VARIABLES AFFECTING

CHILDREN'S BLOOD PRESSURES

by

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ABSTRACT

The blood pressures of fifty hospitalized school age children were measured at intervals to determine if the variables age, weight, sex, and the passage of time between readings have a significant effect on the systolic and diastolic blood pressures and the pulse pressure.

The variables age, weight, and quadratic change over time were found to be significant factors, while sex, sex by time, and linear change over time were not.

The results show that diastolic values remain at relatively constant levels during the ages five to eleven years. Children's blood pressure values seem to be subject to diurnal fluctuations that should be considered when establishing limits of normalcy or when interpreting clinical values.

INTRODUCTION

A problem encountered by the pediatric nurse in interpreting blood pressure values of hospitalized children is a lack of conclusive information on acceptable ranges of children's blood pressure values and the effects of such variables as age, weight, sex, time of day, and emotional state on these values. This lack of limiting data was noted by Chinn[1] in relation to physical assessment of school children.

The purpose of this study is to determine if the variables age, sex, weight, and time between readings have a significant effect on the systolic and diastolic blood pressures and the pulse pressure in hospitalized school age children. Due to a lack of well documented information, the need of establishing definitive data on blood pressure value for children which can be used as a guide to establish normalcy is apparent.

Graham, Hines, and Gage[2] and Moss and Adams[3] have published studies dealing with the normal ranges of blood pressure values in children; and there is little agreement between these authors. Graham (et. al.)[2] did not find sex to be a significant variable and, therefore, lists normal values according to age alone. Moss and Adams[3] list values by age and sex. Neither study considered weight as a variable.

The standard deviations found in both studies are so large as to render their data useless in clinical practice. Moss and Adams,[3] in reporting data for nine-year-old females, give a systolic standard deviation of 9.1 mm Hg and a diastolic standard deviation of 16.2 mm Hg. All major texts in pediatric medicine[4-9] and pediatric nursing[10-13] use the Graham (et. al.)[2] or the Moss and Adams[3] variables as basic data on children's blood pressure values.

The available information dealing with the effects of variables on children's blood pressure values is generally not well-documented. Barness[7] comments in the Manual of Pediatric Diagnosis that crying or apprehension may double both the systolic and the diastolic blood pressure values and that excitement causes the systolic pressure to rise. According to Silver, Kempe, and Bruyn,[6] systolic pressure may increase as much as fifty millimeters of mercury above normal values when excitation or struggling occurs. There are no references for these statements.

Two Russian studies treat the subject of autonomic responses to emotion in children but complete translations are unavailable. Trunova[14] determined that changes in autonomic functions agree with observed behavior during viewing of slide presentations of fairy tales. The subjects were ten children ages three to three and one-half years. Sukhanova[15] reported that autonomic reactions in one to seven year olds are modified under the action of emotions.

MATERIALS AND METHODS

The subjects were fifty children of the ages five to eleven years who were admitted for elective surgery to the pediatric unit of the Utah Valley Latter-day Saints Hospital in Provo, Utah (elevation 4,522 feet). Children became a part of the study as they were admitted to the hospital. After fifty children had been tested, a purely chance distribution of twenty-five female and twenty-five males occurred. For the purpose of this study, elective surgery encompassed tonsillectomy, adenoidectomy, myringotomy, reduction and resection of eye muscles, orthopedic surgery for correction of an acquired defect, cystoscopy, urethrotomy, meatotomy, herniorrhaphy, and excision of moles, hemangiomas and verrucae.

No child was eligible for the study who had diagnosed heart disease, hypertension, renal disease, or nervous system disorder or who was admitted with traumatic injuries. Children whose weights were above the ninetieth or below the tenth percentile on the Children's Medical Center, Boston-Anthropometric Chart[16] were not included in the sample.

The Sphygmostat B-200 was used to determine all blood pressure values. This instrument eliminates the need to asculate the brachial

pulse through the use of a microphone in the cuff. The pulse pressure interval, as detected by the microphone, is indicated by a blinking red light and thus hearing bias is nonexistent. Standard pediatric cuffs of various sizes were used to ensure that at least, but not more than, two-thirds of any child's upper arm was covered by the cuff.[4, 7]

Each subject's blood pressure was measured three times. The first determination was made during the standard hospital admission procedure at approximately three o'clock in the afternoon. The weight was also recorded at this time. The second determination was made four hours after the first, and the third at six-thirty the next morning. The investigator made the first measurement and weighed the subjects. The permanent staff Registered Nurses made the subsequent determinations.

RESULTS

An analysis of covariance[17] on the systolic blood pressure values is given in Table I (page 7). It can be seen that a significance of $\alpha = .05$ was obtained for the variables age and weight. Sex and sex by time showed no significance, nor was there a significant linear change over time. A significance at the $\alpha = .01$ level is given for quadratic change over time (Table IV, page 10).

Diastolic values are summarized in Table II (page 8). In this analysis age and weight were not shown to be significant variables. Sex shows no significance; sex by time is again not significant. Quadratic change over time shows $\alpha = .01$ level as it did in the systolic summary. Linear change over time is not significant.

Table III (page 9) gives an analysis of covariance for pulse pressure values. None of the variables show significance for pulse pressure.

Blood pressure and pulse pressure values obtained according to age at the three test times is given in Table V (page 11).[18] The means for all test times are uniformly lower than those given by Graham (et. al.)[2] and by Moss and Adams.[3] The standard deviations correspond with those given in the above named studies.

Blood pressure and pulse pressure values obtained according to weight at the three test times is given in Table VI (page 12). The standard deviations for mean systolic pressure are consistently higher for the first test time.

TABLE I

Analysis of Covariance on Systolic Blood Pressure Values

Source	df	MS	F	Significance
Age	1	987.60	4.86	$\alpha = .05$
Weight	1	1058.00	5.15	$\alpha = .05$
Sex	1	134.20	<1	n.s.
Patients[a]	46	206.02		
Time	2	76.88	7.07	$\alpha = .01$
1-Linear	1	6.76	<1	n.s.
2-Quadratic	1	147.00	13.52	$\alpha = .01$
Sex x Time	2	1.15	<1	n.s.
Error	96	10.87		

[a] an error term

TABLE II

Analysis of Covariance on Diastolic Blood Pressure Values

Source	df	MS	F	Significance
Age	1	129.1	< 1	n.s.
Weight	1	265.6	1.85	n.s.
Sex	1	468.18	3.27	n.s.
Patients[a]	46	143.27		
Time	2	34.587	4.904	$\alpha = .01$
1-Linear	1	1.96	< 1	n.s.
2-Quadratic	1	67.13	9.4308	$\alpha = .01$
Sex x Time	2	.24	< 1	n.s.
Error	96	7.05		

[a] an error term

TABLE III

Analysis of Covariance on Pulse Pressure Values

Source	df	MS	F	Significance
Age	1	252.6	1.88	n.s.
Weight	1	264.1	1.92	n.s.
Sex	1	97.927	< 1	n.s.
Patients[a]	46	136.92		
Time	2	9.1467	< 1	n.s.
1-Linear	1	1.96	< 1	n.s.
2-Quadratic	1	16.33	1.5453	n.s.
Sex x Time	2	.83	< 1	n.s.
Error	96	10.57		

[a] an error term

TABLE IV

Change in Means over Time

Item	Time 1	Time 2	Time 3
Systolic			
Means	93.16	91.32	93.68
Diastolic			
Means	63.36	62.08	63.64
Pulse Pressure			
Means	29.8	29.24	30.08

Note: The means are adjusted to average age and weight.

TABLE V

Blood Pressure, Pulse Pressure Means and Standard Deviations by Age and Time

Time	Age	Mean Systolic mm Hg	Mean Diastolic mm Hg	Mean Pulse Pressure	Number
1	5	91.1 ± 13.2	63.6 ± 10.5	27.6 ± 7.8	9
2		87.1 ± 11.5	62.0 ± 9.2	24.4 ± 9.2	
3		88.2 ± 9.3	62.0 ± 9.3	26.2 ± 7.3	
1	6	91.1 ± 6.0	62.0 ± 7.6	29.1 ± 7.2	9
2		91.1 ± 6.0	60.9 ± 6.6	30.2 ± 6.5	
3		91.8 ± 6.4	64.0 ± 5.5	27.8 ± 6.9	
1	7	89.5 ± 6.7	62.5 ± 5.4	27.0 ± 5.6	8
2		88.0 ± 8.2	63.5 ± 5.8	24.5 ± 4.1	
3		90.3 ± 6.4	62.8 ± 6.3	27.5 ± 4.0	
1	8	96.7 ± 12.5	66.0 ± 7.0	30.7 ± 10.2	6
2		92.3 ± 9.9	64.0 ± 5.1	28.3 ± 8.1	
3		97.0 ± 10.3	65.3 ± 6.4	31.7 ± 7.3	
1	9	91.4 ± 9.6	62.9 ± 8.6	28.6 ± 9.8	7
2		91.1 ± 9.4	60.3 ± 7.9	30.9 ± 10.0	
3		95.1 ± 9.6	64.6 ± 6.5	30.9 ± 7.6	
1	10	98.0 ± 8.4	66.7 ± 8.6	31.3 ± 3.5	6
2		97.7 ± 9.2	65.7 ± 8.6	32.0 ± 6.7	
3		101.0 ± 12.3	66.7 ± 7.3	34.0 ± 8.5	
1	11	98.8 ± 12.9	60.4 ± 7.8	38.4 ± 8.9	5
2		96.0 ± 9.8	60.4 ± 8.9	35.6 ± 7.4	
3		98.0 ± 9.5	60.4 ± 9.5	37.6 ± 7.1	

TABLE VI

Blood Pressure, Pulse Pressure Means and Standard Deviations by Weight and Time

Time	Weight (lbs.)	Mean Systolic mm Hg	Mean Diastolic mm Hg	Mean Pulse Pressure	Number
1	30-40	97.0 ± 12.5	68.5 ± 11.8	28.5 ± 10.7	4
2		93.5 ± 9.1	66.5 ± 10.2	27.0 ± 10.1	
3		93.0 ± 6.2	65.5 ± 9.1	27.5 ± 9.9	
1	41-50	89.2 ± 9.9	60.8 ± 7.0	28.4 ± 7.5	18
2		87.1 ± 9.3	59.1 ± 5.9	28.0 ± 7.5	
3		89.3 ± 9.3	61.9 ± 6.8	27.4 ± 6.6	
1	51-60	91.6 ± 8.6	63.1 ± 4.4	28.4 ± 7.1	9
2		89.1 ± 7.6	63.3 ± 4.8	25.8 ± 4.9	
3		92.8 ± 7.5	63.7 ± 6.6	29.1 ± 5.0	
1	61-70	94.4 ± 8.5	65.0 ± 10.1	29.4 ± 7.7	10
2		93.4 ± 8.2	62.6 ± 9.6	30.8 ± 8.2	
3		95.0 ± 6.1	64.8 ± 7.3	30.4 ± 6.6	
1	71-80	100.7 ± 11.3	64.6 ± 7.6	36.0 ± 5.3	3
2		100.0 ± 8.7	64.0 ± 4.0	36.0 ± 6.0	
3		99.3 ± 11.0	64.6 ± 5.0	34.7 ± 9.9	
1	81-90	97.0 ± 11.5	62.0 ± 2.8	35.0 ± 12.7	4
2		95.5 ± 8.4	62.0 ± 5.4	33.5 ± 10.4	
3		99.0 ± 5.8	62.5 ± 7.7	36.5 ± 8.2	
1	91-100	only one subject			1
1	101-110	only one subject			1

DISCUSSION

Investigators have traditionally considered age to be the most significant variable influencing blood pressure in children. The fact that standard deviations based on age are large suggests that other factors influence blood pressure. The results of this study clearly show that in determining systolic values weight and age are equally significant. Since all subjects were within the accepted normal weight limits for their age, further investigation into defining normal systolic blood pressure values by weight rather than by age seem warranted. The apparent effect of age may be due to weight; and, if this is the case, the limits of normalcy could be more narrowly defined than they now are by the age standard.

Diastolic means were not significantly different from one age to another or from one weight group to another. The implication seems to be that diastolic values remain at relatively constant levels during the ages five to eleven years. The contradicts Barness[7] who states that both pressures usually rise two to three millimeters of mercury per year of age. This statement is based on the data of Graham (et. al.).[2]

Both the systolic and diastolic means, adjusted for average age

and weight, responded quadratically over time. The second measurement was significantly lower than the first or third. In drawing conclusions from this data it should be remembered that the subjects were hospitalized and, therefore, submitted to stresses that were not measured in this study. These stresses may be reflected in the data in Table IV (page 12) where the standard deviations for mean systolic pressure are consistently higher for the first test time. The first measurement was taken before the subject had become accustomed to the hospital environment. In addition, it appears that children's blood pressure values are subject to diurnal variations that should be considered when establishing limits of normalcy or when interpreting clinical values.

The uniformly lower means that reported in the literature for all three measurements and all three test times may be a function of the altitude at which the measurements were made. Graham (et. al.)[2] and Moss and Adams[3] did not indicate the altitude at which they conducted their studies. The relationship of environmental hematocrit changes to blood pressure measurements in children should be studied.

IMPLICATIONS

There is evidence to indicate that norms for children's blood pressure values should be based on weight rather than age. If, as the data indicate, emotional factors influence hospitalized children's blood pressure, current admission procedures on pediatric units should be evaluated and modified.

SUMMARY

The blood pressure of fifty hospitalized school age children were measured at intervals to determine if the variables age, weight, sex, time of day, and emotional factors have a significant effect on the systolic and diastolic blood pressures and the pulse pressure. The results of the study were:

1. Age and weight were equally significant in an analysis of covariance of systolic values but were not significant for diastolic or pulse pressure values.
2. Sex and sex by time showed no significance.
3. Both the systolic and diastolic means responded quadratically over time with the second measurement significantly lower than the first or third.
4. Diastolic means were not significantly different from one age or weight group to another.
5. The means for all test times were uniformly lower than those traditionally considered normal.

REFERENCES

1. Chinn, P.: A Relationship Between Health and School Problems: A Nursing Assessment. Journal of School Health, 43:89, 1973.

2. Graham, A. W., Hines, E. A., and Gage, R. P.: Blood Pressures in Children Between the Ages of Five and Sixteen Years. American Journal of Diseases in Children, 69(4):203, 1945.

3. Moss, A. J., and Adams, F. H.: Problems of Blood Pressure in Childhood. Charles C. Thomas, Springfield, Illinois, 1962, p. 73.

4. Cooke, R. E.: The Biological Basis of Pediatric Practice. McGraw-Hill, New York, New York, 1968, pp. 1366-7.

5. Nelson, W. E., Vaughn, V. C., and McKay, R. J.: Textbook of Pediatrics, 9th edition. W. B. Saunders, Philadelphia, Pennsylvania, 1969, p. 38.

6. Silver, H. K., Kempe, C. H., and Bruyn, H. B.: Handbook of Pediatrics. Lange Medical Publications, Los Altos, California, 1971, p. 215.

7. Barness, L. A.: Manual of Pediatric Physical Diagnosis, 4th edition. Year Book Medical Publishers, Chicago, Illinois, 1972, pp. 16-17.

8. Green, M., and Haggerty, R. J.: Ambulatory Pediatrics. W. B. Saunders, Philadelphia, Pennsylvania, 1968, p. 430.

9. Wasserman, E., and Slobody, L. B.: Survey of Clinical Pediatrics, 6th edition. McGraw-Hill, New York, New York, 1974, p. 9.

10. Chinn, P., and Leitch, C. J.: Child Health Maintenance. C. V. Mosby Company, Saint Louis, Missouri, 1974, p. 49.

11. Marlowe, D. R.: Textbook of Pediatric Nursing, 4th edition. W. B. Saunders, Philadelphia, Pennsylvania, 1973, p. 72.

12. Latham, H. C., and Heckel, R. V.: Pediatric Nursing, 2nd edition. C. V. Mosby Company, Saint Louis, Missouri, 1972, p. 238.

13. Alexander, M. M., and Brown, M. S.: Pediatric Physical Diagnosis for Nurses. McGraw-Hill, New York, New York, 1974, p. 135.

14. Trunova, N.: Ob izchenii emotsil u detei, Doshkolnoe Vospitanie, 43(5):28-34. (Psychological Abstracts, 1970, No. 920).

15. Sukhanova, N. V.: Osobennosti formirovanii vegetativnogo Komponeta rechevoi reaktsii cheloveka. Zhurnal Uysshei Nervnoi Deyatelnosti, 19:313-18, 1969. (Psychological Abstracts, 1971, No. 6023)

16. Stuart, H. C.: The Children's Medical Center, Boston-Anthropometric Chart. Mead Johnson Laboratories.

17. MAD program for analysis of covariance, Brigham Young University, Department of Statistics--Computer Data Center.

18. Brigham Young University, Department of Statistics--Computer Data Center.

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