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ABSTRACT

The longitudinal study assessed the psychological and educational sequelae of premature birth through the early elementary school years, to determine whether children born prematurely constitute a high risk population in terms of regular school progress. Subjects included 78 children with birth weights of 2500 grams or less, 78 children of normal birth weight whose gestation periods were 37 weeks or less, and 85 controls whose birth weights were greater than 2500 grams and gestation periods greater than 37 weeks. Measures included a 4-month neurological exam, 8-month psychological exam, 12-month neurological exam, 4-year intelligence test, 5-year school readiness test and ITPA, and teacher reports from the ages of 7-11 years. Results indicated that birth weight rather than gestational age is the major predictor of psychological and educational impairment. Subjects low in both birth weight and gestational age evidence an initial disadvantage which was gradually dissipated, with small-for-date subjects eventually showing greater psychological and educational disability than those who were low on both indices. (KW)

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Psychological And Educational Sequelae Of Prematurity

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January, 1972

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U.S. DEPARTMENT OF

HEALTH, EDUCATION, AND WELFARE

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Psychological and Educational Sequelae of Prematurity

The present study is an assessment of the psychological and educational sequelae of premature birth through the early elementary school years. The primary purpose is to determine whether prematurely born children may appropriately be considered a "high risk" population in terms of subsequent difficulties in making progress through the regular school curriculum.

Literature on the psychological outcomes associated with premature birth has been surveyed by Benton (1940), Weiner (1962), Harper and Weiner (1965), and more recently by Caputo and Mandell (1970). Although research findings generally indicate negative relationships between prematurity and performance on measures of intellectual and educational functioning (Eaves, Nutall, Klonoff, & Dunn, 1970; Parmelee & Schulte, 1970; Weiner, Rider, Oppel, & Harper, 1968) reviewers report conflicting findings regarding the degree and duration of such impairments. It has been suggested that inconsistencies in research results may reflect, in part, a lack of uniformity in defining prematurity (Drillien, 1964). Caputo and Mandell (1970) report that

> The terms low birth weight, immaturity, prematurity, and short gestation have been used interchangeably in the literature, often obscuring the generalizability of findings. Very frequently, low birth weight has been employed as the sole criterion of...prematurity..., the implication often being that such infants are of low gestational age...as well. (p. 363)

A number of investigators have acknowledged the need for an interactive definition of prematurity with classification by both birthweight

and gestational age (Caputo & Mandell, 1970; Dawkins, 1965; McDonald, 1965; Weiner, 1968). These recommendations have been incorporated in the design of the present study which entails classification of subjects by gestational age, birthweight and sex.

Procedure

Sample

Subjects were drawn from a pool of 1613 children who are participants in both the Collaborative Perinatal Research Project[1] and the Educational Follow-Up Project, a continuing longitudinal study of the educational and behavioral sequelae of perinatal and early childhood conditions in a population of children born at the University of Minnesota Hospitals between 1960 and 1964 (Balow, Anderson, Reynolds, & Rubin, 1969).

The sample for the present study includes all Educational Follow-Up subjects with birth weights equal to or less than 2500 grams (N=78) as well as those of normal birth weight whose gestation periods were equal to or less than 37 weeks (N=78). In addition, a control group of 85 subjects with birth weights greater than 2500 grams and gestation periods in excess of 37 weeks was drawn from the remainder of the Educational Follow-Up population through a random sampling technique designed to equate maturely born and premature Ss on year of birth. The 78 low birth weight Ss constitute

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[1]This study, "The Collaborative Project for the Study of Cerebral Palsy, Mental Retardation, and other Neurological and Sensory Disorders of Childhood," is a major investigation in twelve medical centers of the antecedents of neurologically related childhood disorders.

4.8% of the total Educational Follow-Up population. This is considerably less than the incidence figure of 7.4% for low birth weight children in the general population (Unger, 1957).

These 241 study subjects were then categorized in the following four groups on the basis of birth weight and gestational age in accordance with the recommendations of the Third Report of the Expert Committeee on Maternal and Child Health (WHO, 1961).

Group I (N=32): Low birth weight (≤2500 grams) prematures (gestation period ≤ 37 weeks)

Group II (N=46): Low birth weight (≤2500 grams) full-term births (gestation period >37 weeks)

Group III (N=78): Normal birth weight (>2500 grams) prematures (gestation period ≤ 37 weeks)

Group IV (N=85): Normal birth weight (>2500 grams) full-term births (gestation period >37 weeks)

Measures

The analyses are based upon the following measures/data:

1. Socioeconomic level - Socioeconomic Index scores were computed for each subject using a formula based upon parental occupation, education, and family income which yields composite scores ranging from 0 to 9.9. The mean for the population of the United States falls in the range between 5.0 and 5.9. (U.S.B.C. Index: Myrianthopoulis & French, 1968).

2. Four-month neurological examination - A physician with special training in pediatrics and neurology reported his clinical impression

of the child's neurological status as normal, neurologically "suspect", or neurologically "abnormal" based on a 73 item examination protocol. For purposes of this analysis subjects identified as either neurologically "suspect" or neurologically "abnormal" were combined and classified as neurologically "abnormal".

3. Eight-month psychological examination - The Bayley Scales of Mental and Motor Development (Perinatal Research Branch, research form)

4. Twelve-month neurological examination - similar to the four-month neurological examination but based on a more extensive, 117-item, protocol. Both neurologically "suspect" and neurologically "abnormal" subjects were classified as "abnormal" in the present analysis.

5. Four-year intelligence test - Stanford-Binet (L-M, Short Form)

6. Five-year measure of school readiness - The Metropolitan Readiness Tests (1965) designed to measure skills and abilities which contribute to readiness for initial first grade work such as auditory and visual perception, motor coordination, linguistic skills, knowledge of numbers, and ability to attend to and follow directions, was individually administered by trained educational examiners.

7. Five-year ITPA - The Illinois Test of Psycholinguistic Abilities (1961) designed to measure specific aspects of psycholinguistic ability in the areas of encoding, decoding, associating and sequencing was individually administered by trained educational examiners.

8. School problems and placement - Each year classroom teachers

of study subjects are asked to report information regarding retention, special class placement, receipt of special services and identification of behavior problems via a mail questionnaire.

Neurological and psychological examinations were administered at the University of Minnesota Hospitals and made available through the cooperation of the Collaborative Project. Information on school readiness, language development, school progress, and behavior were obtained as part of the continuing data collection activities of the Educational Follow-Up Project.

Analysis

Mean scores on standardized measures were compared through three-way analysis of variance procedures[2] with subjects classified by sex, birth weight, and period of gestation. Tests of Significance of the Difference Between Two Proportions (Bruning & Kintz, 1968) were used to compare the proportion of premature subjects in Groups I, II, and III who were diagnosed as neurologically abnormal or identified in various special educational problem categories with the proportion of Group IV, control group, subjects falling in these same categories.

Results

Socioeconomic level

As shown in Table 1 there were no significant differences on the

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Insert Table 1 about here

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[2]Conducted at the University of Minnesota Computer Center by Dr. Douglas Anderson using UMST 570 Multiple Analysis of Variance Program.

Socioeconomic Index between subjects grouped by gestational age, by birth weight, or by sex. The interaction between gestation period and birth weight approached significance ($p < .09$) with Ss who were "large-for-date" as well as those who were "small-for-date" having slightly lower SEI scores than did Ss whose birth weights were commensurate with their gestational ages. This excess of inconsistent birth weight and gestational age data for lower SES Ss may be interpreted as casting doubt upon the accuracy of obtained estimates of gestational age for offspring of lower SES mothers.

Insert Table 2 about here

Neurological abnormalities

As shown in Table 2, at four months of age neurological abnormalities were identified in 13.3% of Group I, 7.7% of Group II, 10.1% of Group III, and in 2.6% of Group IV, the control group. The proportion of neurological abnormalities in Groups I and III were significantly ($p < .01$) greater than the proportion in Group IV.

By the time of the twelve-month neurological examination the proportion of abnormalities in Group II, the "small-for-date" subjects, had more than doubled reaching 17.5% while the incidence of abnormalities in Groups I and II had decreased to 10.0% and 6.9% respectively. At this age only Group II manifested a significantly greater proportion ($p < .01$) of neurological abnormalities than did the control group.

Measures of infant development

Insert Tables 3 & 4 about here

The Bayley Scales of Mental and Motor Development were administered at eight months of age. As shown in Table 3 the mean Mental Scale score of Group IV was 79.58 which is at the mid-point of Bayley's 7-9 month interval and would yield a mean developmental quotient of 100. The mean Mental Scale score of 70.9 for Group I is approximately equivalent to a developmental age of 7 months which would yield a developmental quotient of 87.5 for this group.

On the Motor Scale the mean score of 33.8 obtained by Group IV is equal to a developmental age of 8 months yielding a developmental quotient of 100. Group I averaged 27.10, equal to a developmental age of 7 months which would yield a developmental quotient of 87.5. Thus both the mental and motor development of Group IV as measured by the Bayley Scales were appropriate for their chronological age while the performance of Group I was one month behind their chronological age on both measures.

The analysis of variance of mean scores for the various birth weight-gestational age groups on the Bayley Scales is presented in Tables 3 & 4. On both the Mental and Motor Scales there were significant mean differences between birth weight groups ($p < .001$) and between gestation period groups ($p < .01$) favoring the higher birth weight and higher gestational age subjects. On the Mental Scale there was also a significant sex difference ($p < .02$) favoring females

over males.

In order to determine the contribution of each birth weight gestation period group to the overall analysis of variance results, the Newman-Keuls statistical method for testing differences between pairs of means involved in an ANOVA (Winer, 1962) was utilized. It was found that the mean scores of Group I differed at the .01 level of significance from the means of each of the remaining three groups on both the Mental and Motor Scales. There were no significant differences among groups II, III, and IV on either of these measures. Thus it became apparent that the differences found between birth weight groups and between gestational age groups in the original analysis of variance were caused by the low scores of subjects in Group I for whom low birth weight was combined with premature birth. Groups II and III who differed from the control group on only one of these birth variables did not differ from Group IV on either of the Bayley Scales.

Insert Table 5 about here

Intelligence

The Stanford-Binet (short form) was administered to 207 (86%) of the 241 study subjects at age four. The highly significant difference ($p < .0001$ level) between birth weight groups favoring those with higher birth weights, is consistent with prior research findings (Drillien, 1964; Weiner, et al, 1968). The mean IQ of the control group was 105.05 while the mean IQ of Groups I, II, and III were

92.9, 94.8, and 101.95, respectively. There were no significant differences between high and low gestational age groups nor between males and females.

Insert Tables 6 & 7 about here

Pre-school language and readiness examinations

During the calendar year in which subjects reached their 5th birthday, prior to kindergarten entrance, the Metropolitan Readiness Tests (MRT) and the Illinois Test of Psycholinguistic Abilities (ITPA) were individually administered to 189 (78.4%) and 194 (80.4%) of the study subjects respecitvely. There were significant differences on both the MRT ($p < .02$) and the ITPA ($p < .001$) favoring the heavier birth weight groups over the lower birth weight groups. There were no other significant group differences, nor interactions on either instrument.

The mean ITPA language age score of 59.12 for Group IV was virtually identical to their mean chronological age of 60.0 months while the mean language age scores of Groups I and II, the low birth weight groups, were seven and eight months below their chronological ages, respectively. The mean language age score of Group III was two and one-half months below their mean chronological age.

Insert Table 8 about here

School Placement and Special Services

At the time the study data were collected subjects ranged in age from 7 to 11 and in grade placement from grades 1 to 5 as shown in Table 8 . Twenty-five (30.8%) of the Group IV, composed of normal birth weight and gestation period subjects, had been the recipients of special school services or had been involved in special school placement. This is an increase in special services and placement over the 24.4% figure for the total Educational Follow-Up population previously identified in these same categories (Rubin & Balow, 1971). However, at the time of the present study Ss were two years older than they were when the last report was made which increased opportunities for the identification of additional Ss in need of special educational assistance.

The proportion of subjects in Groups I, II, and III reported in Table 8 were compared with the proportion of Group IV, control group, Ss in these same categories. The proportion of retentions, special class placements, and special service recipients in the three low birth weight and/or gestational age groups were all greater than the proportion of Group IV Ss in these areas, however, the differences between Group III and Group IV were not significant.

A higher proportion of Group I than of Group IV had received special services or were found in one or more special categories, but the differences between the total problems identified in these two groups can be attributed to the greatly increased incidence of problems among Group I males while Group I females did not differ significantly from Group IV in any area. Both males and females in

Group II had significantly higher incidence of retentions, special class placements, and number of Ss found in one or more special categories.

The majority of subjects in Groups I (52.0%) and II (62.8%) were identified in at least one problem category with fully two-thirds of the males in both groups identified in one or more of these areas. It is apparent that birth weight rather than gestational age is more closely associated with occurrence of educational problems since Groups I and II, the low birth weight groups, differed significantly from the control group while Group III, the normal birth weight low gestational age group, did not differ from the control group on any of the educational problem outcomes reported in Table 8. Among the low birth weight subjects those who were "small-for-date", Group II, had a higher incidence of special educational problems than did those who were low in gestational age as well.

Summary and Conclusions

From the time of the four-month neurological examination through the identification of school related problems at ages 7 through 11, results of this study clearly indicate that birth weight rather than gestational age is the major predictor of psychological and educational impairment. The only point at which there were statistically significant differences between groups divided on gestational age alone was at the time of the eight-month psychological examamination when gestational age differences were noted on both the Mental and

Motor Scales of the Bayley. However, these differences were due solely to low scores obtained by the low birth weight - low gestational age group rather than representing the performance of all low gestational age subjects.

There is evidence of a trend within the low birth weight portion of the sample which found Group I at an initial disadvantage as evidenced by higher incidence of neurological abnormalities at four months of age and by depressed Bayley Mental and Motor scores at eight months of age. However, the similarity between Groups I and II increased over time so that there were no longer any significant discrepancies between the two groups on the four-year Binet or the five-year MRT and ITPA examinations although both groups scored lower than normal birth weight subjects on all three of these measures. By the time the subjects were aged 7 through 11 Group II, the "small-for-date" subjects, were more frequently identified in special educational problem categories.

These data suggest an initial disadvantage for those low in both birth weight and gestational age which is gradually dissipated and eventually reversed so that "small-for-date" Ss eventually show greater psychological and educational disability than do those who were low on both initial indices. There is also some indication that low birth weight males eventually show a greater proportion of school problems than do females of similar birth weight. This may reflect a greater vulnerability on the part of the male organism.

Results of this study clearly indicate that low birth weight Ss constitute a "high risk" population in terms of eventual impairment

of school functioning with the majority of low birth weight subjects manifesting problems of sufficient magnitude to warrant special educational placement or special services while in the elementary school grades.

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Table 1

Birth Weight x Gestation Period x Sex Analysis
of Socioeconomic Index Scores

	Group I ≤37 weeks ≤2500 grams		Group II >37 weeks ≤2500 grams		Group III ≤37 weeks >2500 grams		Group IV >37 weeks >2500 grams	
	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$
M	17	5.31	20	4.54	30	5.05	47	5.15
F	13	4.94	26	4.40	45	4.50	38	5.00
Total	30	5.15	46	4.46	75	4.72	85	5.08

Source of Variance	MS	F Ratio (1 + 228 df)	p
Sex	759.41	2.03	.16
Gestation	.000	.00	.99
Birth weight	218.10	.58	.45
Sex x Gestation	162.04	.43	.51
Sex x Birth weight	2.81	.001	.93
Gestation x Birth weight	1112.57	2.98	.09
Sex x Gestation x Birth weight	8.48	.002	.88

Table 2

Proportion of Subjects Showing Neurological Abnormalities at Four Months and at Twelve Months of Age Grouped by Sex, Birth Weight, and Gestation Period

Neurological Exam	Group I ≤37 weeks ≤2500 grams	Group II >37 weeks ≤2500 grams	Group III ≤37 weeks >2500 grams	Group IV >37 weeks >2500 grams
4-month Exam	N = 30	N = 39	N = 69	N = 76
M	3 (16.7%)*	2 (13.3%)	3 (11.5%)	2 (5.0%)
F	1 (08.3%)*	1 (04.2%)	4 (09.3%)**	0 (0)
Total	4 (13.3%)**	3 (07.7%)	7 (10.1%)**	2 (2.6%)
12-month Exam	N = 30	N = 40	N = 72	N = 76
M	2 (12.5%)	2 (12.5%)	3 (10.3%)	2 (5.0%)
F	1 (07.1%)	5 (20.8%)**	2 (04.6%)	1 (2.7%)
Total	3 (10.0%)	7 (17.5%)**	5 (06.9%)	3 (3.9%)

* Significantly different from Group IV at the .05 level
** Significantly different from Group IV at the .01 level

Table 3

Birth Weight x Gestation Period x Sex Analysis
of Bayley Scales of Mental Development Scores

	Group I ≤37 weeks ≤2500 grams		Group II >37 weeks ≤2500 grams		Group III ≤37 weeks >2500 grams		Group IV >37 weeks >2500 grams	
	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$
M	17	68.24	17	76.12	30	77.93	35	78.20
F	12	74.67	23	78.17	38	77.84	35	80.74
Total	29	70.90	40	77.30	68	77.88	70	79.47

Source of Variance	MS	F Ratio (1 + 199 df)	p
Sex.....	309.91	5.17	.02
Gestation.....	421.41	7.03	.01
Birth Weight.....	828.18	13.82	.001
Sex x Gestation.....	2.60	.04	.84
Sex x Birth Weight.....	100.51	1.68	.19
Gestation x Birth Weight.....	189.05	3.16	.08
Sex x Gestation x Birth Weight.....	135.99	2.27	.13

Table 4

Birth Weight x Gestation Period x Sex
Analysis of Bayley Scales of Motor Development Scores

	Group I ≤37 weeks ≤2500 grams		Group II >37 weeks ≤2500 grams		Group III ≤37 weeks >2500 grams		Group IV >37 weeks >2500 grams	
	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$
M	17	26.06	17	31.18	30	32.97	35	33.11
F	12	28.58	23	30.48	38	32.05	35	34.80
Total	29	27.10	40	30.78	68	32.46	70	33.96

Source of Variance	MS	F Ratio (1 + 199 df)	p
Sex.....	25.09	1.16	.28
Gestation.....	193.24	8.95	.003
Birth Weight.....	786.61	36.42	.001
Sex x Gestation.....	.28	.01	.91
Sex x Birth Weight.....	1.58	.07	.79
Gestation x Birth Weight.....	47.73	2.21	.14
Sex x Gestation x Birth Weight.....	93.84	4.35	.04

Table 5

Birth Weight x Gestation x Sex
Analysis of Stanford-Binet Scores Administered
At Age Four

	Gestation Period and Birth Weight							
	Group I ≤37 weeks ≤2500 grams		Group II >37 weeks ≤2500 grams		Group III ≤37 weeks >2500 grams		Group IV >37 weeks >2500 grams	
	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$
M	17	91.35	17	96.00	27	100.11	40	101.60
F	13	95.00	23	93.96	37	103.30	33	109.24
Total	30	92.93	40	94.83	64	101.95	73	105.05

Source of Variance	MS	F Ratio (1 + 199 df)	p
Sex.....	658.84	2.43	.12
Gestation.....	318.28	1.18	.28
Birth Weight.....	4352.14	16.07	.001
Sex x Gestation.....	24.31	.09	.76
Sex x Birth Weight.....	321.05	1.19	.28
Gestation x Birth Weight.....	42.25	.16	.69
Sex x Gestation x Birth Weight.....	288.06	1.06	.30

Table 6

Birth Weight x Gestation Period x Sex
Analysis of Five-Year Metropolitan Readiness Test Scores

	Gestation Period and Birth Weight							
	Group I ≤37 weeks ≤2500 grams		Group II >37 weeks ≤2500 grams		Group III ≤37 weeks >2500 grams		Group IV >37 weeks >2500 grams	
	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$
M	14	21.71	19	22.47	26	28.73	33	27.94
F	13	25.38	19	25.37	36	24.25	29	33.55
Total	27	23.48	38	23.92	62	26.13	62	30.56

Source of Variance	MS	F Ratio (1 + 181 df)	p
Sex.....	81.66	.42	.52
Gestation.....	372.87	1.90	.17
Birth Weight.....	1073.94	5.49	.02
Sex x Gestation.....	434.51	2.22	.14
Sex x Birth Weight.....	50.18	.26	.61
Gestation x Birth Weight.....	157.99	.81	.37
Sex x Gestation x Birth Weight.....	307.11	1.57	.21

Table 7

Birth Weight x Gestation Period x Sex Analysis of
Five-Year Illinois Test of Psycholinguistic Abilities Scores

	Gestation Period and Birth Weight							
	Group I ≤37 weeks ≤2500 grams		Group II >37 weeks ≤2500 grams		Group III ≤37 weeks >2500 grams		Group IV >37 weeks >2500 grams	
	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$
M	14	49.71	20	48.95	27	59.89	34	58.12
F	13	56.08	19	54.73	36	55.72	31	60.23
Total	27	52.78	39	51.77	63	57.51	65	59.12

Source of Variance	MS	F Ratio (1 + 186 df)	p
Sex.....	114.57	.85	.36
Gestation.....	6.79	.01	.82
Birth Weight.....	1696.26	12.55	.001
Sex x Gestation.....	193.59	1.43	.23
Sex x Birth Weight.....	487.13	3.60	.06
Gestation x Birth Weight.....	61.18	.45	.50
Sex x Gestation x Birth Weight.....	124.33	.92	.34

Table 8

Proportions of Subjects Retained in Grade, Placed in Special Class, Receiving Special School Services Grouped by Sex, Birthweight and Period of Gestation

Problem Categories	Gestation Period and Birth Weight							
	Group I ≤37 weeks ≤2500 grams (N = 25)		Group II >37 weeks ≤2500 grams (N = 35)		Group III ≤37 weeks >2500 grams (N = 62)		Group IV >37 weeks >2500 grams (N = 81)	
	N	%	N	%	N	%	N	%
Retentions								
M	3	(20.0%)	8	(44.4%)**	6	(26.0%)	6	(13.3%)
F	2	(20.0%)	5	(29.4%)**	5	(12.8%)	3	(08.3%)
Total	5	(20.0%)	13	(37.1%)**	11	(17.7%)	9	(11.1%)
Special Class								
M	1	(06.6%)	2	(11.1%)*	2	(08.6%)	1	(02.2%)
F	1	(10.0%)	3	(17.6%)*	1	(05.2%)	1	(02.7%)
Total	2	(08.0%)	5	(14.2%)**	3	(04.8%)	2	(02.4%)
Special Services								
M	8	(53.3%)**	4	(22.2%)	8	(34.7%)	10	(22.2%)
F	2	(20.0%)	6	(35.2%)	8	(20.5%)	9	(25.0%)
Total	10	(40.0%)**	10	(28.5%)	16	(25.8%)	19	(23.4%)

Table 8 (con't)

	Gestation Period and Birth Weight							
	Group I ≤37 weeks ≤2500 grams (N = 25)		Group II >37 weeks ≤2500 grams (N = 35)		Group III ≤37 weeks >2500 grams (N = 62)		Group IV >37 weeks >2500 grams (N = 81)	
	N	%	N	%	N	%	N	%
Total number included in one or more of the above categories								
M	10	(66.6%)**	12	(66.6%)**	11	(47.8%)	14	(31.1%)
F	3	(30.0%)	10	(58.8%)**	9	(23.0%)	11	(30.5%)
Total	13	(52.0%)**	22	(62.8%)**	20	(32.3%)	25	(30.8%)

* Significantly different from Group IV at the .05 level

** Significantly different from Group IV at the .01 level