These charts are usually developed using information obtained by measuring anthropometric parameters (e.g. weight, height, head circumference) of the child. These measurements are good indicators of the child's overall growth pattern particularly during the first three years. Thus, the monitoring of a child's growth is very important as an aberration in growth patterns is often the first clue that there is something wrong with the child (Yamashiroya, 2003).

The necessary data for this study were obtained from the records department of St. Luke's Hospital, Anua, Uyo, Akwa Ibom State, Nigeria. Repeated measurements of the three anthropometric parameters were taken on one hundred (100) babies under the same conditions using appropriate instruments. The three anthropometric measurements were taken at the same time by the same person, on each subject. Therefore, we assume that the months constitute a fixed set so that inferences about the parameters only apply to the three months under investigation.

The problem considered in this work is how to apply profile analysis, a multivariate statistical method to the analysis of repeated measurements of some anthropometric parameters (weight, height and Head Circumference) with a view to determining whether there exists significant effect of the parameters on a child's growth rate, and the existence of any relationship among them.

In carrying out profile analysis, three questions which are usually of interest include:

(i) Are the profiles for the three groups parallel?
(ii) If the three profiles are parallel, are there differences among conditions?
(iii) Also, assuming the three group profiles are parallel, are there significant differences between the three groups?

In the usage of experimental design, question (i) refers to the hypothesis of no period (month) by group interaction, question (ii) refers to the hypothesis of equal group effect, while question

(iii) refers to equal time effect (Morrision, 1976). The profile analysis due to Tabachnick and Fidell (2001) was adopted for this work.

Let $Y_{ij} = \{Y_{ij1}, Y_{ij2}, \ldots, Y_{ijp}\} \sim N_p(\mu, v)$ for $i = 1,2,\ldots,k;$ $j = 1,2\ldots,N_i$ and $N = \sum_{i=1} N_i, p = 3.$ The general linear model representation for the observation vector is given by

$$Y_{N\times P} = X_{N\times K} \quad \beta_{K\times P} + \varepsilon_{N\times P}$$

where p=3, means the number of dependent variables is 3 and k=3 groups;
E(Y) = Xβ and the matrix X is of full column rank, k.
The estimates of the means of the three parameters for the three months are given as follows:

$$\bar{Y}_1 = \begin{pmatrix} 3.03, & 4.33, & 5.56 \end{pmatrix}$$

$$\bar{Y}_2 = \begin{pmatrix} 49.61, & 51.06, & 53.47 \end{pmatrix}$$

$$\bar{Y}_3 = \begin{pmatrix} 33.77, & 36.16, & 38.04 \end{pmatrix}$$

A plot of the means of the parameters which gives the profiles of the groups is given in Figure 1.

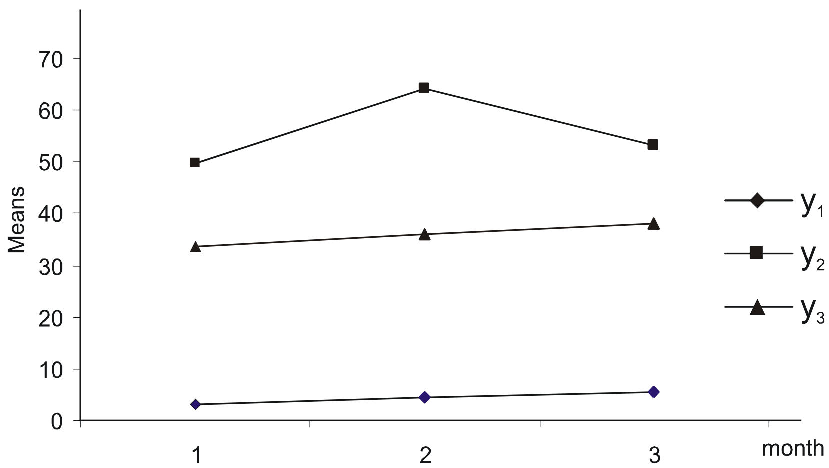

Figure 1: Profiles of the groups

TEST OF PARALLELLELISM OF PROFILES

In profile analysis, the parallelism hypothesis is usually the first to be tested as it is an essential condition for the meaningfulness of the other two hypotheses. The hypothesis states that the slopes of the three population profiles are the same under each condition. Under general assumptions of the multivariate linear model, the parallelism hypothesis is stated as

$$H_{01}: \begin{pmatrix} \mu_{11} - \mu_{12} \\ \mu_{12} - \mu_{13} \end{pmatrix} = \begin{pmatrix} \mu_{21} - \mu_{22} \\ \mu_{22} - \mu_{23} \end{pmatrix} = \begin{pmatrix} \mu_{31} - \mu_{32} \\ \mu_{32} - \mu_{33} \end{pmatrix}$$

and in matrix notations H_{01} is H_{01}: CBA = Γ
where the matrices C, A, and Γ are chosen such that

$$C = \begin{pmatrix} 1 & 0 & -1 \\ 0 & 1 & 1 \end{pmatrix}, \qquad A = \begin{pmatrix} 1 & 0 \\ -1 & 1 \\ 0 & 1 \end{pmatrix}, \qquad \Gamma = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$$

and
$$B = \begin{pmatrix} 3.03 & 4.33 & 5.56 \\ 49.61 & 51.06 & 53.47 \\ 33.77 & 36.16 & 38.04 \end{pmatrix},$$

Notice that B is the matrix of mean vectors of the three groups.
The test statistic is the Wilk's criterion given by

$$\Lambda = \frac{|Q_e|}{|Q_e + Q_h|}, \quad \text{and } H_{01} \text{ is rejected}$$

at α level of significance if $\Lambda < u^{\alpha}(u, v_h, v_e)$; $u = p-1, v_h = k-1, \; v_e = N-1$, where Q_h and Q_e are the hypothesis and error sums of squares given by

$$Q_h = (CBA)'\left\{C(X'X)^{-1}C'\right\}' (CBA), \quad \text{and}$$

$$Q_e = A'Y'\left\{I - X(X'X)^{-1}X'\right\} YA$$

TEST OF EQUALITY OF PROFILES

The equality of profiles, also called the separation of group profile is used to test whether parallel profiles are equal or separated. The hypothesis of interest is given as

$$H_{02} : \begin{pmatrix} \mu_{11} \\ \mu_{21} \\ \mu_{31} \end{pmatrix} = \begin{pmatrix} \mu_{12} \\ \mu_{22} \\ \mu_{32} \end{pmatrix} = \begin{pmatrix} \mu_{13} \\ \mu_{23} \\ \mu_{33} \end{pmatrix}$$

and in matrix notations, H_{02} is represented as

H_{02}: CBA $= \Gamma$, where

$$C = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}, \qquad A = \begin{pmatrix} 1 & 0 \\ 0 & 1 \\ -1 & -1 \end{pmatrix}, \qquad \Gamma = \begin{pmatrix} 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{pmatrix};$$

B is the matrix of mean vectors of the three parameters for the three months under consideration earlier defined.

The test for difference in conditions, H_{02} is obtained by solving the equation (Wilks Criterion)

$$\Lambda = \frac{|Q_e|}{|Q_e + Q_h|}$$

where the hypothesis and error sum of squares are as earlier defined, and the H_{02} is rejected if $\Lambda < u^{\alpha}(p-1, k, N-k)$ at 5% level of significance.

TEST OF EQUALITY OF MEANS

The equality of means test, also known as test of flatness is used to determine whether the means are equal among factor categories for each dependent variable. The hypothesis of interest is given as:

$$H_{03}: \begin{pmatrix} \mu_{11} \\ \mu_{12} \\ \mu_{13} \end{pmatrix} = \begin{pmatrix} \mu_{21} \\ \mu_{22} \\ \mu_{23} \end{pmatrix} = \begin{pmatrix} \mu_{31} \\ \mu_{32} \\ \mu_{33} \end{pmatrix}$$

and in matrix notations,

$$H_{03}: CBA = \Gamma$$

where

$$C = \begin{pmatrix} 1 & 0 & -1 \\ 0 & 1 & -1 \end{pmatrix}, \quad A = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \end{pmatrix}, \quad \Gamma' = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

and B is as earlier defined.

The test statistic for the necessary hypothesis is the Wilk's Criterion earlier defined and the test is rejected if $\Lambda < u^{\alpha}(p, k-1, N-k)$,

ANALYSIS OF ANTHROPOMETRIC DATA

Due to large size of data, the General Linear Model (GLM) of the SPSS package was employed in the analysis. Table 1 gives the test results of H_{01}, H_{02}, and H_{03}.

Table 1: Test results for H_{01}, H_{02} and H_{03}

Test	Λ	Hypothesis df	Error df	F-value
H_{01}	0.905	4	592	7.563
H_{02}		2	297	94.289
H_{03}		4	514	5.224

Result of Table 1 for H_{01} shows that the group by month interaction is not significant, thus sustaining the tenability of the parallelism hypothesis.

Furthermore, the equality of profiles is defined by the main effect of groups (Tabachnick and Fidell, 2001). Test results of H_{-02} as given in Table 1 reveals that the main effect of group is significant, indicating that the profiles differ in level; thus the hypothesis of equality of profiles is rejected, meaning that the three profiles are not equal but separated. Further pair-wise comparisons on the groups show that the mean difference is significant for all the parameters (groups) at five percent level of significance, with the weight being significantly different from the height and head circumference. This means that parameters do change over time.

Test result of H_{03} also shows that the hypothesis of equality of means is not tenable. Because of the non tenability of the hypothesis of equality of means (effect of months), some multiple comparison tests were conducted to show which of the months was significantly different from the others with respect to the measure of the parameters. Results show that the mean differences between the months are significant at the 5 percent level; i.e. the parameters are different in the three months.

EFFECT OF ANTHROPOMETRIC PARAMETERS ON GROWTH RATE.

One of the objectives of this work is to determine whether or not the weight, height and head circumference of the newborns can be used in assessing their growth rate. Generally, anthropometric parameters serve as useful adjuncts to other observations in evaluating neonatal growth and development. An important tool for assessing and monitoring a child's growth rate is the growth chart, which is a plot of the necessary parameters (weight height and head circumference) usually resulting in a curve which is sigmoid in nature.

To measure growth using the anthropometric parameters involves calculating the weight gain, height gain and head circumference gain, which provides a more precise estimation of growth rate. Table 2 – 4 provide the weight, height and head circumference gains using a 10% sample of the total number of babies randomly selected.

Table 2: Weight Gain

S/N	AGE (months)	Approx. Monthly Weight gain (kg)	AGE (months)	Approx. Monthly Weight gain (kg)
10	1 - 2 months	1.7	2 - 3 months	1.7
20		1.1		1.1
30		1.0		1.0
40		1.2		1.2
50		0.8		1.8
60		2.3		2.3
70		1.3		1.3
80		2.3		2.3
90		1.2		1.2
100		1.3		1.3
Mean		1.42		1.42

Table 3: Height Gain

S/N	AGE (months)	Approx. Monthly height gain (cm)	AGE (months)	Approx. Monthly height gain (cm)
10	1 - 2 months	2.0	2 - 3 months	3.0
20		2.0		2.0
30		4.0		2.0
40		1.0		2.0
50		2.0		2.0
60		2.0		2.0
70		3.0		2.0
80		3.0		2.0
90		5.0		3.0
100		4.0		2.0
Mean		2.8		2.2

Table 4: Head Circumference Gain

S/N	AGE (months)	Approx. Monthly HC gain (cm)	AGE (months)	Approx. Monthly HC gain (cm)
10	1 - 2 months	2.0	2 - 3 months	3.0
20		4.0		2.0
30		3.0		5.0
40		1.0		2.0
50		1.0		3.0
60		3.0		2.0
70		4.0		2.0
80		2.0		2.0
90		2.0		2.0
100		4.0		3.0
Mean		2.6		2.6

Results show that the babies increase in size between the time of birth and the time last measurements were taken, the growth being reflected in the size of the anthropometric parameters over the months. For example, the baby's brain growth is reflected in the size of the skull, which is a measure of the head circumference. This is in agreement with the nature of the raw data, which shows that Head circumference is increasing with time. From this result, a pediatrician can diagnose failure of the new-born to thrive; newborns whose weights, heights, and head circumferences fall below the range for a particular age are given a thorough investigation to find out the cause of the problem. We therefore conclude that the growth pattern of a newborn is directly proportional to the overall growth rate of the anthropometric parameters.

RELATIONSHIPS AMONG ANTHROPOMETRIC PARAMETERS

We employ the Pearson's product moment correlation to determine the existence of relationship among the three anthropometric parameters under consideration. Table 5 provides the values of the correlation coefficients (r) for the various combinations or associations. Here, the value of r measures the strength of the linear relationship between any two of the three parameters and also indicate the direction of association.

Table 5**:** Relationship among Weight, Height & Head Circumference

	Weight	**Height**	**Head circumference**
Weight	1	0.623	0.602
Height	0.623	1	0.459
Head Circumference	0.602	0.459	1

The r values given in Table 5 show that there exist strong relationships among anthropometric parameters and this is in agreement with the result of Cheverud et al (1998). Thus, one of the parameters, say, weight, may serve to assess the condition of the newborn in a situation where the other parameters cannot be measured or where there is the problem of missing observations.

CONCLUSION

The result of this work has shown that the overall growth rate of newborns is proportional to the measures of anthropometric parameters, weight, height and head circumference; that is the growth rate of newborn increases as the parameters increase. Also, we have seen that there exists a strong relationship among the three anthropometric parameters.

REFERENCES

Cheverud, J., Gordon, C., Walker, R. A., Jacquish, C., Kjohm, L., A., and Yamashita, N. (1998): 1998 Anthropometric Survey of U. S Army Personel (Technical Reports 90/031 through 036 ed.).

Morrison D. f. (1976): Multivariate Statistical Methods. 2nd ed. McGraw-Hill, New York.

Tabachnick, B. G. and Fidell L. S. (2001). Profile analysis: The Multivariate approach to repeated measures.

Yamashiroya, V. K. MD (2003): Case based on pediatrics for Medical Students and Residents, University of Hawaii.