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# Classification of Newborns Based on Maturity Rating and Intrauterine Growth at the Medical College of Virginia Hospitals

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This is to certify that the thesis prepared by Lydia Holmes Sund entitled *Classification of Newborns Based on Maturity and Intrauterine Growth at the Medical College of Virginia Hospitals* has been approved by her committee as satisfactory completion of the thesis requirement for the degree of Master of Science.

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# Classification of Newborns Based on Maturity Rating and Intrauterine Growth at the Medical College of Virginia Hospitals

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the Department of Biostatistics at Virginia Commonwealth University.

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Classification of Newborns Based on Maturity Rating and Intrauterine Growth at the Medical College of Virginia Hospitals

ABSTRACT

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the Department of Biostatistics at Virginia Commonwealth University.

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Nurses at the Medical College of Virginia Hospitals (MCVH) in Richmond, Virginia, use the Newborn Maturity Rating and Classification Tool to identify high risk infants. An estimate of gestational age is made and using this estimate, weight, length, and head circumference measurements are plotted on graphs on the tool to determine if the infant achieves intrauterine growth smaller, larger or equal to gestational age.

The data used to generate the graphs on the Newborn Maturity Rating and Classification Tool were collected in Colorado during the 1950's. Two nurses at MCVH questioned the use of these graphs. They wanted to know if graphs produced from their population would be different from the

graphs they now use because of population and time differences.

An initial pilot study was done to examine any problems with measurement reliability. There were no problems with interrater reliability for the length and head circumference measurements. Examination of the chest circumference measurements revealed that one rater had consistently larger measurements than the other.

Data from 98 infants were collected and graphs of weight, length, and head circumference produced. There were differences between the Richmond and Colorado graphs. The 10th percentile for weight for Richmond infants is higher than the 10th percentile for the Colorado infants for 35-42 weeks of gestation. At 40 and 41 weeks of gestation the 90th percentile for the Richmond infants is larger than the 90th percentile for the Colorado infants. These differences result in fewer Richmond infants being identified as small for gestational age and more Richmond infants being classified as large for gestational age than when the Colorado graphs are used.

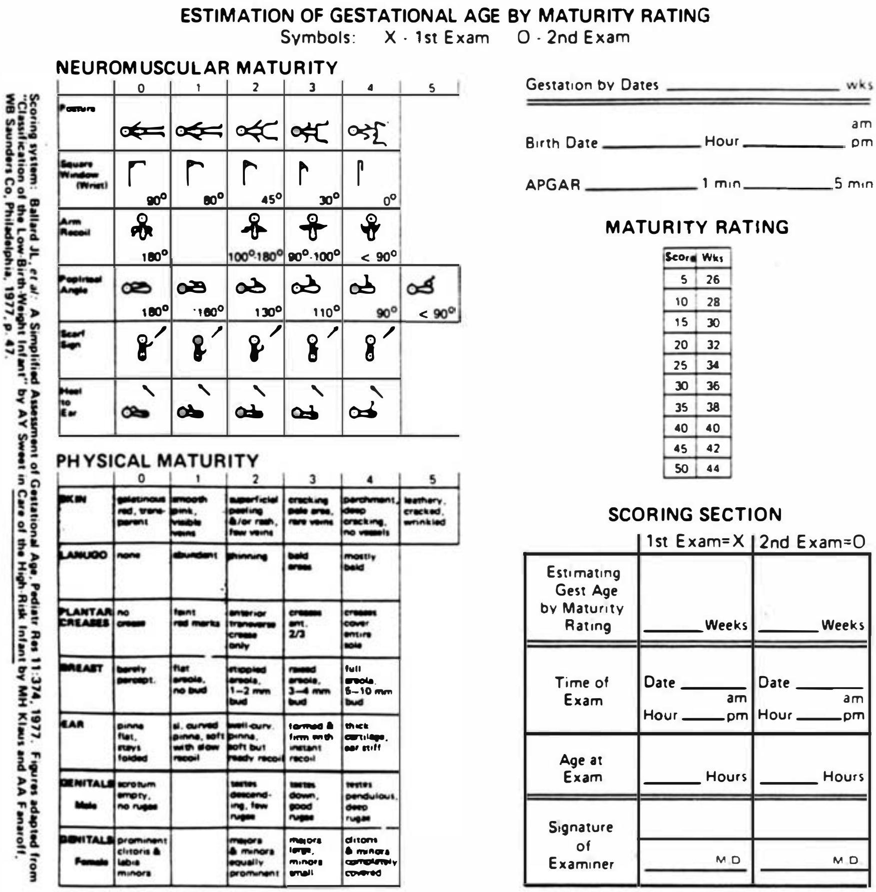
# Chapter 1

# Overview

## Introduction

Nurses at the Medical College of Virginia Hospitals in Richmond, Virginia, use the Newborn Maturity Rating and Classification tool shown in figures 1 and 2 to identify high risk infants. Use of the tool includes plotting an infant's weight, length, and head circumference on the graphs in figure 49. This allows determination of appropriate, large, or small size for gestational age. Measurements from 5,635 infants born between 1948 and 1961 in Colorado were used to generate these graphs.

The nurses questioned the accuracy of the graphs because of population differences and possible differences in measurements between infants in Colorado and Richmond. They wanted to collect measurements from their population, produce weight, length, and head circumference graphs, and compare the graphs of the Colorado and Richmond infants. A pilot study was completed and a final study initiated.



ESTIMATION OF GESTATIONAL AGE BY MATURITY RATING

Symbols: X - 1st Exam O - 2nd Exam

NEUROMUSCULAR MATURITY

| | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Posture | | | | | | |
| Square Window (Wrist) | 90° | 60° | 45° | 30° | 0° | |
| Arm Recoil | 180° | | 100°-180° | 90°-100° | < 90° | |
| Popliteal Angle | 180° | 160° | 130° | 110° | 90° | < 90° |
| Scarf Sign | | | | | | |
| Heel to Ear | | | | | | |

PHYSICAL MATURITY

| | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| SKIN | gelatinous red, trans-parent | smooth pink, visible veins | superficial peeling &/or rash, few veins | cracking pale area, rare veins | parchment, deep cracking, no vessels | leathery, cracked, wrinkled |
| LANUGO | none | abundant | thinning | bald areas | mostly bald | |
| PLANTAR CREASES | no crease | faint red marks | anterior transverse crease only | creases ant. 2/3 | creases cover entire sole | |
| BREAST | barely percept. | flat areola, no bud | stippled areola, 1–2 mm bud | raised areola, 3–4 mm bud | full areola, 5–10 mm bud | |
| EAR | pinna flat, stays folded | sl. curved pinna, soft with slow recoil | well-curv. pinna, soft but ready recoil | formed & firm with instant recoil | thick cartilage, ear stiff | |
| GENITALS Male | scrotum empty, no rugae | | testes descend-ing, few rugae | testes down, good rugae | testes pendulous, deep rugae | |
| GENITALS Female | prominent clitoris & labia minora | | majora & minora equally prominent | majora large, minora small | clitoris & minora completely covered | |

Scoring system: Ballard JL, *et al*: A Simplified Assessment of Gestational Age, Pediatr Res 11:374, 1977. Figures adapted from "Classification of the Low-Birth-Weight Infant" by AY Sweet in Care of the High-Risk Infant by MH Klaus and AA Fanaroff, WB Saunders Co, Philadelphia, 1977, p. 47.

Gestation by Dates ______________ wks

Birth Date __________ Hour __________ am pm

APGAR __________ 1 min __________ 5 min

MATURITY RATING

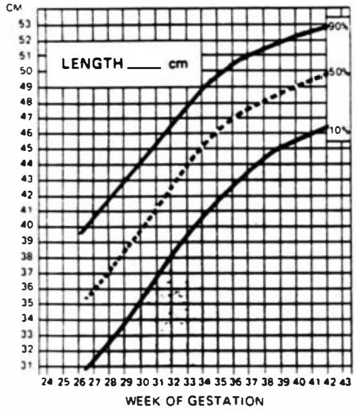
| Score | Wks |
|---|---|
| 5 | 26 |
| 10 | 28 |
| 15 | 30 |
| 20 | 32 |
| 25 | 34 |
| 30 | 36 |
| 35 | 38 |
| 40 | 40 |
| 45 | 42 |
| 50 | 44 |

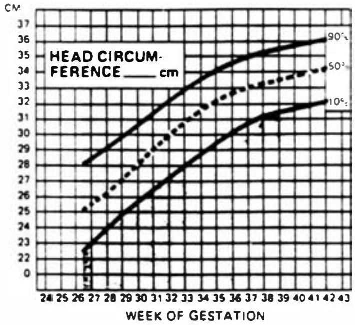
SCORING SECTION

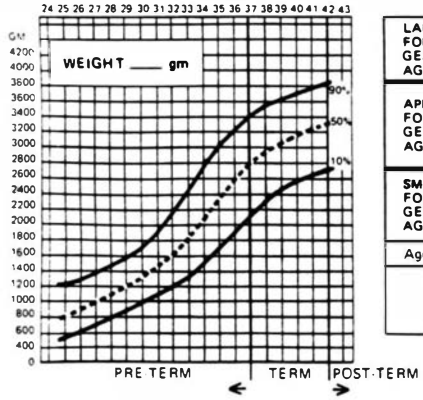
| | 1st Exam=X | 2nd Exam=O |
|---|---|---|
| Estimating Gest Age by Maturity Rating | ______ Weeks | ______ Weeks |
| Time of Exam | Date ______ Hour ______ am pm | Date ______ Hour ______ am pm |
| Age at Exam | ______ Hours | ______ Hours |
| Signature of Examiner | ______ M.D. | ______ M.D. |

Figure 1. Newborn Maturity Ratings and Classification Side 1

**CLASSIFICATION OF NEWBORNS –**
**BASED ON MATURITY AND INTRAUTERINE GROWTH**
Symbols: X · 1st Exam O · 2nd Exam




| | 1st Exam (X) | 2nd Exam (O) |
|---|---|---|
| LARGE FOR GESTATIONAL AGE (LGA) | | |
| APPROPRIATE FOR GESTATIONAL AGE (AGA) | | |
| SMALL FOR GESTATIONAL AGE (SGA) | | |
| Age at Exam | hrs | hrs |
| Signature of Examiner | M.D. | M.D. |

Figure 2. Newborn Maturity Ratings and Classification Side 2

After collecting data from 98 infants of the 5,000 planned in the final study, the nurses asked if preliminary graphs could be produced to see if there was a difference between the graphs on the Newborn Maturity Rating and Classification tool (figures 1 and 2) and the graphs produced from their data. They found the data collection tedious and did not want to continue if there did not seem to be a difference between the graphs.

The objective of this thesis is to examine the data collected by these nurses. Reasons for the analysis are identified. The pilot study is explained and the data from the pilot study analyzed. Recommendations for the final study are made. Graphs are developed from measurements of the first 98 infants in the final study and compared with the graphs now in use.

## Outline

The analysis begins in chapter 2 with an explanation of the development of the length, head circumference, and weight graphs used on the Newborn Maturity Rating and Classification (figures 1 and 2). This includes a description of the patient population and methods used to collect the data. These original studies are examined so that the same methods may be used to produce graphs from the data collected in the final study. Reasons why the nurses believed their graphs would be different are explained and the nurses plans reviewed.

In chapter 3, the pilot study is examined. Twenty infants were initially studied to identify problems of interrater error. The nurses wanted to be sure that interrater error was not a problem in their measurements of length, head circumference, chest circumference, mid arm circumference, and gestational age assessments.

Chapter 4 presents the weight, length, and head circumference graphs based on measurements of the 98 infants in the current study. Nonparametric methods are used to produce the graphs and a comparison of the graphs is presented. The graphs are also compared to the original graphs of weight, length, and head circumference graphs.

Chapter 5 presents the conclusions and recommendations from this analysis. Suggestions for future studies are made. Systat (Wilkinson, 1989) is used for statistical analysis and graphing throughout the thesis.

# Chapter 2

# Introduction

In this chapter, the development and use of the Newborn Maturity Rating and Classification tool (figures 1 and 2) to identify high risk infants is explained. The methods used to collect the measurements for the length, head circumference, and weight graphs and the methods used to produce the graphs are examined. The reasons for the study are reviewed.

The purpose of the chapter is to understand the use and development of the original graphs. This information is important so that the graphs produced from the Colorado measurements may be compared with the graphs produced from the Richmond measurements. For comparison purposes, the methods used to produce the graphs must be as similar as possible.

## Background

Studies have shown that gestational age at birth and body size affect infant mortality and morbidity rates (Koops et al, 1982). Since few mothers know the actual date of conception, the precise gestational age of an infant is usually not known. Gestational age may be calculated from the first day of the mother's last menstrual period or from ultrasound examinations during pregnancy. These methods are not always reliable. Some mothers are unsure of their last menstrual period and ultrasound measurements may be inaccurate (Mott et al, 1990).

In 1970 Dubowitz, Dubowitz, and Goldberg (Dubowitz et al, 1970) developed a tool to assess gestational age after birth. The tool uses 10 neurologic criteria and 11 physical criteria and must be performed within the first 24 hours after birth. It is considered accurate within 1 to 2 weeks of the actual gestational age (Mott et al, 1990).

Subsequent studies indicated problems with the Dubowitz examination for infants less than 34 weeks in gestational age (Shukl et al, 1987). Additionally, some of the neurological items could not be tested in ill infants. In 1977, Ballard, Kamaier, and Driver developed a shortened version of the Dubowitz assessment. The new assessment included 6 neurologic and 6 physical criteria (Ballard, 1977). These criteria are shown in figure 1. For each of these 12 traits, the infant is given a score of 0 to 5. A maturity rating table (figure 1) relates total score to weeks gestation. The Ballard version has shown to be a reliable estimate of an infant's gestational age (Ballard et al, 1979).

Gestational age is divided into three categories. Full-term includes infants with gestational ages between 38 and 42 weeks. Pre-term includes infants with gestational ages less than 38 weeks. Post-term includes infants with gestational ages greater than 42 weeks.

Infants are classified into 5 groups by body size. Very low birth weight (VLBW) are infants weighing less than 1500 grams. Low birth weight infants (LBW) weigh less than 2500 grams. The majority of infants are classified as average for gestational age (AGA) because their birth weights fall between the 10th and 90th percentile for their gestational age. The weight for the small for gestational age infant (SGA) is below the 10th percentile for infants of that gestational age and the weight for the large for gestational age infant (LGA) is above the 90th percentile for that gestational age.

## Newborn Maturity Rating and Classification

Healthy newborn infants are admitted to one of two well baby nurseries at the Medical College of Virginia Hospitals. Registered nurses perform an initial examination which includes the Newborn Maturity Rating and Classification Tool (figures 1 and 2). The infant is given a score for each of the 12 Ballard criteria and using the Maturity Rating table an estimate of gestational age is made.

The length, head circumference, and weight are recorded on the back of the Newborn Maturity Rating and Classification sheet (figure 2). Using the gestational age estimate, these measurements are plotted on the appropriate graphs. The infant is placed into one of the three groups (i.e. SGA, AGA, LGA) when any two of the measurements fall in the same area on the graphs. The classifications of VLBW and LBW are not used.

This two-out-of-three method of assigning classification is different from other methods described in the literature (Avery, 1987; Mott et al, 1990). The classification of SGA, AGA, or LGA refers to weight and the infant is classified based on the weight graph. The length and head circumference are also evaluated to determine if they are appropriate for gestational age. The nursery nurses originally looked only at weight when classifiying the infant, but on a recommendation by a pediatrician in the nursery they adopted a two-out-of-three method. They have used this method since then. Using this two-out-of-three method deserves further examination.

Development of Graphs

The classification graphs used in the Newborn Maturity Rating and Classification Tool were developed by physicians at the University of Colorado Medical Center. Data were collected at Colorado General Hospital from July, 1948, to January, 1961 and included 5,635 infants. The sample included only Caucasian infants. Thirty per cent of the sample were infants of Spanish American heritage. The patients were identified as medically indigent or "part pay." These terms were not defined. Gestational age was calculated from the mother's last normal menstrual period (Lubchenco, 1966).

In 1963, the weight charts were published. The infants were grouped by age of gestation in weeks, birth weights tabulated at 100 gram intervals, and ogives constructed for each week. The figures were graphed at the midpoint of each week for the 10th, 25th, 50th, 75th, and 90th percentiles and then "smoothed arithmetically" (Lubchenco, 1963). The mean weights for male and female infants were approximately 100 grams different for the 38-41 week infants. Additionally, the median weights of the Colorado infants were lower than the national median and lower than the medians from three other studies. It was suggested that high altitude may play a role in infant weight (Lubchenco, 1963).

In 1966 the percentile graphs for the head and length measurements were published. Head circumferences were available for 4720 infants and lengths were available for 4716 infants. The graphs were generated using the same method as the weight graph. The percentile curves were "twice smoothed by arithmetic three-point means" (Lubchenco, 1966).

The phrase "smoothed arithmetically" was not defined in the 1963 study and there was no further explanation in the 1967 study except "twice smoothed by arithmetic three-point means." Interpretation of these phrases will be considered in chapter 4.

In 1967, using the weight and gestational age graphs, Battaglia and Lubchenco suggested a nine group classification system for identifying high risk infants (Battaglia, 1967). The infants are divided into three groups by gestational age - preterm, term, and postterm. Each of these groups is further divided into three groups by birth weight: SGA, AGA, and LGA. The system now in use is based on this classification system.

Study Objectives

The nurses in the well baby nursery at the Medical College of Virginia questioned the appropriateness of these graphs. They wondered if improved prenatal care over the last thirty years had effected the size of infants. It seemed to them that most of the infants they measured were above the 50 percent mark. They also noted population differences. The majority of the their patients are black, but the original study included no black patients. Were there differences in weights, lengths, and head circumferences because of race? Studies by other researchers showed differences in infant weights for different populations (Babson et al, 1970; Freeman et al, 1970; Brenner et al, 1976).

The nurses wanted to collect and study infant measurements from their population of patients and construct head circumference, length, and weight graphs. They were interested in finding out if their patients' measurements would generate different graphs from the ones they use now.

# Chapter 3

# Pilot Study

The nurses were concerned about the reliability of the length, head circumference, chest circumference, mid arm circumference, and Ballard score. Problems with unreliable measurements have been shown to have untoward consequences (Fleiss, 1986). A pilot study was done to examine the reliability of their measurements.

The purpose of this chapter is to examine the data from the pilot study. The variables collected are identified and the method of data collection explained. Descriptive statistics involving both the mother and infant are examined. Tests for rater effects for length, head circumference, chest circumference, mid arm circumference, and gestational age measurements are analyzed. An estimate of the reliability for each of these measurements in the final study is made.

## Methodology

Twenty infants were measured and examined by the two nurses conducting the study. Selection of infants for inclusion in the study was not random. The infants were selected because they were in the nursery when the nurses were on duty and available to perform the measurements. The variables collected in the pilot study are listed in figure 3; table 1 contains all the data collected in the study.

Length, head circumference, chest circumference, and mid arm circumference were measured and recorded by both nurses. Infant length was also measured by the labor and delivery nursing staff and recorded.

All infants are weighed by the labor and delivery nursing staff and again in the nursery by the nursery staff. Discrepancies of more than two ounces are corrected by taking a third measurement in the nursery. Because of these replications in measurement, the weight measurement is considered accurate and only the final weight measurement was recorded.

Using the Ballard criteria, gestational age estimates were calculated. There were three estimates for each infant, one score for each of the two nurses in the study and the Ballard score obtained by the nurse admitting the infant to the nursery.

**NUMBER** patient study number

**SEX$**

M male F female

**RACE$**

B black W white

**WEIGHT** infant weight in grams

**LENGTH** infant length in centimeters

**RATER$** indicates rater who obtained the measurements

N nurse 1
B nurse 2
O length measured in Labor and Delivery or Ballard Score by admitting nurse

**HEAD** head circumference in centimeters

**CHEST** chest circumference in centimeters

**MIDARM** mid arm circumference in centimeters

**BALLARD** Ballard Score

**AGE** age of mother

**EDC** expected date of confinement

**METHOD$** method used to determine EDC

U or 1 ultrasound
D or 2 last menstrual period

**DEL$** type of delivery

C Cesarean section
F low Simpson forceps
S spontaneous vaginal delivery

**G** number of pregnancies

**P** number of deliveries greater than 20 weeks

**AB** number of pregnancy losses less than 20 weeks

Figure 3. Variables

**COMP$** maternal complications during pregnancy

Pilot Study

| | | |
|---|---|---|
| 1 | Chronic hypertension | CHTN |
| 2 | Cigarette smoker | CIG |
| 3 | Alcohol use | ETOH |
| 4 | Marijuana use | MAR |
| 5 | Pregnancy induced hypertension | PIH |
| 6 | Preterm labor | PTL |

Final Study **COMP$** is letter and **COMP** is number under lettered category

A. none
B. preterm labor
   1. treated with magnesium sulfate
   2. not treated with magnesium sulfate
C. pregnancy induced hypertension
D. chronic hypertension
E. diabetes
   1. A1 2. A2
   3. B 4. C
   5. D 6. R
F. smoker
   1. 1-10 cigarettes per day
   2. 10-20 cigarettes per day
   3. greater than 20 cigarettes per day
G. alcohol use
   1. occasional
   2. daily 1-6
   3. greater than 6
H. marijuana use
I. cocaine use
J. heroin use
K. premature rupture of membranes
L. anemia
M. bleeding
N. multiple gestation

**GAIN** maternal weight gain during pregnancy

**SOCIO1$** occupation of mother

**SOCIO2** education of mother

Figure 3—*Continued*

**PNC** number of prenatal visits

Pilot Study

1 less than 10
2 10 or more

Final Study

A. None
B. 1-10
C. 10-20
D. greater than 20
E. hospitalized

**CLASS$** classification groups of infants

L large for gestational age (LGA)
A average for gestational age (AGA)
S small for gestational age (SGA)

Figure 3—*Continued*

Table 1

**Data From Pilot Study**

| NUMBER | SEX$ | RACE$ | WEIGHT | LENGTH | RATER$ | HEAD | CHEST | MIDARM | BALLARD |
|---|---|---|---|---|---|---|---|---|---|
| 1.0 | M | B | 3780.0 | 52.5 | N | 36.0 | 34.5 | 12.0 | 40.0 |
| 1.0 | M | B | 3780.0 | 53.0 | B | 36.0 | 35.5 | 13.0 | 41.0 |
| 1.0 | M | B | 3780.0 | 52.0 | O | . | . | . | 40.0 |
| 2.0 | M | W | 4020.0 | 52.0 | N | 36.5 | 33.5 | 12.0 | 40.0 |
| 2.0 | M | W | 4020.0 | 49.5 | B | 36.0 | 34.0 | 12.5 | 40.0 |
| 2.0 | M | W | 4020.0 | . | O | . | . | . | 41.0 |
| 3.0 | M | B | 3940.0 | 55.5 | N | 36.0 | 34.0 | 11.0 | 41.0 |
| 3.0 | M | B | 3940.0 | 56.5 | B | 36.0 | 34.5 | 11.0 | 42.0 |
| 3.0 | M | B | 3940.0 | 56.0 | O | . | . | . | 42.0 |
| 4.0 | F | B | 3570.0 | 50.5 | N | 35.5 | 32.5 | 11.0 | 40.0 |
| 4.0 | F | B | 3570.0 | 50.0 | B | 35.5 | 31.0 | 11.0 | 40.0 |
| 4.0 | F | B | 3570.0 | 52.0 | O | . | . | . | 41.0 |
| 5.0 | M | B | 2950.0 | 49.0 | N | 34.0 | 32.5 | 9.0 | 39.0 |
| 5.0 | M | B | 2950.0 | 48.5 | B | 34.0 | 31.0 | 10.0 | 41.0 |
| 5.0 | M | B | 2950.0 | 48.0 | O | . | . | . | 40.0 |
| 6.0 | M | B | 2320.0 | 48.0 | N | 33.5 | 29.5 | 9.0 | 40.0 |
| 6.0 | M | B | 2320.0 | 46.0 | B | 33.5 | 27.5 | 9.0 | 42.0 |
| 6.0 | M | B | 2320.0 | 48.0 | O | . | . | . | 40.0 |
| 7.0 | F | B | 3040.0 | 49.5 | N | 35.0 | 30.5 | 10.0 | 41.0 |
| 7.0 | F | B | 3040.0 | 49.0 | B | 35.0 | 30.0 | 11.0 | 41.0 |
| 7.0 | F | B | 3040.0 | 54.0 | O | . | . | . | 40.0 |
| 8.0 | M | B | 4550.0 | 53.0 | N | 36.5 | 36.0 | 12.0 | 40.0 |
| 8.0 | M | B | 4550.0 | 54.0 | B | 37.0 | 35.0 | 13.0 | 42.0 |
| 8.0 | M | B | 4550.0 | 54.5 | O | . | . | . | 42.0 |
| 9.0 | F | B | 3480.0 | 50.0 | N | 34.0 | 34.0 | 11.0 | 41.0 |
| 9.0 | F | B | 3480.0 | 50.0 | B | 33.5 | 34.0 | 11.0 | 40.0 |
| 9.0 | F | B | 3480.0 | 51.0 | O | . | . | . | 40.0 |

Table 1—*Continued*

| NUMBER | SEX$ | RACE$ | WEIGHT | LENGTH | RATER$ | HEAD | CHEST | MIDARM | BALLARD |
|---|---|---|---|---|---|---|---|---|---|
| 10.0 | F | B | 3390.0 | 51.0 | N | 34.5 | 33.5 | 10.5 | 40.0 |
| 10.0 | F | B | 3390.0 | 53.0 | B | 35.0 | 33.0 | 10.0 | 42.0 |
| 10.0 | F | B | 3390.0 | 53.0 | O | . | . | . | 39.0 |
| 11.0 | F | B | 3940.0 | 53.0 | N | 36.0 | 35.5 | 11.5 | 40.0 |
| 11.0 | F | B | 3940.0 | 53.0 | B | 36.5 | 35.0 | 11.0 | 40.0 |
| 11.0 | F | B | 3940.0 | 55.0 | O | . | . | . | 38.0 |
| 12.0 | M | B | 2230.0 | 46.0 | N | 31.5 | 28.0 | 8.5 | 38.0 |
| 12.0 | M | B | 2230.0 | 44.0 | B | 31.0 | 27.5 | 9.0 | 38.0 |
| 12.0 | M | B | 2230.0 | 47.5 | O | . | . | . | 36.0 |
| 13.0 | M | B | 2980.0 | 49.0 | N | 34.0 | 30.0 | 9.5 | 39.0 |
| 13.0 | M | B | 2980.0 | 50.0 | B | 34.5 | 29.5 | 9.5 | 39.0 |
| 13.0 | M | B | 2980.0 | 49.0 | O | . | . | . | 38.0 |
| 14.0 | F | B | 3040.0 | 48.5 | N | 34.0 | 31.5 | 10.5 | 40.0 |
| 14.0 | F | B | 3040.0 | 49.5 | B | 33.0 | 30.5 | 10.0 | 41.0 |
| 14.0 | F | B | 3040.0 | 51.0 | O | . | . | . | 39.0 |
| 15.0 | F | W | 2620.0 | 47.0 | N | 33.0 | 29.5 | 9.0 | 38.0 |
| 15.0 | F | W | 2620.0 | 47.0 | B | 33.0 | 29.5 | 9.0 | 37.0 |
| 15.0 | F | W | 2620.0 | 51.0 | O | . | . | . | 35.0 |
| 16.0 | M | B | 3810.0 | 53.0 | N | 34.5 | 33.0 | 10.5 | 40.0 |
| 16.0 | M | B | 3810.0 | 52.0 | B | 34.5 | 32.0 | 10.5 | 40.0 |
| 16.0 | M | B | 3810.0 | 53.0 | O | . | . | . | 40.0 |
| 17.0 | M | W | 2550.0 | 47.0 | N | 33.0 | 29.0 | 8.5 | 40.0 |
| 17.0 | M | W | 2550.0 | 48.0 | B | 33.0 | 29.0 | 8.5 | 40.0 |
| 17.0 | M | W | 2550.0 | 48.0 | O | . | . | . | 40.0 |
| 18.0 | M | W | 4010.0 | 54.0 | N | 35.0 | 34.5 | 11.0 | 40.0 |
| 18.0 | M | W | 4010.0 | 55.5 | B | 35.5 | 34.0 | 10.5 | 40.0 |
| 18.0 | M | W | 4010.0 | 54.0 | O | . | . | . | 40.0 |
| 19.0 | F | B | 3200.0 | 50.0 | N | 34.0 | 32.0 | 10.5 | 40.0 |
| 19.0 | F | B | 3200.0 | 49.5 | B | 34.5 | 31.5 | 10.0 | 41.0 |
| 19.0 | F | B | 3200.0 | 48.5 | O | . | . | . | 41.0 |
| 20.0 | F | B | 2940.0 | 49.0 | N | 33.0 | 30.5 | 9.5 | 39.0 |
| 20.0 | F | B | 2940.0 | 47.5 | B | 33.0 | 30.0 | 9.5 | 39.0 |
| 20.0 | F | B | 2940.0 | 48.0 | O | . | . | . | 41.0 |

Table 1—*Continued*

| NUMBER | AGE | EDC | METHOD$ | DEL$ | G | P | AB | COMP$ | GAIN | SOCIO1$ | SOCIO2 | PNC | CLASS$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 22.0 | 40.0 | U | S | 5.0 | 4.0 | .0 | | 40.0 | | . | 1.0 | L |
| 1 | 22.0 | 40.0 | U | S | 5.0 | 4.0 | .0 | | 40.0 | | . | 1.0 | L |
| 1 | 22.0 | 40.0 | U | S | 5.0 | 4.0 | .0 | | 40.0 | | . | 1.0 | L |
| 2 | 23.0 | 40.0 | U | C | 2.0 | 1.0 | .0 | CHTN | 15.0 | CLERICAL | . | 2.0 | L |
| 2 | 23.0 | 40.0 | U | C | 2.0 | 1.0 | .0 | CHTN | 15.0 | CLERICAL | . | 2.0 | L |
| 2 | 23.0 | 40.0 | U | C | 2.0 | 1.0 | .0 | CHTN | 15.0 | CLERICAL | . | 2.0 | L |
| 3 | 20.0 | 41.0 | U | C | 7.0 | .0 | .0 | PIH | . | | . | 1.0 | L |
| 3 | 20.0 | 41.0 | U | C | 7.0 | .0 | .0 | PIH | . | | . | 1.0 | L |
| 3 | 20.0 | 41.0 | U | C | 7.0 | .0 | .0 | PIH | . | | . | 1.0 | L |
| 4 | 18.0 | 38.0 | U | S | 3.0 | 1.0 | 1.0 | PTL | . | SEMISKILLED | 10.0 | 1.0 | A |
| 4 | 18.0 | 38.0 | U | S | 3.0 | 1.0 | 1.0 | PTL | . | SEMISKILLED | 10.0 | 1.0 | A |
| 4 | 18.0 | 38.0 | U | S | 3.0 | 1.0 | 1.0 | PTL | . | SEMISKILLED | 10.0 | 1.0 | A |
| 5 | 23.0 | 39.0 | U | S | 5.0 | 4.0 | .0 | PIH/PTL | . | NONE | . | 1.0 | A |
| 5 | 23.0 | 39.0 | U | S | 5.0 | 4.0 | .0 | PIH/PTL | . | NONE | . | 1.0 | A |
| 5 | 23.0 | 39.0 | U | S | 5.0 | 4.0 | .0 | PIH/PTL | . | NONE | . | 1.0 | A |
| 6 | 19.0 | 38.0 | U | C | 3.0 | 1.0 | 2.0 | PTL | . | NONE | 9.0 | 2.0 | A |
| 6 | 19.0 | 38.0 | U | C | 3.0 | 1.0 | 2.0 | PTL | . | NONE | 9.0 | 2.0 | A |
| 6 | 19.0 | 38.0 | U | C | 3.0 | 1.0 | 2.0 | PTL | . | NONE | 9.0 | 2.0 | A |
| 7 | 21.0 | 37.0 | U | S | 3.0 | 1.0 | 1.0 | | 37.0 | NONE | 10.0 | 1.0 | A |
| 7 | 21.0 | 37.0 | U | S | 3.0 | 1.0 | 1.0 | | 37.0 | NONE | 10.0 | 1.0 | A |
| 7 | 21.0 | 37.0 | U | S | 3.0 | 1.0 | 1.0 | | 37.0 | NONE | 10.0 | 1.0 | A |
| 8 | 28.0 | 41.0 | U | C | 2.0 | 1.0 | .0 | PTL | 50.0 | CLERICAL | . | 2.0 | L |
| 8 | 28.0 | 41.0 | U | C | 2.0 | 1.0 | .0 | PTL | 50.0 | CLERICAL | . | 2.0 | L |
| 8 | 28.0 | 41.0 | U | C | 2.0 | 1.0 | .0 | PTL | 50.0 | CLERICAL | . | 2.0 | L |
| 9 | 19.0 | 39.0 | U | S | 2.0 | 1.0 | .0 | | . | | . | 1.0 | A |
| 9 | 19.0 | 39.0 | U | S | 2.0 | 1.0 | .0 | | . | | . | 1.0 | A |
| 9 | 19.0 | 39.0 | U | S | 2.0 | 1.0 | .0 | | . | | . | 1.0 | A |
| 10 | 18.0 | 41.0 | D | C | 2.0 | 1.0 | .0 | CIG | 35.0 | CONSTRUCTION | 12.0 | 1.0 | A |
| 10 | 18.0 | 41.0 | D | C | 2.0 | 1.0 | .0 | CIG | 35.0 | CONSTRUCTION | 12.0 | 1.0 | A |
| 10 | 18.0 | 41.0 | D | C | 2.0 | 1.0 | .0 | CIG | 35.0 | CONSTRUCTION | 12.0 | 1.0 | A |

Table 1—*Continued*

| NUMBER | AGE | EDC | METHOD$ | DEL$ | G | P | AB | COMP$ | GAIN | SOCIO1$ | SOCIO2 | PNC | CLASS$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 21.0 | 41.0 | D | S | 4.0 | 3.0 | .0 | CIG/MAR | . | NONE | . | 1.0 | L |
| 11 | 21.0 | 41.0 | D | S | 4.0 | 3.0 | .0 | CIG/MAR | . | NONE | . | 1.0 | L |
| 11 | 21.0 | 41.0 | D | S | 4.0 | 3.0 | .0 | CIG/MAR | . | NONE | . | 1.0 | L |
| 12 | 24.0 | 34.0 | D | S | 3.0 | 2.0 | .0 | | . | NONE | 9.0 | 1.0 | A |
| 12 | 24.0 | 34.0 | D | S | 3.0 | 2.0 | .0 | | . | NONE | 9.0 | 1.0 | A |
| 12 | 24.0 | 34.0 | D | S | 3.0 | 2.0 | .0 | | . | NONE | 9.0 | 1.0 | A |
| 13 | 25.0 | 40.0 | D | S | 3.0 | 2.0 | .0 | | 6.0 | | 12.0 | 2.0 | A |
| 13 | 25.0 | 40.0 | D | S | 3.0 | 2.0 | .0 | | 6.0 | | 12.0 | 2.0 | A |
| 13 | 25.0 | 40.0 | D | S | 3.0 | 2.0 | .0 | | 6.0 | | 12.0 | 2.0 | A |
| 14 | 16.0 | 38.0 | U | S | 1.0 | .0 | .0 | CIG | 40.0 | STUDENT | 10.0 | 2.0 | A |
| 14 | 16.0 | 38.0 | U | S | 1.0 | .0 | .0 | CIG | 40.0 | STUDENT | 10.0 | 2.0 | A |
| 14 | 16.0 | 38.0 | U | S | 1.0 | .0 | .0 | CIG | 40.0 | STUDENT | 10.0 | 2.0 | A |
| 15 | 19.0 | 36.0 | U | S | 1.0 | .0 | .0 | PIH | 36.0 | BABYSAT | 4.0 | 1.0 | A |
| 15 | 19.0 | 36.0 | U | S | 1.0 | .0 | .0 | PIH | 36.0 | BABYSAT | 4.0 | 1.0 | A |
| 15 | 19.0 | 36.0 | U | S | 1.0 | .0 | .0 | PIH | 36.0 | BABYSAT | 4.0 | 1.0 | A |
| 16 | 35.0 | 40.0 | U | F | 3.0 | 2.0 | .0 | PIH/CIG/ETOH | 60.0 | NURSING ASSI | 12.0 | 1.0 | L |
| 16 | 35.0 | 40.0 | U | F | 3.0 | 2.0 | .0 | PIH/CIG/ETOH | 60.0 | NURSING ASSI | 12.0 | 1.0 | L |
| 16 | 35.0 | 40.0 | U | F | 3.0 | 2.0 | .0 | PIH/CIG/ETOH | 60.0 | NURSING ASSI | 12.0 | 1.0 | L |
| 17 | 22.0 | 39.0 | U | S | 2.0 | 1.0 | .0 | | 40.0 | WAITRESS | 8.0 | 2.0 | A |
| 17 | 22.0 | 39.0 | U | S | 2.0 | 1.0 | .0 | | 40.0 | WAITRESS | 8.0 | 2.0 | A |
| 17 | 22.0 | 39.0 | U | S | 2.0 | 1.0 | .0 | | 40.0 | WAITRESS | 8.0 | 2.0 | A |
| 18 | 17.0 | 41.0 | D | S | 1.0 | .0 | .0 | | 30.0 | STUDENT | 9.0 | 2.0 | L |
| 18 | 17.0 | 41.0 | D | S | 1.0 | .0 | .0 | | 30.0 | STUDENT | 9.0 | 2.0 | L |
| 18 | 17.0 | 41.0 | D | S | 1.0 | .0 | .0 | | 30.0 | STUDENT | 9.0 | 2.0 | L |
| 19 | 18.0 | 39.0 | D | S | 1.0 | .0 | .0 | | 43.0 | | 10.0 | 1.0 | A |
| 19 | 18.0 | 39.0 | D | S | 1.0 | .0 | .0 | | 43.0 | | 10.0 | 1.0 | A |
| 19 | 18.0 | 39.0 | D | S | 1.0 | .0 | .0 | | 43.0 | | 10.0 | 1.0 | A |
| 20 | 22.0 | 38.0 | U | S | 3.0 | 1.0 | 1.0 | | 29.0 | BARRELMAKER | 12.0 | 1.0 | A |
| 20 | 22.0 | 38.0 | U | S | 3.0 | 1.0 | 1.0 | | 29.0 | BARRELMAKER | 12.0 | 1.0 | A |
| 20 | 22.0 | 38.0 | U | S | 3.0 | 1.0 | 1.0 | | 29.0 | BARRELMAKER | 12.0 | 1.0 | A |

The gestational age of the infants was also calculated prior to delivery using either the mother's last menstrual period or ultrasound measurements. The variable EDC indicates this estimate. The variable METHOD indicates whether the estimate was by last menstrual period or ultrasound.

Information about a patient's socioeconomic status was collected. The nurses planned to use the Hollingshead's Two Factor Index of Social Position to obtain an Index of Social Position score (ISP) for each patient (figure 4). This index uses education and occupation to obtain a score indicating social position (Miller, 1983). Figure 4 shows the seven occupational and educational levels, the formula used to obtain the Index of Social Position score, and the table used to identify the patient's social class after the ISP is calculated.

Maternal Descriptive Statistics

Characteristics of the mothers and infants were examined. Since the infants were not chosen for inclusion randomly, it is uncertain if the characteristics of this sample represent the characteristics of the population of infants born at the Medical College of Virginia. These statistics were examined to determine unforeseen problems with variables or data

**Occupational Scale**

| Rating | Occupation |
|---|---|
| 1 | Major executives of large concerns, major professionals, and proprietors. |
| 2 | Lesser professionals and proprietors, and business managers. |
| 3 | Administrative personnel, owners of small business, and minor professionals. |
| 4 | Clerical and sales workers, and technicians. |
| 5 | Skilled trades. |
| 6 | Machine operators and semiskilled workers. |
| 7 | Unskilled employees. |

**Educational Scale**

| Rating | Education |
|---|---|
| 1 | Professionals (Master's degree, doctorate, or professional degree |
| 2 | College graduates. |
| 3 | 1-3 years college or business school. |
| 4 | High school graduates. |
| 5 | 10-11 years of schooling |
| 6 | 7-9 years of schooling |
| 7 | Under 7 years of schooling |

Figure 4. Hollingshead's Two-Factor Index of Social Position

**Calculation of Index of Social Position**

ISP = (7 X Occupation Rating) + (4 X Education Rating)

**Relationship of ISP to Social Class**

| Social Class | ISP |
|---|---|
| I | 11-17 |
| II | 18-27 |
| III | 28-43 |
| IV | 44-60 |
| V | 61-77 |

Figure 4—*Continued*

collection in the final study and also to suggest any characteristics which might require further investigation.

The mothers' ages ranged from 16 to 35 with the mean age being 21.5. There were 16 black mothers and 4 white mothers. Four of the women were having their first baby. Thirteen of the mothers had less than 10 prenatal visits. Weight gain was collected on 13 of the mothers and ranged from 6 pounds to 60 pounds with a mean weight gain of 35.5 pounds.

Seven complications were identified for 11 of the mothers. The complications and frequency for each are shown below in table 2.

Table 2 Antepartum Complications

| | |
|---|---|
| Chronic hypertension | 1 |
| Pregnancy induced hypertension | 4 |
| Preterm labor | 4 |
| Cigarette smoking | 4 |
| Marihuana use | 1 |
| Alcohol use | 1 |

Three of the mothers had more than one complication and four of the mothers had complications involving substance abuse.

Occupational information was collected for 15 of the mothers. Five of these 15 had no occupation. The 15 occupations identified range from the 4th to the 7th level of the Hollingshead occupational scale. These are the four lowest levels of the occupational scale.

Educational level was collected for 13 of the mothers. The educational level ranged from 4th to 12th grade with 9.8 being the mean grade completed. Both occupational and educational information were collected for 11 of the mothers. This means that a Hollingshead score can be obtained for only 11 of the patients.

## Infant Descriptive Statistics

Fifteen of the infants were delivered vaginally with one forcep delivery. The remaining five infants were delivered by Cesarean section. The infants' weights ranged from 2230 grams to 4550 grams with a mean weight of 3318 grams. There were 9 females and 11 males in the group.

The gestational weeks and the method used for calculating are shown in table 3 below.

Table 3 Gestational Age and Method

| Weeks | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 |
|---|---|---|---|---|---|---|---|---|
| LMP | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 3 |
| Ultrasound | 0 | 0 | 1 | 1 | 4 | 3 | 3 | 2 |
| Totals | 1 | 0 | 1 | 1 | 4 | 4 | 4 | 5 |

Six of the gestational ages were calculated from the last menstrual period (LMP) and 14 by ultrasound. Four of the six gestational ages calculated by last menstrual period fell at the extremes of the gestational weeks. The majority of the infants were 38-41 weeks. With only three infants below 38 weeks there may be too few infants in these categories to generate accurate graphs.

Although there were differences in the lengths, head circumferences, and Ballard scores obtained by the two nurses, their final classification of SGA, AGA, or LGA were in agreement for all infants. Thirteen of the infants were classified as AGA and seven of the infants were classified as LGA. If the weight graphs are the same for the Richmond and Colorado population and this is a representative sample, one would expect at most two LGA and two SGA infants out of the twenty. There are five more LGA infants than expected and no SGA infants. This indicates the infants in this sample are heavier for their gestational age than the infants in the Colorado study.

Table 4 shows the gestational age in weeks by the classification of the infants.

Table 4 Classification of Infants by Gestational Age

| | AGA | LGA | TOTAL |
|---|---|---|---|
| 34 WEEKS | 1 | 0 | 1 |
| 35 WEEKS | 0 | 0 | 0 |
| 36 WEEKS | 1 | 0 | 1 |
| 37 WEEKS | 1 | 0 | 1 |
| 38 WEEKS | 4 | 0 | 4 |
| 39 WEEKS | 4 | 0 | 4 |
| 40 WEEKS | 1 | 3 | 4 |
| 41 WEEKS | 1 | 4 | 5 |
| TOTAL | 13 | 7 | 20 |

The table shows that all seven LGA infants were all 40 or 41 weeks gestation. Only 2 of the 13 AGA infants were more than 39 weeks. This suggests that the weight curve of the Richmond infants may be higher at 40 and 41 weeks.

Table 5 shows the relationship between the classification and sex of the infants.

Table 5 Infant Classification by Sex

| | AGA | LGA | TOTAL |
|---|---|---|---|
| FEMALE | 8 | 1 | 9 |
| MALE | 5 | 6 | 11 |
| TOTAL | 13 | 7 | 20 |

The males are fairly evenly distributed between AGA and LGA, but there are 8 females in the AGA group and only 1 female in the LGA group. For this sample, the infants who are LGA are almost all males. Previous studies have shown the mean weight of male infants is higher than the mean weight of female infants (Sterky, 1970). This may mean that more males are LGA. This needs further examination in the final study.

A Statistical Model for Interexaminer Reliability

The nurses were interested in determining the reliability of the length, head circumference, chest circumference, mid arm circumference, and Ballard Score measurements. Both nurses performed these measurements on 20 infants. For length, head circumference, chest circumference and mid arm circumference, a test is performed to determine if the rater effects differ from one another. Additionally, the Intraclass Correlation Coefficient (ICC) is calculated to estimate the reliability of these measurements in the final study.

Length, head circumference, chest circumference, and arm circumference are quantitative measurements. The Ballard score is a categorical assignment and different tests for interexaminer reliability must be used.

Rater Effects

For this model, rater effects and random effects combine to form a typical observation, $X_{ij}$, where $X_{ij}$ is the measurement on Patient i produced by Rater j.

$$X_{ij}=T_i+\rho_j+e_{ij}$$

where,

i = 1, . . . , N and j = 1, . . . , k

$T_1,\ldots,T_N$, the patients' error-free scores vary normally with mean $\mu$ and variance $\sigma_T^2$.

$\rho_1,\ldots,\rho_k$, the raters' effects where $\sum_1^j \rho_j=0$.

$e_{ij}$, the random errors vary normally about a mean of 0 with a variance of $\sigma_e^2$.

$T_1,\ldots,T_N$ and $e_{ij}$'s are independent. (Fleiss, 1986)

Table 6 contains an analysis of variance table for the results of an interexaminer reliability study.

The null hypothesis is $\rho_1=\ldots=\rho_k$, the rater effects do not differ significantly from each other. The alternative hypothesis is that at least one of the $\rho_k$'s is different from the others. The test statistic is

$$F=\frac{RMS}{EMS}, \; k-1, \; (N-1)(k-1)$$

where RMS is the mean square for rater
EMS is the mean square for error

The null hypothesis is rejected if $F>F_{k-1,(N-1)(k-1),.05}$ (Fleiss, 1986).

The Intraclass Correlation Coefficient

The intraclass correlation coefficient of reliability has been shown to express the relative magnitude of the components of the variance of $X_{ij}$. This quantity is

$$R=\frac{\sigma_T^2}{\sigma_T^2+\sigma_\varepsilon^2}$$

The maximum value is unity and the minimum zero. Reliability increases as $\sigma_\varepsilon^2/\sigma_T^2$ decreases. As error becomes less of what is observed, R approaches 1. As error

Table 6

Analysis of Variance for Interexaminer

Reliability Study

| Source of Variation | df | SS | MS | E(MS) Raters Fixed | E(MS) Raters Random |
|---|---|---|---|---|---|
| Patients | $N-1$ | $k\sum(\bar{X}_{i.}-\bar{X}_{..})^2$ | PMS | $\sigma_e^2+k\sigma_p^2$ | $\sigma_e^2+k\sigma_p^2$ |
| Raters | $k-1$ | $N\sum(\bar{X}_{.j}-\bar{X}_{..})^2$ | RMS | $\sigma_e^2+\frac{N}{k-1}\sum\rho_j^2$ | $\sigma_e^2+N\sigma_r^2$ |
| Error | $(N-1)(k-1)$ | By subtraction | EMS | $\sigma_e^2$ | $\sigma_e^2$ |
| Total | $Nk-1$ | $\sum\sum(X_{ij}-\bar{X}_{..})^2$ | | | |

(Fleiss, 1986)

increases, $\sigma_e^2/\sigma_T^2$ increases and reliability decreases and R approaches zero (Fleiss,1986).

In the final study, each infant will be measured by one of the two examiners in the pilot study. The selection of the examiner will be random. The variance of the measurements obtained in the final study will be

$$\sigma_X^2=\sigma_T^2+\frac{1}{k}\sum_1^k \rho_j^2+\sigma_e^2$$

The intraclass correlation coefficient becomes

$$R=\frac{\sigma_T^2}{\sigma_T^2+\frac{1}{k}\sum_1^k \rho_j^2+\sigma_e^2}$$

Using the information in table 6, substituting the estimators from the table, and performing a few algebraic manipulations, an estimator of the intraclass correlation coefficient when the raters are fixed effects becomes

$$\hat{R}=\frac{N(PMS-EMS)}{N(PMS)+(k-1)RMS+(N-1)(k-1)EMS}$$

where,

PMS is the mean squares for patients
RMS is the mean squares for raters
EMS is the mean squares for error. (Fleiss, 1986)

This estimated reliability coefficient relates to measurements in the future study when differences between examiners will not be controlled except by randomization of the assignment of examiner.

## Reliability of Qualitative Variables

Cohen's kappa statistic has been shown to be the appropriate measure of reliability when the data are qualitative (Fleiss, 1986). The proportions are tabulated as shown in table 7.

Table 7 Joint proportions of Ratings

| | Rater B | | | | |
|---|---|---|---|---|---|
| Rater A | 1 | 2 | ... | k | Total |
| 1 | $p_{11}$ | $p_{12}$ | ... | $p_{1k}$ | $p_{1.}$ |
| 2 | $p_{21}$ | $p_{22}$ | ... | $p_{2k}$ | $p_{2.}$ |
| . | | | | | |
| . | | | | | |
| . | | | | | |
| k | $p_{k1}$ | $p_{k2}$ | ... | $p_{kk}$ | $p_{k.}$ |
| Total | $p_{.1}$ | $p_{.2}$ | ... | $p_{.k}$ | 1 |

The weighted kappa uses weights to quantify the seriousness of disagreements. The weights used are

$$w_{ij} = 1 - \frac{(i-j)^2}{(k-1)^2}$$

where,
$i = 1, \ldots, k$
$j = 1, \ldots, k$

Fleiss and Cohen have shown that, except for a term involving the factor 1/n, weighted kappa is identical to the intraclass correlation coefficient when these weights are used.

The observed weighted proportion of agreement is

$$P_{o(w)}=\sum_{i=1}^{k}\sum_{j=1}^{k} w_{ij}p_{ij}$$

and the chance-expected weighted proportion of agreement is

$$P_{e(w)}=\sum_{i=1}^{k}\sum_{j=1}^{k} w_{ij}p_{i.}p_{.j}$$

Weighted kappa is then calculated by

$$\hat{k}_w=\frac{p_{o(w)}-p_{e(w)}}{1-p_{e(w)}}$$

When weighted kappa is >= .75 the agreement is excellent among raters. A weighted kappa of <= .40 indicated poor agreement (Fleiss, 1986).

Examination of Interrater Error

Table 8 contains the results of the length measurements for each of the 20 infants made by the two nurse examiners

Table 8

Pilot Study

**Length Measurements**

| Infant | Examiner 1 | Examiner 2 | Labor and Delivery |
|---|---|---|---|
| 1 | 52.5 | 53.0 | 52.0 |
| 2 | 52.0 | 49.5 | . |
| 3 | 55.5 | 56.5 | 56.0 |
| 4 | 50.5 | 50.0 | 52.0 |
| 5 | 49.0 | 48.5 | 48.0 |
| 6 | 48.0 | 46.0 | 48.0 |
| 7 | 49.5 | 49.0 | 54.0 |
| 8 | 53.0 | 54.0 | 54.5 |
| 9 | 50.0 | 50.0 | 51.0 |
| 10 | 51.0 | 53.0 | 53.0 |
| 11 | 53.0 | 53.0 | 55.0 |
| 12 | 46.0 | 44.0 | 47.5 |
| 13 | 49.0 | 50.0 | 49.0 |
| 14 | 48.5 | 49.5 | 51.0 |
| 15 | 47.0 | 47.0 | 51.0 |
| 16 | 53.0 | 52.0 | 53.0 |
| 17 | 47.0 | 48.0 | 48.0 |
| 18 | 54.0 | 55.5 | 54.0 |
| 19 | 50.0 | 49.5 | 48.5 |
| 20 | 49.0 | 47.5 | 48.0 |

and the lengths obtained by the labor and delivery nursing staff. One labor and delivery measurement is missing. The measurements range from 44 centimeters to 56.5 centimeters.

The differences in measurements between the two raters is shown in table 9. The differences range from 0 to 2.5 centimeters. The differences between each examiner and the labor and delivery measurement are shown in table 10. There are two differences ranging from 2.5 to 5 centimeters.

Head circumference measurements from the two examiners are shown in table 11. The measurements range from 31 centimeters to 37 centimeters. The greatest difference in measurement between the two examiners is 1 centimeter. The examiners' measurements agree in 10 of the cases.

Chest circumference measurements are listed in table 12. These measurements range from 27.5 centimeters to 36 centimeters. The largest difference in measurement is 2 centimeters. The examiners' measurements agree in 3 of the 20 cases.

The mid arm measurements are shown in table 13. The largest observed difference is 1 centimeter with agreement between the raters in 9 of the cases. The measurements range from 8.5 to 13 centimeters.

Table 9

Pilot Study

**Differences in Length Measurements Between Examiners**

| Infant | Examiner 1 | Examiner 2 | Difference |
|---|---|---|---|
| 1 | 52.5 | 53.0 | - .5 |
| 2 | 52.0 | 49.5 | 2.5 |
| 3 | 55.5 | 56.5 | -1.0 |
| 4 | 50.5 | 50.0 | .5 |
| 5 | 49.0 | 48.5 | .5 |
| 6 | 48.0 | 46.0 | 2.0 |
| 7 | 49.5 | 49.0 | .5 |
| 8 | 53.0 | 54.0 | -1.0 |
| 9 | 50.0 | 50.0 | .0 |
| 10 | 51.0 | 53.0 | -2.0 |
| 11 | 53.0 | 53.0 | .0 |
| 12 | 46.0 | 44.0 | 2.0 |
| 13 | 49.0 | 50.0 | -1.0 |
| 14 | 48.5 | 49.5 | -1.0 |
| 15 | 47.0 | 47.0 | .0 |
| 16 | 53.0 | 52.0 | 1.0 |
| 17 | 47.0 | 48.0 | -1.0 |
| 18 | 54.0 | 55.5 | -1.5 |
| 19 | 50.0 | 49.5 | .5 |
| 20 | 49.0 | 47.5 | 2.5 |

Table 10

Pilot Study

**Differences in Length Measurements Between Examiners and Labor and Delivery Staff**

| Infant | Examiner 1 | Examiner 2 | Labor and Delivery (L+D) | Difference Examiner 1 and L+D | Difference Examiner 2 and L+D |
|---|---|---|---|---|---|
| 1 | 52.5 | 53.0 | 52.0 | .5 | 1.0 |
| 2 | 52.0 | 49.5 | . | . | . |
| 3 | 55.5 | 56.5 | 56.0 | - .5 | .5 |
| 4 | 50.5 | 50.0 | 52.0 | -1.5 | -2.0 |
| 5 | 49.0 | 48.5 | 48.0 | 1.0 | .5 |
| 6 | 48.0 | 46.0 | 48.0 | 0.0 | -2.0 |
| 7 | 49.5 | 49.0 | 54.0 | -4.5 | -5.0 |
| 8 | 53.0 | 54.0 | 54.5 | -1.5 | - .5 |
| 9 | 50.0 | 50.0 | 51.0 | -1.0 | -1.0 |
| 10 | 51.0 | 53.0 | 53.0 | -2.0 | 0.0 |
| 11 | 53.0 | 53.0 | 55.0 | 0.0 | -2.0 |
| 12 | 46.0 | 44.0 | 47.5 | -1.5 | -3.5 |
| 13 | 49.0 | 50.0 | 49.0 | 0.0 | 1.0 |
| 14 | 48.5 | 49.5 | 51.0 | -2.5 | -1.5 |
| 15 | 47.0 | 47.0 | 51.0 | -4.0 | -4.0 |
| 16 | 53.0 | 52.0 | 53.0 | 0.0 | -1.0 |
| 17 | 47.0 | 48.0 | 48.0 | -1.0 | 0.0 |
| 18 | 54.0 | 55.5 | 54.0 | 0.0 | 1.5 |
| 19 | 50.0 | 49.5 | 48.5 | 1.5 | 1.0 |
| 20 | 49.0 | 47.5 | 48.0 | 1.0 | -.5 |

Table 11

Pilot Study

**Head Circumference Measurements**

| Infant | Examiner 1 | Examiner 2 |
|---|---|---|
| 1 | 36.0 | 36.0 |
| 2 | 36.5 | 36.0 |
| 3 | 36.0 | 36.0 |
| 4 | 35.5 | 35.5 |
| 5 | 34.0 | 34.0 |
| 6 | 33.5 | 33.5 |
| 7 | 35.0 | 35.0 |
| 8 | 36.5 | 37.0 |
| 9 | 34.0 | 33.5 |
| 10 | 34.5 | 35.0 |
| 11 | 36.0 | 36.5 |
| 12 | 31.5 | 31.0 |
| 13 | 34.0 | 34.5 |
| 14 | 34.0 | 33.0 |
| 15 | 33.0 | 33.0 |
| 16 | 34.5 | 34.5 |
| 17 | 33.0 | 33.0 |
| 18 | 35.0 | 35.5 |
| 19 | 34.0 | 34.5 |
| 20 | 33.0 | 33.0 |

Table 12

Pilot Study

## Chest Circumference Measurements

| Infant | Examiner 1 | Examiner 2 |
|---|---|---|
| 1 | 34.5 | 35.5 |
| 2 | 33.5 | 34.0 |
| 3 | 34.0 | 34.5 |
| 4 | 32.5 | 31.0 |
| 5 | 32.5 | 31.0 |
| 6 | 29.5 | 27.5 |
| 7 | 30.5 | 30.0 |
| 8 | 36.0 | 35.0 |
| 9 | 34.0 | 34.0 |
| 10 | 33.5 | 33.0 |
| 11 | 35.5 | 35.0 |
| 12 | 28.0 | 27.5 |
| 13 | 30.0 | 29.5 |
| 14 | 31.5 | 30.5 |
| 15 | 29.5 | 29.5 |
| 16 | 33.0 | 32.0 |
| 17 | 29.0 | 29.0 |
| 18 | 34.5 | 34.0 |
| 19 | 32.0 | 31.5 |
| 20 | 30.5 | 30.0 |

Table 13

Pilot Study

**Midarm Circumference Measurements**

| Infant | Examiner 1 | Examiner 2 |
|---|---|---|
| 1 | 12.0 | 13.0 |
| 2 | 12.0 | 12.5 |
| 3 | 11.0 | 11.0 |
| 4 | 11.0 | 11.0 |
| 5 | 9.0 | 10.0 |
| 6 | 9.0 | 9.0 |
| 7 | 10.0 | 11.0 |
| 8 | 12.0 | 13.0 |
| 9 | 11.0 | 11.0 |
| 10 | 10.5 | 10.0 |
| 11 | 11.5 | 11.0 |
| 12 | 8.5 | 9.0 |
| 13 | 9.5 | 9.5 |
| 14 | 10.5 | 10.0 |
| 15 | 9.0 | 9.0 |
| 16 | 10.5 | 10.5 |
| 17 | 8.5 | 8.5 |
| 18 | 11.0 | 10.5 |
| 19 | 10.5 | 10.0 |
| 20 | 9.5 | 9.5 |

The Ballard scores for the two examiners and the admitting nurse in the nursery are shown in table 14. The scores from the two examiners range from 37 to 42 weeks. There is never a difference of more than two weeks between the two examiners scores. The scores of the two examiners agree for 10 of the infants. For the infants with an EDC of 38 weeks or less, the Ballard score is consistently higher than the EDC.

The Ballard score is accurate only to within two weeks of the actual date. It is not until a difference of three or more weeks exists that a real discrepancy is considered. In practice, both estimates are considered but nursery care is based on the Ballard score (Avery, 1981).

There is one 35 and one 36 week Ballard score in the nursery group. Except for infants 10 and 15, the Ballard scores obtained by the nursery personnel fall within two weeks of the scores obtained by the two examiners.

Rater Effect

The rater effect is tested as explained in Section 3.4.1. The analysis of variance tables for these measurements are shown in tables 15-18. The p-values for the tests of rater effects are listed table 19. The p-values for length, head circumference, and mid arm circumference are not significant

Table 14

Pilot Study

**Ballard Scores**

| Infant | Examiner 1 | Examiner 2 | Nursery |
|---|---|---|---|
| 1 | 40 | 41 | 40 |
| 2 | 40 | 40 | 41 |
| 3 | 41 | 42 | 42 |
| 4 | 40 | 40 | 41 |
| 5 | 39 | 41 | 40 |
| 6 | 40 | 42 | 40 |
| 7 | 41 | 41 | 40 |
| 8 | 40 | 42 | 42 |
| 9 | 41 | 40 | 40 |
| 10 | 40 | 42 | 39 |
| 11 | 40 | 40 | 38 |
| 12 | 38 | 38 | 36 |
| 13 | 39 | 39 | 38 |
| 14 | 40 | 41 | 39 |
| 15 | 38 | 37 | 35 |
| 16 | 40 | 40 | 40 |
| 17 | 40 | 40 | 40 |
| 18 | 40 | 40 | 40 |
| 19 | 40 | 41 | 41 |
| 20 | 39 | 39 | 41 |

Table 15

**LENGTHS**

GENERAL LINEAR MODELS PROCEDURE

DEP VAR: LENGTH N: 40 MULTIPLE R: .976 SQUARED MULTIPLE R: .953

ANALYSIS OF VARIANCE

| SOURCE | SUM-OF-SQUARES | DF | MEAN-SQUARE | F-RATIO | P |
|---|---|---|---|---|---|
| PATIENT | 303.7750 | 19 | 15.9882 | 20.3876 | 0.0000 |
| RATER | 0.1000 | 1 | 0.1000 | 0.1275 | 0.7250 |
| ERROR | 14.9000 | 19 | 0.7842 | | |

Table 16

**HEAD CIRCUMFERENCE**

GENERAL LINEAR MODELS PROCEDURE

DEP VAR: HEAD N: 40 MULTIPLE R: .989 SQUARED MULTIPLE R: .979

ANALYSIS OF VARIANCE

| SOURCE | SUM-OF-SQUARES | DF | MEAN-SQUARE | F-RATIO | P |
|---|---|---|---|---|---|
| PATIENT | 75.6188 | 19 | 3.9799 | 46.7143 | 0.0000 |
| RATER | 0.0063 | 1 | 0.0063 | 0.0734 | 0.7894 |
| ERROR | 1.6188 | 19 | 0.0852 | | |

Table 17

**CHEST CIRCUMFERENCE**

GENERAL LINEAR MODELS PROCEDURE

DEP VAR: CHEST N: 40 MULTIPLE R: .989 SQUARED MULTIPLE R: .978

ANALYSIS OF VARIANCE

| SOURCE | SUM-OF-SQUARES | DF | MEAN-SQUARE | F-RATIO | P |
|---|---|---|---|---|---|
| PATIENT | 217.4000 | 19 | 11.4421 | 43.4800 | 0.0000 |
| RATER | 2.5000 | 1 | 2.5000 | 9.5000 | 0.0061 |
| ERROR | 5.0000 | 19 | 0.2632 | | |

Table 18

**MIDARM CIRCUMFERENCE**

GENERAL LINEAR MODELS PROCEDURE

DEP VAR: MIDARM N: 40 MULTIPLE R: .976 SQUARED MULTIPLE R: .952

ANALYSIS OF VARIANCE

| SOURCE | SUM-OF-SQUARES | DF | MEAN-SQUARE | F-RATIO | P |
|---|---|---|---|---|---|
| PATIENT | 53.8688 | 19 | 2.8352 | 19.8138 | 0.0000 |
| RATER | 0.1563 | 1 | 0.1563 | 1.0920 | 0.3092 |
| ERROR | 2.7187 | 19 | 0.1431 | | |

Table 19

Pilot Study

P-Values For Tests of Rater Effects

| | |
|---|---|
| Length | .7250 |
| Head Circumference | .7894 |
| Chest Circumference | .0061 |
| Mid Arm Circumference | .3092 |

at the five percent level. This means there is no significant rater difference between the two raters in their mean levels of measurement for length, head circumference, and mid arm circumference for these 20 infants.

The p-value for the test of rater effect for chest circumference is significant. This means there is a difference between the two raters in their mean levels of chest measurements. Table 12 shows that except for the first three infants, the first examiner's measurements are all the same or larger than the second examiner's measurements.

Because of the small sample size, the power of these tests for rater effects is low. This means that the test has a low probability of rejecting the null hypothesis when the alternative hypothesis is true. The test has a low probability of identifying a rater effect. Since the power of these tests is low, plots of the data are examined to detect differences between raters.

Plots of the two raters measurements for length, head circumference, chest circumference, and mid arm circumference are shown in figures 5-8. The closer the points follow a straight line from the lower left corner to the upper right corner, the closer are the two raters measurements.

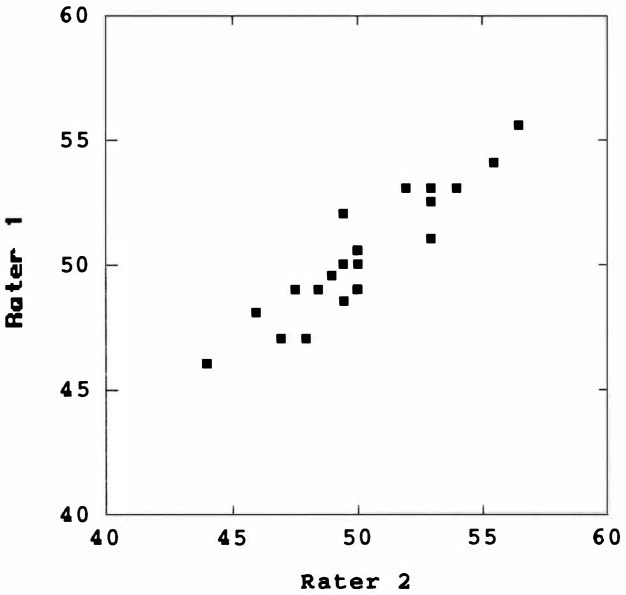



Figure 5.  Raters and Length

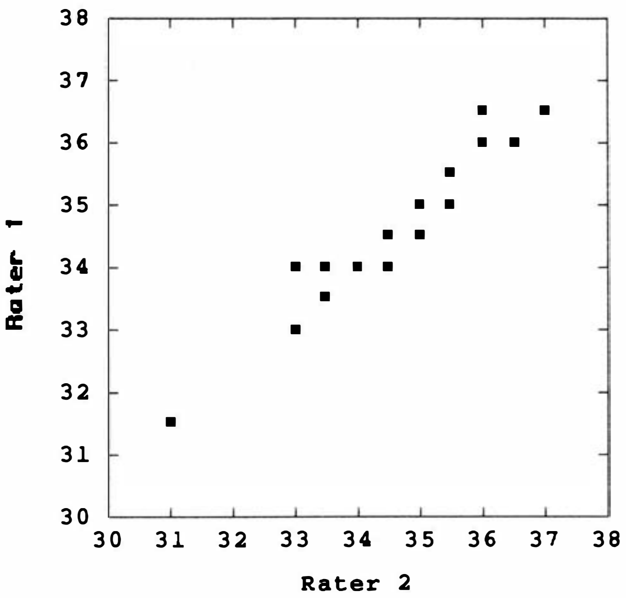



Figure 6. Raters and Head Circumference

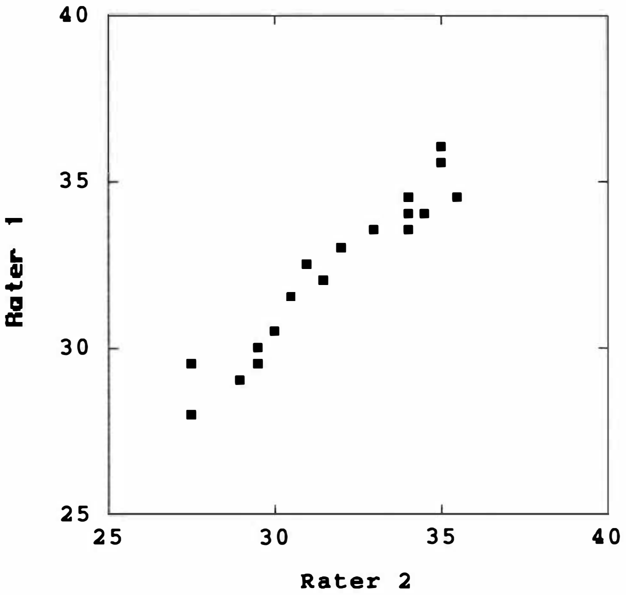



Figure 7. Raters and Chest Circumference

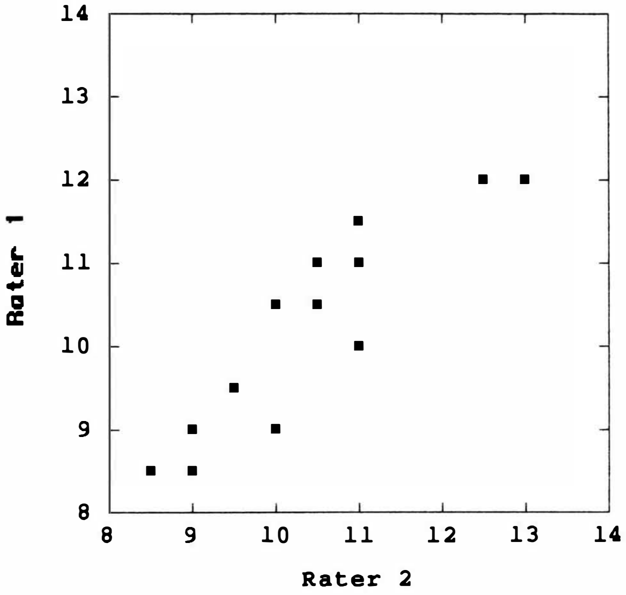



Figure 8. Raters and Mid Arm Circumference

The points in the plots for length and head circumference follow a fairly straight line from the lower left corner of the graph to the upper right corner of the graph. This indicates close agreement between the two raters for these measurements. The middle values of mid arm are shifted up. This indicates the measurements of rater 1 are larger than rater 2 for these measurements of mid arm circumference. The remaining points are scattered on either side of the line indicating no other patterns of difference between the two raters for length, head circumference, and mid arm circumference.

The points in the plot for chest circumference measurements between the two raters (figure 8) follow a fairly straight line from the lower left corner of the graph to the upper right corner of the graph. However, the line of points is shifted up indicating the measurements of chest circumference for rater 1 are consistently larger than the measurements of chest circumference for rater 2.

Although the power of the tests for rater effects is low, the results of examination of these plots agree with the results of the tests for rater effects. The plots indicate that for the middle values mid arm circumference, rater 1 measurements are larger than rater 2 measurements. There are no other rater effects in the length, head circumference, and mid arm circumference measurements. The measurements of chest circumference for rater 1 are consistently larger than the chest circumference measurements for rater 2.

## Intraclass Correlation Coefficient

Figure 9 contains the Microsoft QuickBASIC 1.0 program used to calculate the ICC. Table 20 lists the values of the intraclass correlation coefficient for length, head circumference, chest circumference, and mid arm circumference. The coefficients range from .91 to .96 indicating excellent reliability of these measurements in the final study.

## Weighted Kappa

Table 21 shows the frequency of agreement of the Ballard score between the two raters and the proportion of infants in each category is shown in table 22. Weighted kappa is used to quantify interrater agreement. The weights used are shown in table 23. The weighted kappa for these data is .89. This indicates excellent agreement between the two raters on the Ballard score.

```
'INTRACLASS CORRELATION COEFFICIENT
'BY LYDIA SUND


'THIS BASIC PROGRAM CALCULATES THE
'INTRACLASS CORRELATION COEFFICIENT
' FOR A STUDY OF RATER EFFECTS
' WHEN THE RATER
'EFFECTS ARE FIXED


'THE FORMULA IS FROM
     'THE DESIGN AND ANALYSIS OF CLINICAL EXPERIMENTS
     'BY JOSEPH C. FLEISS     NEW YORK: WILEY, 1986
     'PAGE 21


PRINT, "ENTER N -- THE TOTAL SAMPLE SIZE"
INPUT N
PRINT, "ENTER PMS -- THE PATIENT MEAN SQUARE"
INPUT PMS
PRINT, "ENTER RMS -- THE RATER MEAN SQUARE"
INPUT RMS
PRINT, "ENTER EMS -- THE ERROR MEAN SQUARE"
INPUT EMS
PRINT, "ENTER THE NUMBER OF RATERS"
INPUT K

RHAT=
(N*(PMS-EMS))/((N*(PMS))+((K-1)*(RMS))+((N-1)*(K-1)*(EMS)))
PRINT RHAT
```

Figure 9. Calculating The Intraclass Correlation Coefficient

Table 20

Pilot Study

**Estimates of the Intraclass Correlation Coefficient (ICC)**

| MEASUREMENT | ICC |
|---|---|
| LENGTH | .91 |
| HEAD | .96 |
| CHEST | .95 |
| MIDARM | .91 |
| BALLARD | .62 |

Table 21

Pilot Study

**Frequency of Agreement on Ballard Score Between The Two Raters**

TABLE OF RATER1 (ROWS) BY RATER2 (COLUMNS)

FREQUENCIES

| | 37 | 38 | 39 | 40 | 41 | 42 | TOTAL |
|---|---|---|---|---|---|---|---|
| 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | 1 | 1 | 0 | 0 | 0 | 0 | 2 |
| 39 | 0 | 0 | 2 | 0 | 1 | 0 | 3 |
| 40 | 0 | 0 | 0 | 6 | 3 | 3 | 12 |
| 41 | 0 | 0 | 0 | 1 | 1 | 1 | 3 |
| 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 1 | 1 | 2 | 7 | 5 | 4 | 20 |

Table 22

Pilot Study

**Proportion of Infants in Each Category Based on Ballard Scores of the Two Raters**

TABLE OF RATER1 (ROWS) BY RATER2 (COLUMNS)

FREQUENCIES

| | 37 | 38 | 39 | 40 | 41 | 42 | TOTAL |
|---|---|---|---|---|---|---|---|
| 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | .05 | .05 | 0 | 0 | 0 | 0 | .10 |
| 39 | 0 | 0 | .10 | 0 | .05 | 0 | .15 |
| 40 | 0 | 0 | 0 | .30 | .15 | .15 | .60 |
| 41 | 0 | 0 | 0 | .05 | .05 | .05 | .15 |
| 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | .05 | .05 | .10 | .35 | .25 | .20 | 1.00 |

Table 23

Pilot Study

**Weights Used for Calculation of Weighted Kappa**

TABLE OF RATER1 (ROWS) BY RATER2 (COLUMNS)

FREQUENCIES

| | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|
| 37 | 1 | .96 | .84 | .64 | .36 | 0 |
| 38 | .96 | 1 | .96 | .84 | .64 | .36 |
| 39 | .84 | .96 | 1 | .96 | .84 | .64 |
| 40 | .64 | .84 | .96 | 1 | .96 | .84 |
| 41 | .36 | .64 | .84 | .96 | 1 | .96 |
| 42 | 0 | .36 | .64 | .84 | .96 | 1 |

Conclusions and Recommendations

1. The differences in measurements for length and head circumference did not have an effect on final infant classification.

2. The estimates for interrater reliability for length, head circumference, chest circumference, and mid arm circumference for the final study indicate high reliability for these measurements.

3. There are observed differences between the two nurses in their calculations of the Ballard score for the infants. Their estimates of gestational age agree with each other within a two week period. The weighted kappa indicates excellent agreement between the raters.

4. Seventeen of the infants had gestational ages greater than 38 weeks. There may not be enough infants in the final study in the less than 37 week area to generate an accurate graph.

5. The relationship between sex, race, number of prenatal visits and infant classification needs to be examined in the larger study.

# Chapter 4

# Graphs

This chapter examines the data collected for the first 98 infants in the final study. The purpose of this chapter is to describe graphs developed from the data of weight, length, and head circumference by gestational age and compare these graphs with the ones by Lubchenco in 1963 and 1966 (Lubchenco et al, 1963, 1966). These data are listed in table 48 in the appendix and the variables are described in figure 3.

Weight, length, and head circumference are examined separately. The same graphing techniques used by Lubchenco (Lubchenco et al, 1963, 1966) are applied to the data. The other variables collected are examined to understand the characteristics of the sample and identify data collection problems.

## Weight

The weights of the infants ranged from 2070 to 4760 grams with a mean weight of 3222. Gestational ages ranged from 34 to 42 weeks with a mean gestational age of 38.7 weeks. Table

24 shows the number of infants by gestational week. The extreme gestational ages contain few infants. The 34 week and 42 weeks gestational age groups have two infants each. The graphs may not be accurate at these gestations since there are so few infants in these groups. The majority of the infants (82%) are between 37 and 41 weeks. Gestational age is missing for six of the infants; therefore, measurements from 92 of the infants are used in the development of the graphs.

Lubchenco Method

The method used by Lubchenco (Lubchenco et al,1963) to produce the weight graph currently in use was briefly examined in the section, Development of Graphs. The method involved grouping the infants by gestational age and weight, calculating percentiles within each group, and then smoothing the percentiles across groups. In this section, the method will be reviewed and its application to the current data explained.

In the Lubchenco study (Lubchenco et al, 1963), the infants were first grouped by gestational age. The gestational age was collected in number of weeks plus days. The infants born from the beginning of one week to the beginning of another week were grouped together. This is different from the gestational age measurement in the current

Table 24

Infants by Gestation

| Weeks | Number of Infants |
|---|---|
| 34 | 2 |
| 35 | 4 |
| 36 | 4 |
| 37 | 12 |
| 38 | 11 |
| 39 | 24 |
| 40 | 23 |
| 41 | 10 |
| 42 | 2 |

study. In this case, gestational age has been rounded to the closest whole week. The gestational age grouping would not be the same for some infants. For example, an infant with a gestational age of 37 5/7 weeks would be considered 37 weeks by Lubchenco and 38 weeks in the current study. It is not clear what effect this difference has on the final weight graph. Table 25 shows the weights by gestational age.

After the infants were grouped by gestational age, the birth weights were tabulated at 100 gram intervals. Table 25 shows the tabulation by 100 gram intervals for the 92 infants in the current study. Some of the precision is lost by this grouping. Lubchenco (Lubchenco et al, 1963) does not explain why this grouping is done but the purpose may be to ease calculation.

After grouping the gestational ages and weights, ogives were constructed using these groupings. An ogive is a line chart of a cumulative frequency distribution (Van Matre 1983). Using the ogives, values for the 10th, 25th, 50th, 75th, and 90th percentiles were read.

Using the density plot procedure in Systat (Wilkinson, 1989) cumulative frequency histograms were drawn from the weight and gestational age groupings of the current data. The polygon option was used which produced lines connecting the tops of the bars on each histogram. Additional lines

Table 25

Gestational Age and Weight

| Weight | Gestational Age | Method | Weights in 100 Gm. Intervals |
|---|---|---|---|
| 2540.0 | . | 1.0 | 2500.0 |
| 2551.0 | . | . | 2500.0 |
| 2680.0 | . | . | 2600.0 |
| 3090.0 | . | . | 3000.0 |
| 3230.0 | . | . | 3200.0 |
| 3530.0 | . | . | 3500.0 |
| 2330.0 | 34.0 | 1.0 | 2300.0 |
| 2430.0 | 34.0 | 1.0 | 2400.0 |
| 2523.0 | 35.0 | 2.0 | 2500.0 |
| 2720.0 | 35.0 | 2.0 | 2700.0 |
| 2840.0 | 35.0 | 2.0 | 2800.0 |
| 2950.0 | 35.0 | 1.0 | 2900.0 |
| 2070.0 | 36.0 | 1.0 | 2000.0 |
| 2190.0 | 36.0 | 1.0 | 2100.0 |
| 2790.0 | 36.0 | 2.0 | 2700.0 |
| 2980.0 | 36.0 | 1.0 | 2900.0 |
| 2410.0 | 37.0 | 2.0 | 2400.0 |
| 2660.0 | 37.0 | 2.0 | 2600.0 |
| 2750.0 | 37.0 | 2.0 | 2700.0 |
| 2830.0 | 37.0 | 2.0 | 2800.0 |
| 3030.0 | 37.0 | 1.0 | 3000.0 |
| 3110.0 | 37.0 | 1.0 | 3100.0 |
| 3230.0 | 37.0 | 1.0 | 3200.0 |
| 3330.0 | 37.0 | 1.0 | 3300.0 |
| 3320.0 | 37.0 | 1.0 | 3300.0 |
| 3610.0 | 37.0 | 2.0 | 3600.0 |
| 3770.0 | 37.0 | 1.0 | 3700.0 |
| 4000.0 | 37.0 | 1.0 | 4000.0 |
| 2740.0 | 38.0 | 1.0 | 2700.0 |
| 2980.0 | 38.0 | 1.0 | 2900.0 |
| 3080.0 | 38.0 | 2.0 | 3000.0 |
| 3170.0 | 38.0 | 2.0 | 3100.0 |
| 3120.0 | 38.0 | 2.0 | 3100.0 |
| 3190.0 | 38.0 | 2.0 | 3100.0 |
| 3260.0 | 38.0 | 1.0 | 3200.0 |
| 3340.0 | 38.0 | 1.0 | 3300.0 |
| 3430.0 | 38.0 | 2.0 | 3400.0 |
| 3570.0 | 38.0 | 2.0 | 3500.0 |
| 4260.0 | 38.0 | 1.0 | 4200.0 |

Table 25—*Continued*

| Weight | Gestational Age | Method | Weights in 100 Gm. Intervals |
|---|---|---|---|
| 2220.0 | 39.0 | 2.0 | 2200.0 |
| 2670.0 | 39.0 | 2.0 | 2600.0 |
| 2650.0 | 39.0 | 2.0 | 2600.0 |
| 2600.0 | 39.0 | 1.0 | 2600.0 |
| 2770.0 | 39.0 | 1.0 | 2700.0 |
| 2840.0 | 39.0 | 2.0 | 2800.0 |
| 2840.0 | 39.0 | 1.0 | 2800.0 |
| 2800.0 | 39.0 | 1.0 | 2800.0 |
| 2930.0 | 39.0 | 1.0 | 2900.0 |
| 3000.0 | 39.0 | 1.0 | 3000.0 |
| 3180.0 | 39.0 | 1.0 | 3100.0 |
| 3170.0 | 39.0 | 1.0 | 3100.0 |
| 3120.0 | 39.0 | 2.0 | 3100.0 |
| 3170.0 | 39.0 | 1.0 | 3100.0 |
| 3175.0 | 39.0 | 1.0 | 3100.0 |
| 3110.0 | 39.0 | 2.0 | 3100.0 |
| 3280.0 | 39.0 | 2.0 | 3200.0 |
| 3330.0 | 39.0 | 2.0 | 3300.0 |
| 3300.0 | 39.0 | 1.0 | 3300.0 |
| 3420.0 | 39.0 | 1.0 | 3400.0 |
| 3780.0 | 39.0 | 2.0 | 3700.0 |
| 3870.0 | 39.0 | 1.0 | 3800.0 |
| 4140.0 | 39.0 | 1.0 | 4100.0 |
| 4760.0 | 39.0 | 1.0 | 4700.0 |
| 2650.0 | 40.0 | 1.0 | 2600.0 |
| 2710.0 | 40.0 | 2.0 | 2700.0 |
| 2870.0 | 40.0 | 1.0 | 2800.0 |
| 2960.0 | 40.0 | 1.0 | 2900.0 |
| 2930.0 | 40.0 | 2.0 | 2900.0 |
| 3070.0 | 40.0 | 2.0 | 3000.0 |
| 3000.0 | 40.0 | 2.0 | 3000.0 |
| 3080.0 | 40.0 | 1.0 | 3000.0 |
| 3190.0 | 40.0 | 2.0 | 3100.0 |
| 3110.0 | 40.0 | 1.0 | 3100.0 |
| 3180.0 | 40.0 | 2.0 | 3100.0 |
| 3280.0 | 40.0 | 2.0 | 3200.0 |
| 3320.0 | 40.0 | 2.0 | 3300.0 |
| 3460.0 | 40.0 | 1.0 | 3400.0 |
| 3420.0 | 40.0 | 1.0 | 3400.0 |
| 3480.0 | 40.0 | 2.0 | 3400.0 |
| 3420.0 | 40.0 | 1.0 | 3400.0 |
| 3500.0 | 40.0 | 1.0 | 3500.0 |
| 3650.0 | 40.0 | 2.0 | 3600.0 |
| 3940.0 | 40.0 | 1.0 | 3900.0 |
| 3900.0 | 40.0 | 1.0 | 3900.0 |
| 4370.0 | 40.0 | 2.0 | 4300.0 |
| 4300.0 | 40.0 | 2.0 | 4300.0 |

Table 25—*Continued*

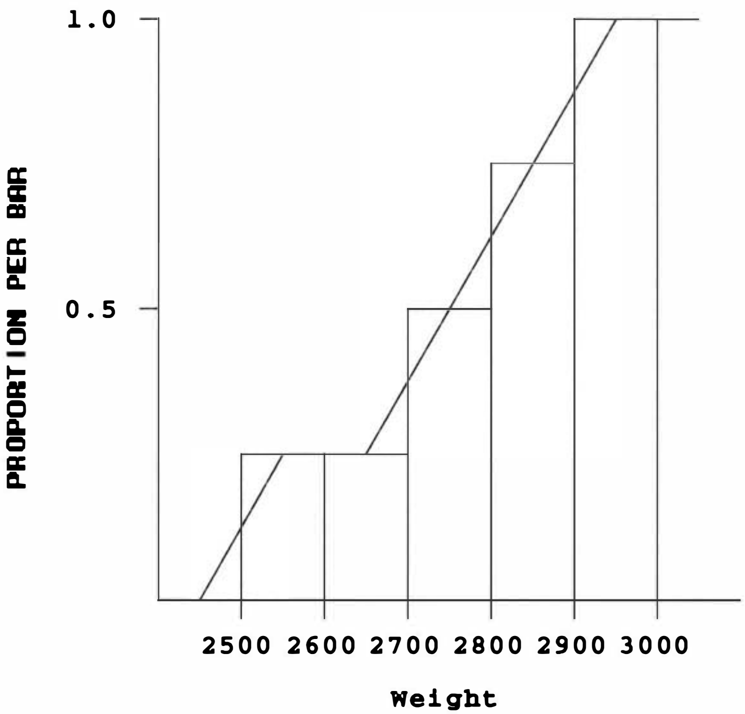
| Weight | Gestational Age | Method | Weights in 100 Gm. Intervals |
|---|---|---|---|
| 2950.0 | 41.0 | 2.0 | 2900.0 |
| 3540.0 | 41.0 | 2.0 | 3500.0 |
| 3550.0 | 41.0 | 2.0 | 3500.0 |
| 3630.0 | 41.0 | 1.0 | 3600.0 |
| 3750.0 | 41.0 | 1.0 | 3700.0 |
| 3790.0 | 41.0 | 1.0 | 3700.0 |
| 3830.0 | 41.0 | 1.0 | 3800.0 |
| 4090.0 | 41.0 | 1.0 | 4000.0 |
| 4320.0 | 41.0 | 1.0 | 4300.0 |
| 4500.0 | 41.0 | 1.0 | 4500.0 |
| 3490.0 | 42.0 | 2.0 | 3400.0 |
| 3720.0 | 42.0 | 2.0 | 3700.0 |

were hand drawn on the plots, where needed, to produce the ogives. Figures 10-16 show the ogives for each gestational week and table 26 contains the tabulated cumulative frequencies. Using the ogives in figures 10-16, the percentile groups were calculated and are listed at the bottom of each ogive.

To calculate a percentile group, the desired percentage was first found on the y axis of each ogive by measuring the appropriate distance from the origin. A line was drawn parallel to the x axis from this point. From the point where this line intersected the ogive, a line was drawn perpendicular down to the x axis. The value on the x axis is the value for the desired percentile.

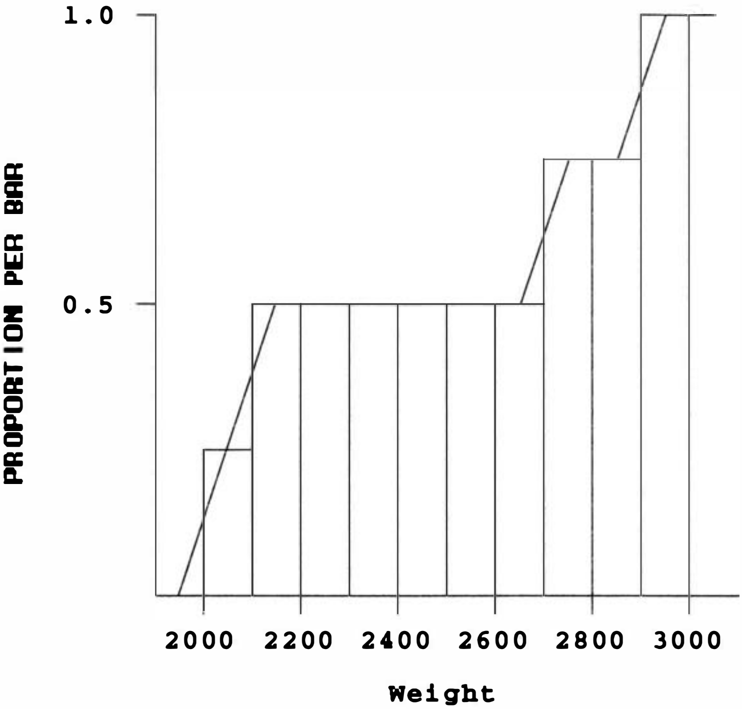
The values obtained from the ogives were compared with the cumulative frequencies in table 26 to make sure the values were fairly close. There were some errors in graph reading, but after these were corrected all the values were within 50 grams of values in the cumulative frequency table.

In the Lubchenco study (Lubchenco et al, 1963), the percentiles obtained from the ogives were graphed versus gestational age and smoothed arithmetically. There is no further explanation of the term "smoothed arithmetically." In the article explaining the development of the length and head circumference graphs (Lubchenco et al, 1966), smoothing



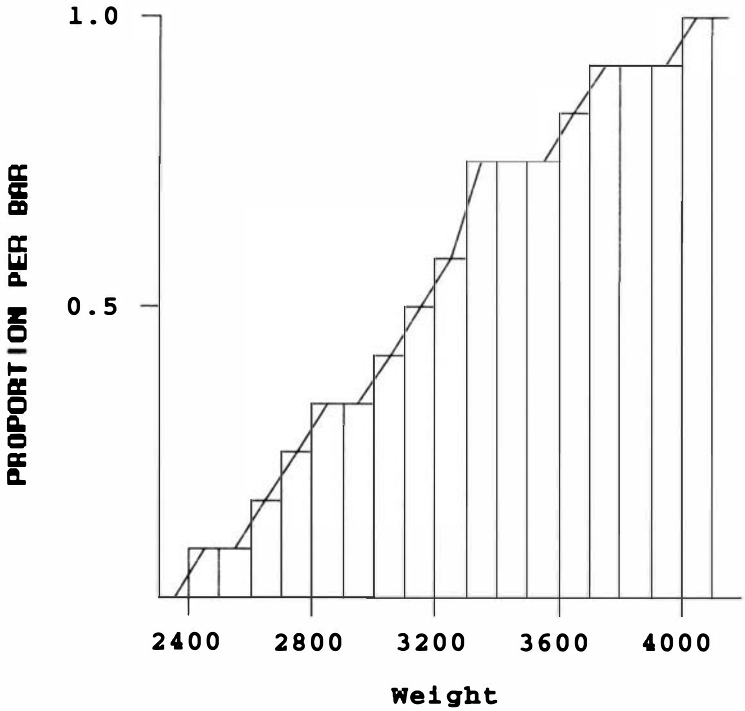

| Percentile | Weight |
|---|---|
| 90th | 2860 |
| 75th | 2800 |
| 50th | 2700 |
| 25th | 2500 |
| 10th | 2430 |

Figure 10. Weight at 35 Weeks



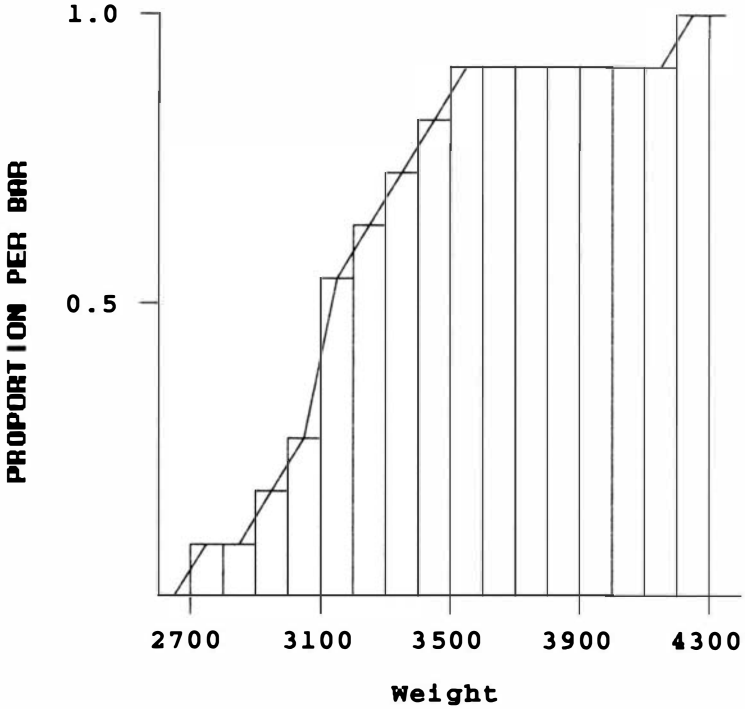

| Percentile | Weight |
|---|---|
| 90th | 2825 |
| 75th | 2700 |
| 50th | 2100 |
| 25th | 2000 |
| 10th | 1930 |

Figure 11. Weight at 36 Weeks



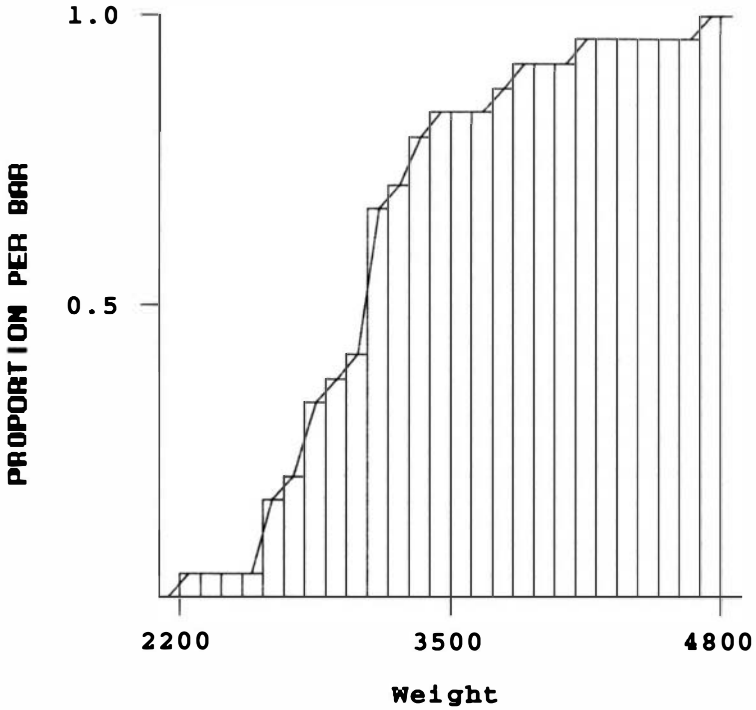

| Percentile | Weight |
|---|---|
| 90th | 3700 |
| 75th | 3300 |
| 50th | 3100 |
| 25th | 2700 |
| 10th | 2400 |

Figure 12. Weight at 37 Weeks



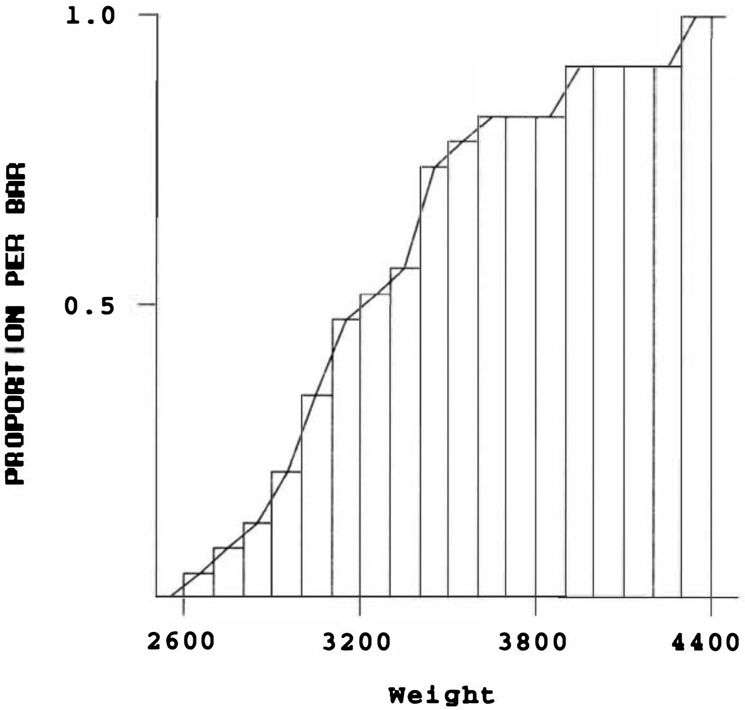

| Percentile | Weight |
|---|---|
| 90th | 3490 |
| 75th | 3320 |
| 50th | 3080 |
| 25th | 2975 |
| 10th | 2725 |

Figure 13. Weight at 38 Weeks



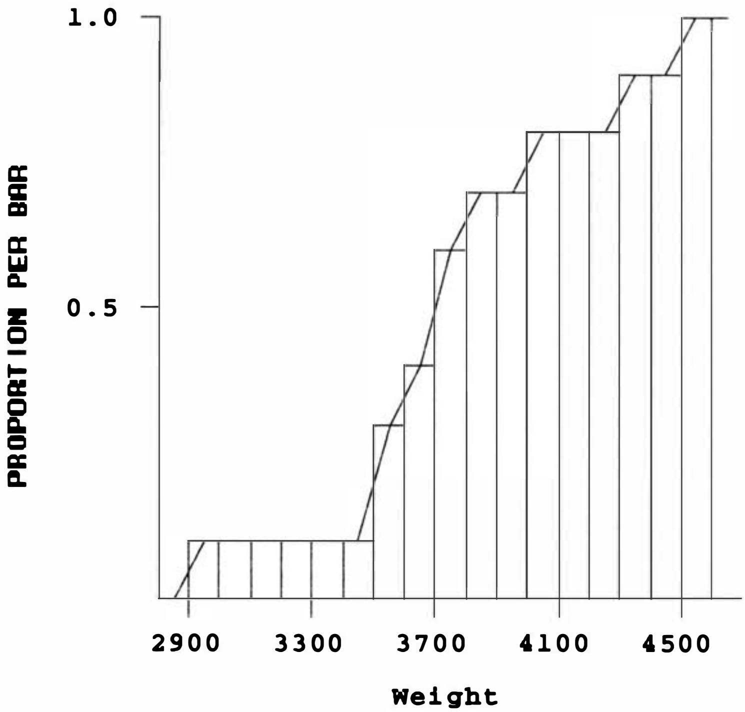

| Percentile | Weight |
|---|---|
| 90th | 3775 |
| 75th | 3250 |
| 50th | 3025 |
| 25th | 2725 |
| 10th | 2325 |

Figure 14. Weight at 39 Weeks




| Percentile | Weight |
|---|---|
| 90th | 3825 |
| 75th | 3425 |
| 50th | 3150 |
| 25th | 2920 |
| 10th | 2730 |

Figure 15. Weight at 40 Weeks




| Percentile | Weight |
|---|---|
| 90th | 4300 |
| 75th | 3900 |
| 50th | 3660 |
| 25th | 3370 |
| 10th | 2900 |

Figure 16. Weight at 41 Weeks

Table 26

Cumulative Frequency by Gestational Age

Birth Weights Tabulated in 100 Gm. Intervals

THE FOLLOWING RESULTS ARE FOR: GEST = 34

| COUNT | CUM COUNT | PCT | CUM PCT | WGTGROUP |
|---|---|---|---|---|
| 1 | 1 | 50.0 | 50.0 | 2300.000 |
| 1 | 2 | 50.0 | 100.0 | 2400.000 |

THE FOLLOWING RESULTS ARE FOR: GEST = 35

| COUNT | CUM COUNT | PCT | CUM PCT | WGTGROUP |
|---|---|---|---|---|
| 1 | 1 | 25.0 | 25.0 | 2500.000 |
| 1 | 2 | 25.0 | 50.0 | 2700.000 |
| 1 | 3 | 25.0 | 75.0 | 2800.000 |
| 1 | 4 | 25.0 | 100.0 | 2900.000 |

THE FOLLOWING RESULTS ARE FOR: GEST = 36

| COUNT | CUM COUNT | PCT | CUM PCT | WGTGROUP |
|---|---|---|---|---|
| 1 | 1 | 25.0 | 25.0 | 2000.000 |
| 1 | 2 | 25.0 | 50.0 | 2100.000 |
| 1 | 3 | 25.0 | 75.0 | 2700.000 |
| 1 | 4 | 25.0 | 100.0 | 2900.000 |

Table 26—*Continued*

THE FOLLOWING RESULTS ARE FOR: GEST = 37

| COUNT | CUM COUNT | PCT | CUM PCT | WGTGROUP |
|---|---|---|---|---|
| 1 | 1 | 8.3 | 8.3 | 2400.000 |
| 1 | 2 | 8.3 | 16.7 | 2600.000 |
| 1 | 3 | 8.3 | 25.0 | 2700.000 |
| 1 | 4 | 8.3 | 33.3 | 2800.000 |
| 1 | 5 | 8.3 | 41.7 | 3000.000 |
| 1 | 6 | 8.3 | 50.0 | 3100.000 |
| 1 | 7 | 8.3 | 58.3 | 3200.000 |
| 2 | 9 | 16.7 | 75.0 | 3300.000 |
| 1 | 10 | 8.3 | 83.3 | 3600.000 |
| 1 | 11 | 8.3 | 91.7 | 3700.000 |
| 1 | 12 | 8.3 | 100.0 | 4000.000 |

THE FOLLOWING RESULTS ARE FOR: GEST = 38.000

| COUNT | CUM COUNT | PCT | CUM PCT | WGTGROUP |
|---|---|---|---|---|
| 1 | 1 | 9.1 | 9.1 | 2700.000 |
| 1 | 2 | 9.1 | 18.2 | 2900.000 |
| 1 | 3 | 9.1 | 27.3 | 3000.000 |
| 3 | 6 | 27.3 | 54.5 | 3100.000 |
| 1 | 7 | 9.1 | 63.6 | 3200.000 |
| 1 | 8 | 9.1 | 72.7 | 3300.000 |
| 1 | 9 | 9.1 | 81.8 | 3400.000 |
| 1 | 10 | 9.1 | 90.9 | 3500.000 |
| 1 | 11 | 9.1 | 100.0 | 4200.000 |

THE FOLLOWING RESULTS ARE FOR: Gest = 39

| COUNT | CUM COUNT | PCT | CUM PCT | WGTGROUP |
|---|---|---|---|---|
| 1 | 1 | 4.2 | 4.2 | 2200.000 |
| 3 | 4 | 12.5 | 16.7 | 2600.000 |
| 1 | 5 | 4.2 | 20.8 | 2700.000 |
| 3 | 8 | 12.5 | 33.3 | 2800.000 |
| 1 | 9 | 4.2 | 37.5 | 2900.000 |
| 1 | 10 | 4.2 | 41.7 | 3000.000 |
| 6 | 16 | 25.0 | 66.7 | 3100.000 |
| 1 | 17 | 4.2 | 70.8 | 3200.000 |
| 2 | 19 | 8.3 | 79.2 | 3300.000 |
| 1 | 20 | 4.2 | 83.3 | 3400.000 |
| 1 | 21 | 4.2 | 87.5 | 3700.000 |
| 1 | 22 | 4.2 | 91.7 | 3800.000 |
| 1 | 23 | 4.2 | 95.8 | 4100.000 |
| 1 | 24 | 4.2 | 100.0 | 4700.000 |

Table 26—*Continued*

THE FOLLOWING RESULTS ARE FOR: Gest = 40

| COUNT | CUM COUNT | PCT | CUM PCT | WGTGROUP |
|---|---|---|---|---|
| 1 | 1 | 4.3 | 4.3 | 2600.000 |
| 1 | 2 | 4.3 | 8.7 | 2700.000 |
| 1 | 3 | 4.3 | 13.0 | 2800.000 |
| 2 | 5 | 8.7 | 21.7 | 2900.000 |
| 3 | 8 | 13.0 | 34.8 | 3000.000 |
| 3 | 11 | 13.0 | 47.8 | 3100.000 |
| 1 | 12 | 4.3 | 52.2 | 3200.000 |
| 1 | 13 | 4.3 | 56.5 | 3300.000 |
| 4 | 17 | 17.4 | 73.9 | 3400.000 |
| 1 | 18 | 4.3 | 78.3 | 3500.000 |
| 1 | 19 | 4.3 | 82.6 | 3600.000 |
| 2 | 21 | 8.7 | 91.3 | 3900.000 |
| 2 | 23 | 8.7 | 100.0 | 4300.000 |

THE FOLLOWING RESULTS ARE FOR: Gest = 41

| COUNT | CUM COUNT | PCT | CUM PCT | WGTGROUP |
|---|---|---|---|---|
| 1 | 1 | 10.0 | 10.0 | 2900.000 |
| 2 | 3 | 20.0 | 30.0 | 3500.000 |
| 1 | 4 | 10.0 | 40.0 | 3600.000 |
| 2 | 6 | 20.0 | 60.0 | 3700.000 |
| 1 | 7 | 10.0 | 70.0 | 3800.000 |
| 1 | 8 | 10.0 | 80.0 | 4000.000 |
| 1 | 9 | 10.0 | 90.0 | 4300.000 |
| 1 | 10 | 10.0 | 100.0 | 4500.000 |

THE FOLLOWING RESULTS ARE FOR: Gest = 42

| COUNT | CUM COUNT | PCT | CUM PCT | WGTGROUP |
|---|---|---|---|---|
| 1 | 1 | 50.0 | 50.0 | 3400.000 |
| 1 | 2 | 50.0 | 100.0 | 3700.000 |

is explained as using arithmetic three point means. Therefore, three point running means (Mosteller, 1977) for each percentile group are used to generate the graphs of the current data.

The smoothing technique of three point running means uses the two values adjacent to a specific point to yield a new value for that time period. A new estimate of weight for each gestational age group is found by averaging the weights for that group with the groups on either side. The end values do not change when this smoothing technique is applied since the end points have only one adjacent value.

Table 27 contains the percentiles before smoothing and table 28 contains the percentiles after smoothing. Figure 17 is a graph of the smoothed values. As shown in tables 27 and 28, the end values, 35 and 41 weeks gestation, are unchanged by this smoothing process.

Table 29 shows the smoothed values for both the Lubchenco study and the current data (Luchenco et al, 1963). These data are graphed in figure 18. The greatest differences between Richmond and Colorado are at the ends where the Richmond data are unsmoothed. The Richmond data needs smoothing so a comparison can be made with the Colorado data.

Table 27 Infant Weights

Percentiles before Smoothing

| Gestational Age | 10 | 25 | 50 | 75 | 90 |
|---|---|---|---|---|---|
| 35 | 2430 | 2500 | 2700 | 2800 | 2860 |
| 36 | 1930 | 2000 | 2100 | 2700 | 2825 |
| 37 | 2400 | 2700 | 3100 | 3300 | 3700 |
| 38 | 2725 | 2975 | 3080 | 3320 | 3490 |
| 39 | 2325 | 2725 | 3025 | 3250 | 3775 |
| 40 | 2730 | 2920 | 3150 | 3425 | 3825 |
| 41 | 2900 | 3370 | 3660 | 3900 | 4300 |

Table 28 Intrauterine Growth Males and Females

**Ends unsmoothed**

| Gestational Age | Patients | Mean Weight | Smoothed Percentiles 10 | 25 | 50 | 75 | 90 |
|---|---|---|---|---|---|---|---|
| 35 | 4 | 2758 | 2430 | 2500 | 2700 | 2800 | 2860 |
| 36 | 4 | 2507 | 2253 | 2400 | 2633 | 2933 | 3128 |
| 37 | 12 | 3171 | 2352 | 2558 | 2760 | 3106 | 3338 |
| 38 | 11 | 3285 | 2483 | 2800 | 3068 | 3290 | 3655 |
| 39 | 24 | 3172 | 2593 | 2873 | 3085 | 3331 | 3697 |
| 40 | 23 | 3339 | 2652 | 3005 | 3278 | 3525 | 3967 |
| 41 | 10 | 3795 | 2900 | 3370 | 3660 | 3900 | 4300 |

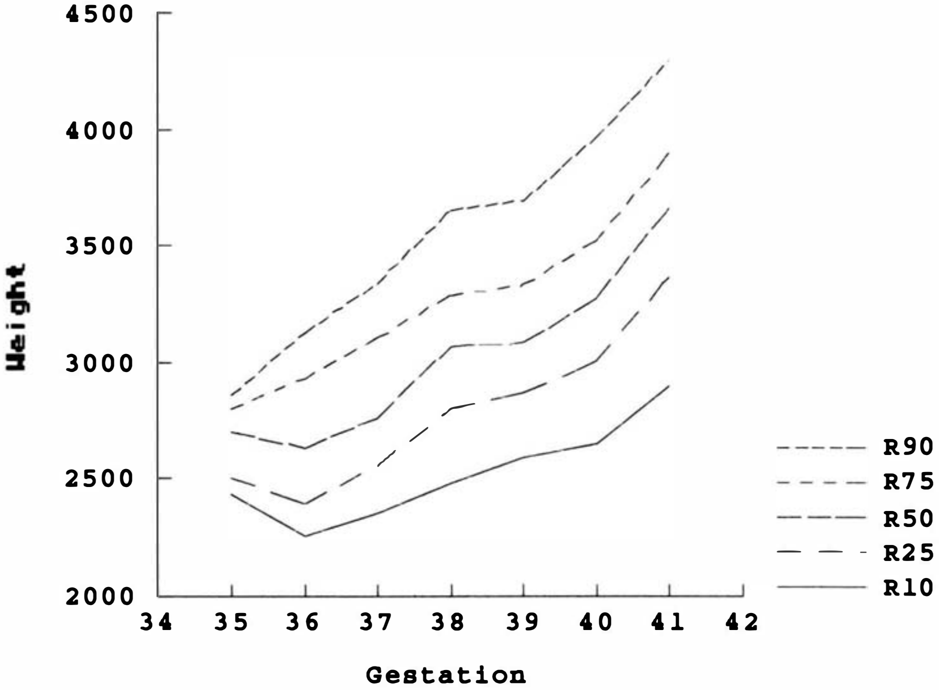



Figure 17. Richmond Percentiles Smoothed Ends Smoothed

Table 29 Intrauterine Growth Males and Females

Comparison of Richmond and Colorado

**Richmond Ends Unsmoothed**

Richmond *Colorado*

| Gestational Age | Patients | Mean Weight | Smoothed Percentiles 10 | 25 | 50 | 75 | 90 |
|---|---|---|---|---|---|---|---|
| 35 | 4 | 2758 | 2430 | 2500 | 2700 | 2800 | 2860 |
| *35* | *188* | *2483* | *1800* | *2130* | *2485* | *2870* | *3200* |
| 36 | 4 | 2507 | 2253 | 2400 | 2633 | 2933 | 3128 |
| *36* | *202* | *2753* | *2050* | *2360* | *2710* | *3090* | *3390* |
| 37 | 12 | 3171 | 2352 | 2558 | 2760 | 3106 | 3338 |
| *37* | *372* | *2866* | *2260* | *2565* | *2900* | *3230* | *3520* |
| 38 | 11 | 3285 | 2483 | 2800 | 3068 | 3290 | 3655 |
| *38* | *636* | *3025* | *2430* | *2720* | *3030* | *3360* | *3640* |
| 39 | 24 | 3172 | 2593 | 2873 | 3085 | 3331 | 3697 |
| *39* | *1010* | *3130* | *2550* | *2845* | *3140* | *3435* | *3735* |

Table 29—*Continued*

Richmond *Colorado*

| Gestational Age | Patients | Mean Weight | Smoothed Percentiles 10 | 25 | 50 | 75 | 90 |
|---|---|---|---|---|---|---|---|
| 40 | 23 | 3339 | 2652 | 3005 | 3278 | 3525 | 3967 |
| *40* | *1164* | *3226* | *2630* | *2930* | *3230* | *3520* | *3815* |
| 41 | 10 | 3795 | 2900 | 3370 | 3660 | 3900 | 4300 |
| *41* | *632* | *3307* | *2690* | *2990* | *3290* | *3580* | *3870* |

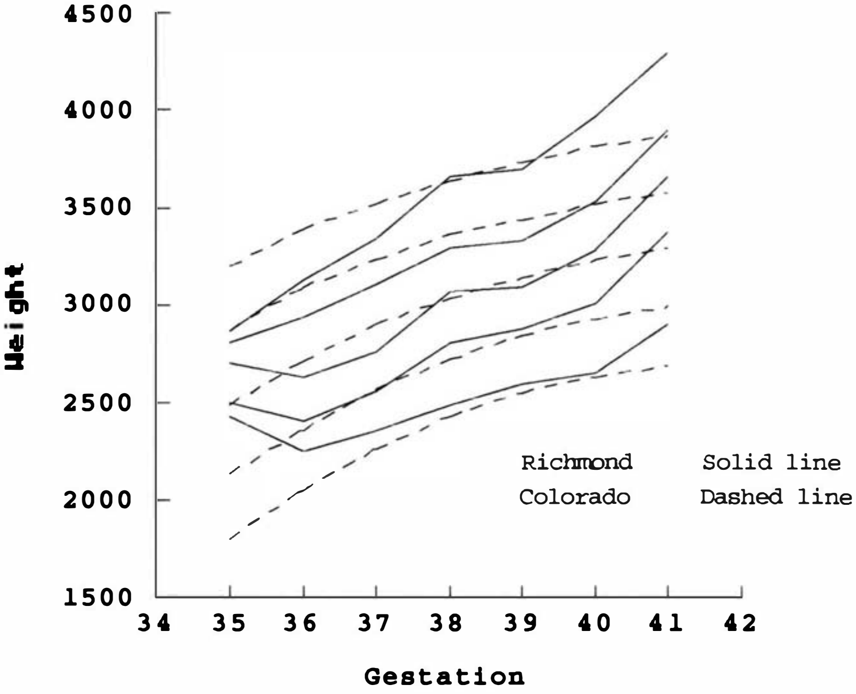



Figure 18. Weight Percentiles for Richmond and Colorado

Since Lubchenco et al (Lubchenco et al, 1963) did not specify their method used to smooth the ends, Tukey's method using straight line extrapolation is used to smooth the ends of the Richmond data (Tukey, 1977). First, a straight line is fit through the two points adjacent to the end point to estimate a new value at the time period on the other side of the end. For example in this data, 35 weeks is one end point. A straight line is fit through the weights at 36 and 37 weeks to estimate the weight at 34 weeks. Second, the end point and values on either side are averaged and this average is used as the new estimate for the end point. The weights at 34, 35, and 36 weeks are averaged and this average becomes the estimate for 35 weeks.

Table 30 lists the smoothed percentiles with the ends smoothed. These percentiles are graphed in figure 19. Smoothing the ends lowered the 41 week weight for all percentiles. For the 35 week weights, smoothing lowered the 10-75th percentiles. The 90th percentile weight increased 33 grams. Table 31 lists the Richmond and Colorado data with the ends now smoothed for the Richmond data. Figure 20 graphs these weights for the Richmond and Colorado data. Differences between the two studies in the 10th and the 90th percentiles are the most important since it is these percentiles that determine infant classification. The 10th and 90th percentiles are graphed in figure 21. The numbers

Table 30 Intrauterine Growth Males and Females

**Ends smoothed**

| Gestational Age | Patients | Mean Weight | Smoothed Percentiles 10 | 25 | 50 | 75 | 90 |
|---|---|---|---|---|---|---|---|
| 35 | 4 | 2758 | 2246 | 2328 | 2571 | 2773 | 2899 |
| 36 | 4 | 2507 | 2253 | 2400 | 2633 | 2933 | 3128 |
| 37 | 12 | 3171 | 2352 | 2558 | 2760 | 3106 | 3338 |
| 38 | 11 | 3285 | 2483 | 2800 | 3068 | 3290 | 3655 |
| 39 | 24 | 3172 | 2593 | 2873 | 3085 | 3331 | 3697 |
| 40 | 23 | 3339 | 2652 | 3005 | 3278 | 3525 | 3967 |
| 41 | 10 | 3795 | 2774 | 3215 | 3534 | 3779 | 4258 |

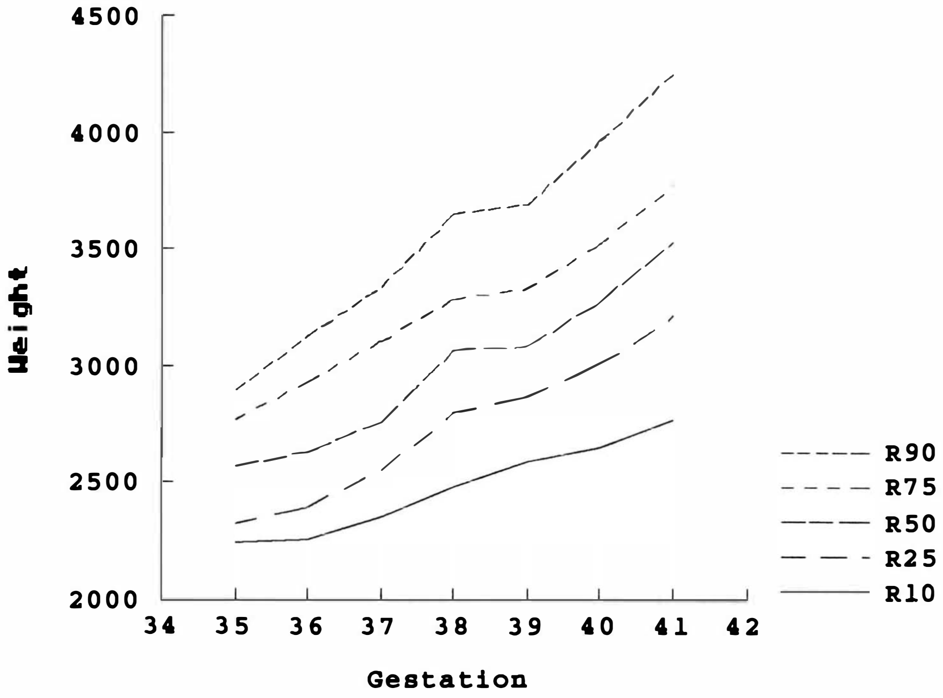



Figure 19. Richmond Percentiles Ends Smoothed

Table 31 Intrauterine Growth Males and Females

Comparison of Richmond and Colorado

**Richmond Ends Smoothed**

Richmond *Colorado*

| Gestational Age | Patients | Mean Weight | 10 | 25 | 50 | 75 | 90 |
|---|---|---|---|---|---|---|---|
| | | | Smoothed Percentiles | | | | |
| 35 | 4 | 2758 | 2246 | 2328 | 2571 | 2773 | 2899 |
| *35* | *188* | *2483* | *1800* | *2130* | *2485* | *2870* | *3200* |
| 36 | 4 | 2507 | 2253 | 2400 | 2633 | 2933 | 3128 |
| *36* | *202* | *2753* | *2050* | *2360* | *2710* | *3090* | *3390* |
| 37 | 12 | 3171 | 2352 | 2558 | 2760 | 3106 | 3338 |
| *37* | *372* | *2866* | *2260* | *2565* | *2900* | *3230* | *3520* |
| 38 | 11 | 3285 | 2483 | 2800 | 3068 | 3290 | 3655 |
| *38* | *636* | *3025* | *2430* | *2720* | *3030* | *3360* | *3640* |
| 39 | 24 | 3172 | 2593 | 2873 | 3085 | 3331 | 3697 |
| *39* | *1010* | *3130* | *2550* | *2845* | *3140* | *3435* | *3735* |

Table 31—*Continued*

Richmond *Colorado*

| Gestational Age | Patients | Mean Weight | Smoothed Percentiles 10 | 25 | 50 | 75 | 90 |
|---|---|---|---|---|---|---|---|
| 40 | 23 | 3339 | 2652 | 3005 | 3278 | 3525 | 3967 |
| *40* | *1164* | *3226* | *2630* | *2930* | *3230* | *3520* | *3815* |
| 41 | 10 | 3795 | 2774 | 3215 | 3534 | 3779 | 4258 |
| *41* | *632* | *3307* | *2690* | *2990* | *3290* | *3580* | *3870* |

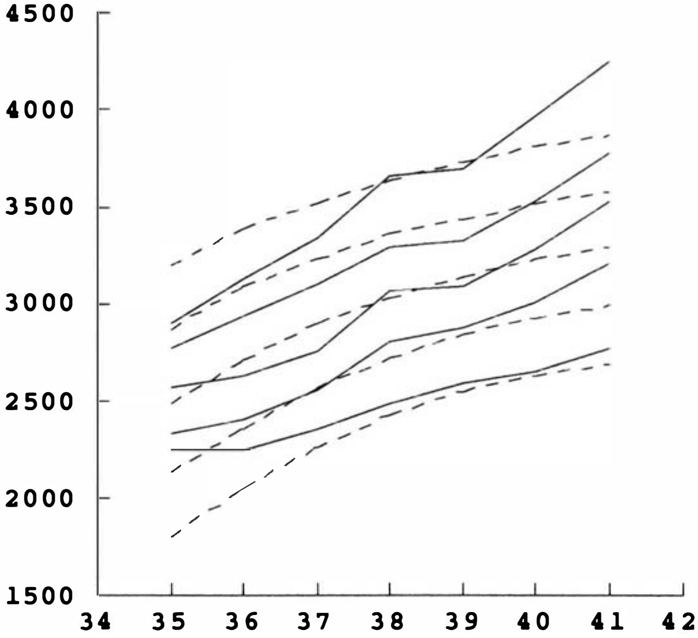



Figure 20. Weight for Richmond and Colorado Ends Smoothed

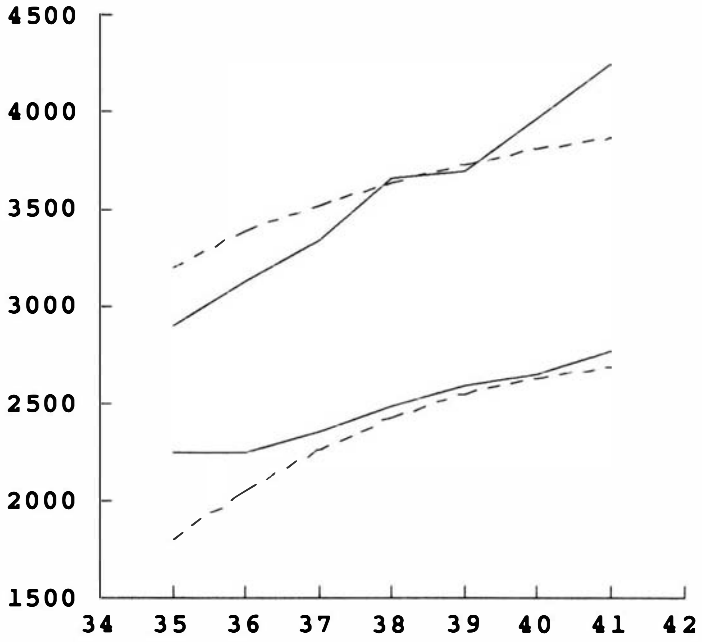



Figure 21. Smoothed 10th and 90th Percentiles for Richmond and Colorado

in table 31 and figure 21 do indicate differences at the 10th and 90th percentiles between the Richmond and Colorado data.

The 10th percentile weights of the Colorado infants are all smaller than the 10th percentile weights for the Richmond infants. The differences between the two groups, decrease from 35 to 40 weeks. This agrees with the pilot study data which had no infants in the SGA group. If the 10th percentile line for Richmond infants is actually higher than the 10th percentile on the weight graph used now, fewer infants will be classified as SGA when the Colorado graph is used.

The differences observed in the 90th percentile are more variable. The Colorado infant weights are heavier for the 35, 36, and 37th weeks. The 90th percentiles for the 38th and 39th weeks are only different by 15 and 38 grams respectively. At the 90th percentile for the 40 and 41 week groups, the Richmond infants are heavier. Again this agrees with the pilot study data. The LGA infants were 40 or 41 weeks gestation. If the 90th percentile for these two weeks is actually higher than on the current graph, more Richmond infants will be identified as LGA when the Colorado graph is used.

Table 32 shows the classification of the infants using the Colorado graphs.

Table 32 Weight Classifications Using Colorado Graphs

| WEEKS | 35 | 36 | 37 | 38 | 39 | 40 | 41 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| SGA | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 4 |
| LGA | 0 | 0 | 1 | 3 | 4 | 5 | 1 | 14 |

Four of the infants are classified as SGA and 14 of the infants are classified as LGA. Table 33 shows the classifications when the graphs generated from the Richmond data are used.

Table 33 Weight Classifications Using Richmond Graphs

| WEEKS | 35 | 36 | 37 | 38 | 39 | 40 | 41 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| SGA | 0 | 2 | 0 | 0 | 2 | 3 | 1 | 8 |
| LGA | 0 | 0 | 1 | 2 | 4 | 3 | 1 | 11 |

In this case eight of the infants are classified as SGA and eleven as LGA. Two of these SGA and LGA classifications are in the 35 and 36 week group. There are four patients used to generate the graph in this area. It is questionable if the observed difference in classification is the result of a small sample size or a true difference. Use of the Richmond graph resulted in more infants being classified as SGA and fewer classified as LGA when compared to classification using the Colorado graphs.

The graphs and tables comparing the Richmond and Colorado data show differences at the 10th and 90th percentiles. The

10th percentile for the Richmond data is actually higher than the 10th percentile for the Colorado data. This results in fewer infants being identified as SGA when the Colorado graphs are used. The Colorado graph is lower at 40 and at 41 weeks than the Richmond graph. This results in more Richmond infants being identified as LGA in the 40 week groups.

Two Standard Deviations from the Mean

Weight graphs have been developed using two standard deviations from the mean as the upper and lower limits for AGA infants. It is unclear whether graphs using this method are better at identifying high risk infants (Avery, 1987). The purpose of this section is to develop graphs using two standard deviations from the mean and compare these graphs to the ones used now and the ones produced from the Richmond data.

Table 34 shows the mean weights and standard deviations for each gestational age. The lower weight limits for an AGA infant for each gestational age were calculated by subtracting twice the standard deviation from the mean. The upper weight limits for an AGA infant were calculated by adding twice the standard deviation from the mean. These limits are graphed in figure 22. These limits were then smoothed using three point arithmetic means (Tukey, 1977) and the ends smoothed as previously described. The lower

Table 34 Weight and Standard Deviations

| Gestation | Mean Weight | Standard Deviation (SD) | Mean - 2 SD | Mean + 2 SD | Smoothed Lower | Smoothed Upper |
|---|---|---|---|---|---|---|
| 35.0 | 2758.0 | 182.8 | 2392.4 | 3123.6 | 2159.2 | 3194.5 |
| 36.0 | 2507.5 | 445.5 | 1616.5 | 3398.5 | 2078.8 | 3545.4 |
| 37.0 | 3170.8 | 471.7 | 2227.4 | 4114.2 | 2115.0 | 3860.9 |
| 38.0 | 3285.5 | 392.2 | 2501.1 | 4069.9 | 2270.9 | 4147.9 |
| 39.0 | 3171.9 | 543.9 | 2084.1 | 4259.7 | 2336.7 | 4194.0 |
| 40.0 | 3338.7 | 456.9 | 2424.9 | 4252.5 | 2475.8 | 4394.6 |
| 41.0 | 3795.0 | 438.3 | 2918.4 | 4671.6 | 2716.1 | 4621.0 |

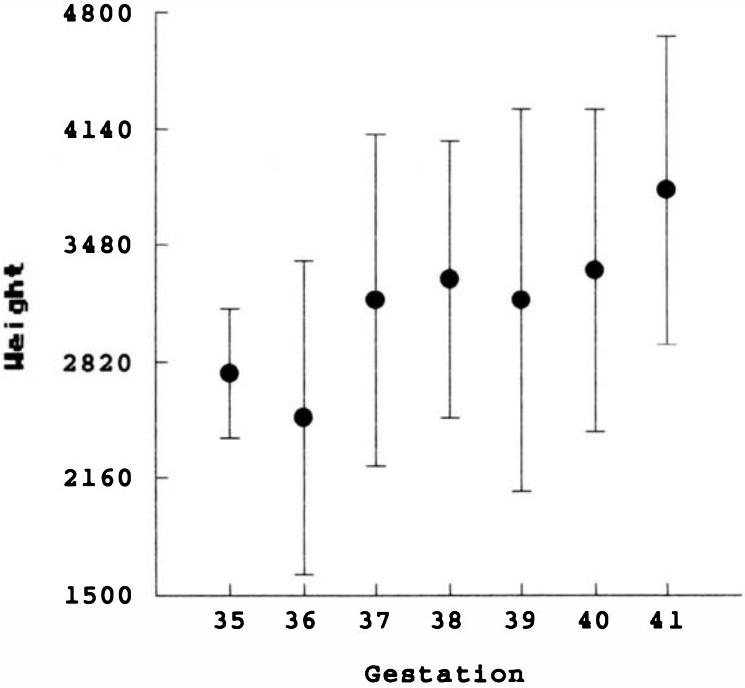



Figure 22. Weight +- Two Standard Deviations

and upper limits and the smoothed values are shown in table 34. These smoothed limits are graphed in figure 23.

Figure 24 illustrates the smoothed mean plus or minus two standard deviations and the Colorado data. The smoothed mean minus two standard deviations for Richmond falls below the 10th percentiles for Colorado between 37 and 40 weeks. The smoothed mean plus two standard deviations is higher than the 90th percentile for the Colorado data from 35 to 41 weeks.

Figure 25 shows both the smoothed percentiles and the mean plus or minus two standard deviations for the Richmond data. The mean plus two standard deviations is higher than the 90th percentile for all weeks. The mean minus two standard deviations is lower than the 10th percentile for all weeks.

Each infant was then classified as SGA, AGA, or LGA using these graphs. Table 35 shows the number and classification of infants by gestational age.

Table 35 Classification Using Standard Deviations

| Weeks | 35 | 36 | 37 | 38 | 39 | 40 | 41 | Total |
|---|---|---|---|---|---|---|---|---|
| SGA | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 3 |
| LGA | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 3 |

This method identifies fewer infants as SGA or LGA. The greatest difference is in identification of LGA infants.

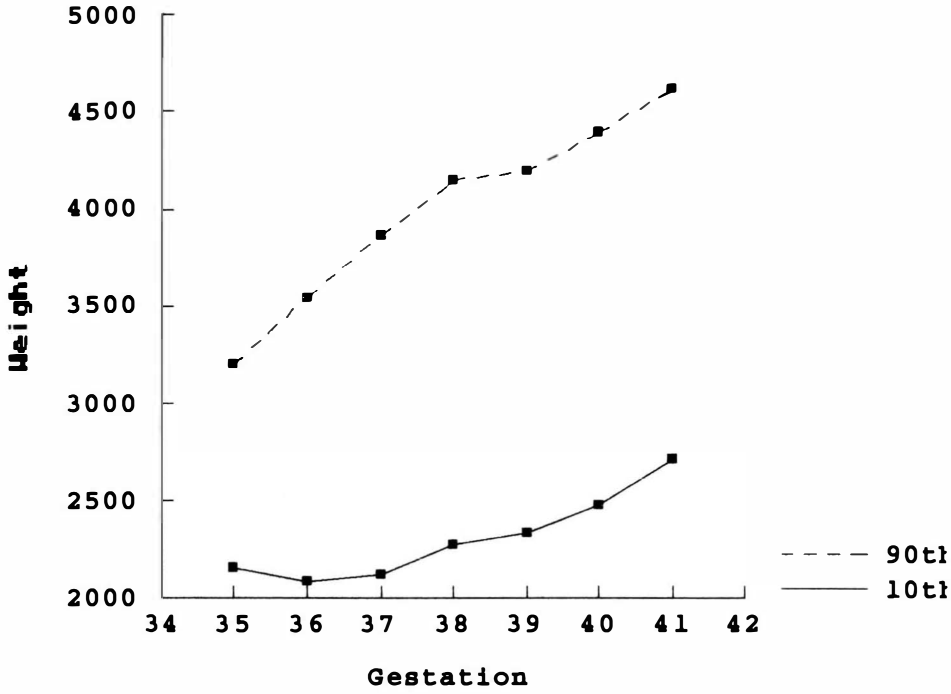



Figure 23. Weight +- 2 Standard Deviations from the Mean

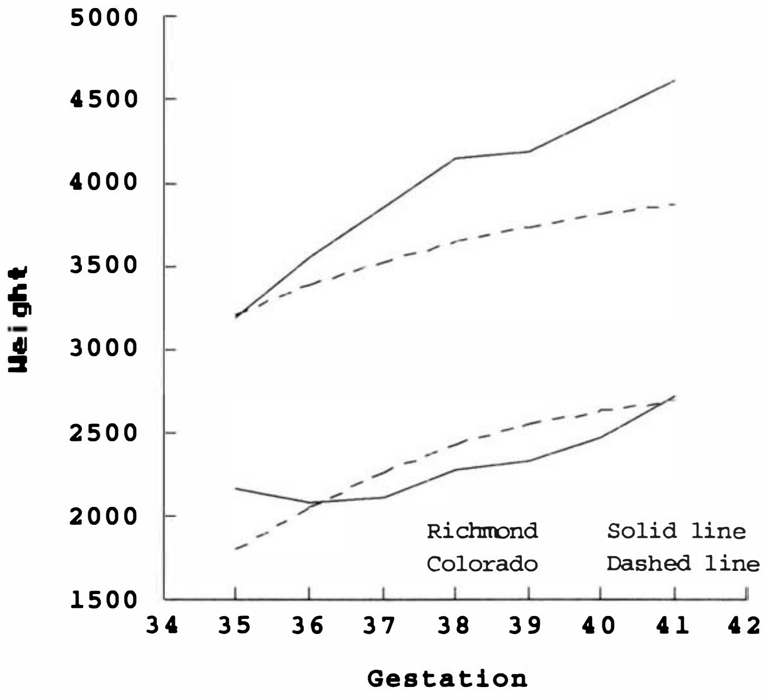



Figure 24. Mean +- 2 Standard Deviations Richmond and Colorado 10th and 90th Percentiles

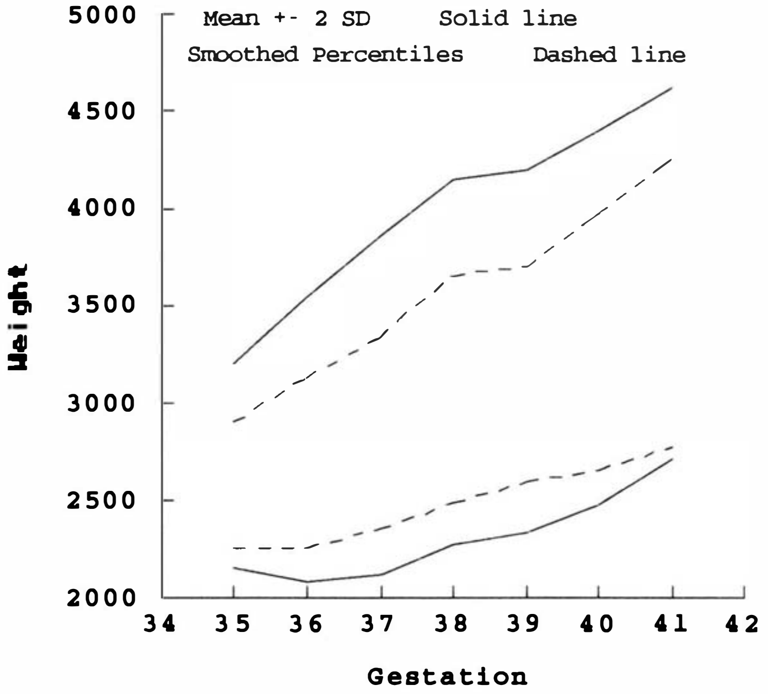



Figure 25. Mean +- 2 Standard Deviations for Richmond Plotted Against Smoothed Richmond Percentiles

Only three infants are identified as LGA compared to 11 and 14 when the Richmond and Colorado graphs are used.

The graphs using the mean plus or minus two standard deviations are more liberal than either the Richmond or Colorado graphs. Fewer infants are identified as at risk.

Some of the differences among these graphs can be understood by examination of figure 26 showing the scatter plot of the weights. The distribution of the weight at 38, 39 and 40 weeks is skewed to the right. This skewness is shifting the mean up. In these cases the mean is larger than the median. Since the mean plus or minus two standard deviations is using the mean as the center, the upper boundary of AGA is shifted up when compared to the Richmond smoothed percentiles and the Colorado graphs. As a result fewer infants are identified as LGA when the graph of two standard deviations from the mean are used.

Length

The length of the infants ranged from 43 centimeters to 55 centimeters with a mean length of 49.9 centimeters. As with the weight data, six of the gestational ages were missing so measurements from 92 of the infants were used to develop a length graph.

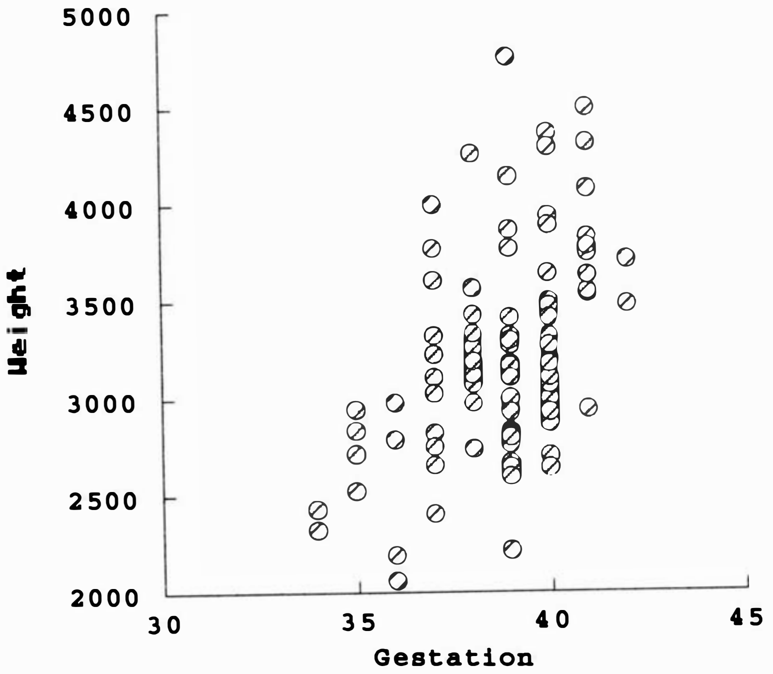



Figure 26. Weight and Gestational Age

The lengths are plotted against gestational age in figure 27. Length increases as gestational age increases. The points appear clustered together except for two points at 36 weeks gestation. At 36 weeks gestation, two infants had lengths shorter than 45 centimeters.

The original length and head circumference graphs by Lubchenco were published three years after the weight graphs. The method given by Lubchenco in the 1966 article was used to develop the length and head circumference graphs from the Richmond measurements (Lubchenco et al, 1966).

The methods used in the original study and the current study to obtain the length measurements are similar. Length measurements were obtained in the original study by either suspending the infant by his ankles or placing the head of the infant at the end of the bassinet and extending one leg (Lubchenco et al, 1966). For the current data, infants were measured by placing the head at the end of the bassinet and extending one leg.

The percentile charts for length were made using the same method as weight. The infants were grouped by gestational age and length, percentiles calculated, and the percentiles then smoothed (Lubchenco et al, 1966). There is no specific mention of length grouping.

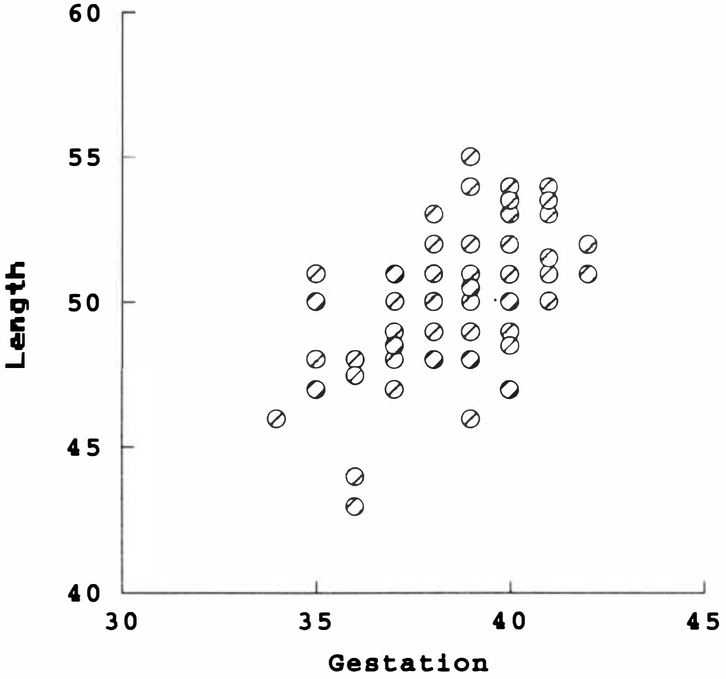



Figure 27. Length and Gestational Age

Table 36 lists the cumulative frequency tables for length for the Richmond data. Since the number of unique lengths is much smaller than the number of unique weights, the lengths were not grouped. Figures 28-34 show the ogives for these data and the calculated percentiles are listed at the bottom of the ogives. The ogives were constructed and the percentiles calculated as explained in section 4.1.1.

Figure 35 is the graph of the unsmoothed percentiles. The length at 36 weeks gestation is shorter than the length at 35 and 37 week gestations. Length should be increasing. There are only four infants in the 35 and 36 week groups. The percentiles may not be accurate for one or both of these groups since the sample size is so small.

The length percentiles for the original data were twice smoothed using three point means (Lubchenco et al, 1966). The method used to smooth the ends is not explained. Tukey's method of straight line extrapolation is used to smooth the ends of the current length data (Tukey, 1977). Figures 36 and 37 show the 10th and the 90th percentiles for the current data after one and two smoothings respectively. Table 37 lists the percentiles after the second smoothing. These two smoothings have increased the percentiles at 36 weeks gestation and lowered the percentiles at 37 weeks gestation.

Table 36

Cumulative Frequencies for Length

THE FOLLOWING RESULTS ARE FOR:
GEST = 34.000

| COUNT | CUM COUNT | PCT | CUM PCT | LENGTH |
|---|---|---|---|---|
| 2 | 2 | 100.0 | 100.0 | 46.000 |

THE FOLLOWING RESULTS ARE FOR:
GEST = 35.000

| COUNT | CUM COUNT | PCT | CUM PCT | LENGTH |
|---|---|---|---|---|
| 1 | 1 | 25.0 | 25.0 | 47.000 |
| 1 | 2 | 25.0 | 50.0 | 48.000 |
| 1 | 3 | 25.0 | 75.0 | 50.000 |
| 1 | 4 | 25.0 | 100.0 | 51.000 |

THE FOLLOWING RESULTS ARE FOR:
GEST = 36.000

| COUNT | CUM COUNT | PCT | CUM PCT | LENGTH |
|---|---|---|---|---|
| 1 | 1 | 25.0 | 25.0 | 43.000 |
| 1 | 2 | 25.0 | 50.0 | 44.000 |
| 1 | 3 | 25.0 | 75.0 | 47.500 |
| 1 | 4 | 25.0 | 100.0 | 48.000 |

THE FOLLOWING RESULTS ARE FOR:
GEST = 37.000

| COUNT | CUM COUNT | PCT | CUM PCT | LENGTH |
|---|---|---|---|---|
| 2 | 2 | 16.7 | 16.7 | 47.000 |
| 1 | 3 | 8.3 | 25.0 | 48.000 |
| 1 | 4 | 8.3 | 33.3 | 48.500 |
| 1 | 5 | 8.3 | 41.7 | 49.000 |
| 4 | 9 | 33.3 | 75.0 | 50.000 |
| 3 | 12 | 25.0 | 100.0 | 51.000 |

Table 36—*Continued*

THE FOLLOWING RESULTS ARE FOR:
GEST = 38.000

| COUNT | CUM COUNT | PCT | CUM PCT | LENGTH |
|---|---|---|---|---|
| 2 | 2 | 18.2 | 18.2 | 48.000 |
| 3 | 5 | 27.3 | 45.5 | 49.000 |
| 1 | 6 | 9.1 | 54.5 | 50.000 |
| 2 | 8 | 18.2 | 72.7 | 51.000 |
| 2 | 10 | 18.2 | 90.9 | 52.000 |
| 1 | 11 | 9.1 | 100.0 | 53.000 |

THE FOLLOWING RESULTS ARE FOR:
GEST = 39.000

| COUNT | CUM COUNT | PCT | CUM PCT | LENGTH |
|---|---|---|---|---|
| 1 | 1 | 4.2 | 4.2 | 46.000 |
| 7 | 8 | 29.2 | 33.3 | 48.000 |
| 4 | 12 | 16.7 | 50.0 | 49.000 |
| 3 | 15 | 12.5 | 62.5 | 50.000 |
| 1 | 16 | 4.2 | 66.7 | 50.500 |
| 4 | 20 | 16.7 | 83.3 | 51.000 |
| 1 | 21 | 4.2 | 87.5 | 52.000 |
| 2 | 23 | 8.3 | 95.8 | 54.000 |
| 1 | 24 | 4.2 | 100.0 | 55.000 |

THE FOLLOWING RESULTS ARE FOR:
GEST = 40.000

| COUNT | CUM COUNT | PCT | CUM PCT | LENGTH |
|---|---|---|---|---|
| 1 | 1 | 4.3 | 4.3 | 47.000 |
| 2 | 3 | 8.7 | 13.0 | 48.500 |
| 6 | 9 | 26.1 | 39.1 | 49.000 |
| 4 | 13 | 17.4 | 56.5 | 50.000 |
| 3 | 16 | 13.0 | 69.6 | 51.000 |
| 2 | 18 | 8.7 | 78.3 | 52.000 |
| 2 | 20 | 8.7 | 87.0 | 53.000 |
| 1 | 21 | 4.3 | 91.3 | 53.500 |
| 2 | 23 | 8.7 | 100.0 | 54.000 |

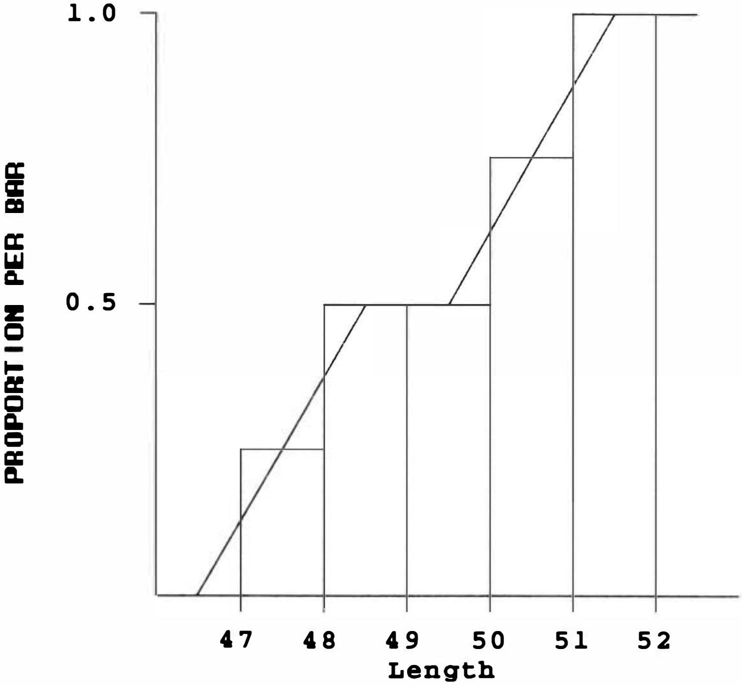
Table 36—*Continued*

THE FOLLOWING RESULTS ARE FOR:
GEST = 41.000

| COUNT | CUM COUNT | PCT | CUM PCT | LENGTH |
|---|---|---|---|---|
| 1 | 1 | 10.0 | 10.0 | 50.000 |
| 2 | 3 | 20.0 | 30.0 | 51.000 |
| 1 | 4 | 10.0 | 40.0 | 51.500 |
| 1 | 5 | 10.0 | 50.0 | 53.000 |
| 3 | 8 | 30.0 | 80.0 | 53.500 |
| 2 | 10 | 20.0 | 100.0 | 54.000 |

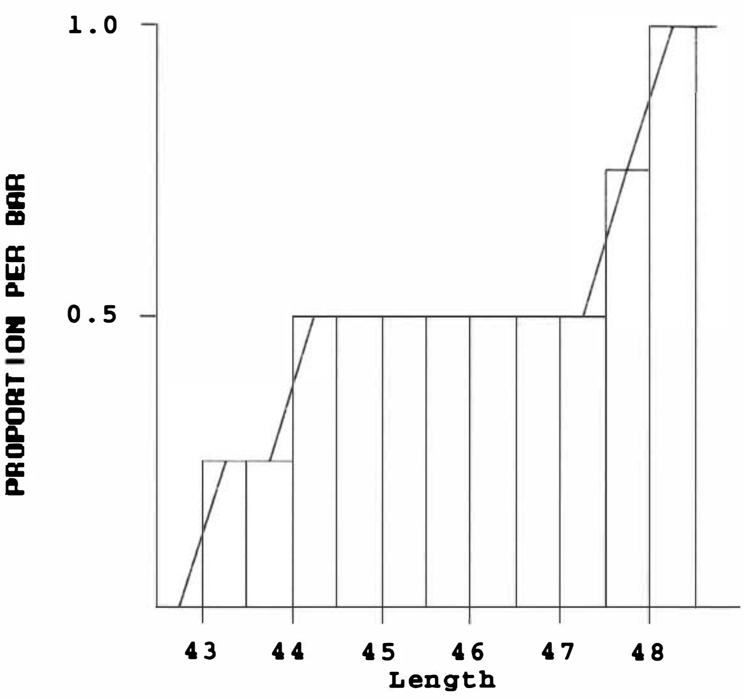
THE FOLLOWING RESULTS ARE FOR:
GEST = 42.000

| COUNT | CUM COUNT | PCT | CUM PCT | LENGTH |
|---|---|---|---|---|
| 1 | 1 | 50.0 | 50.0 | 51.000 |
| 1 | 2 | 50.0 | 100.0 | 52.000 |



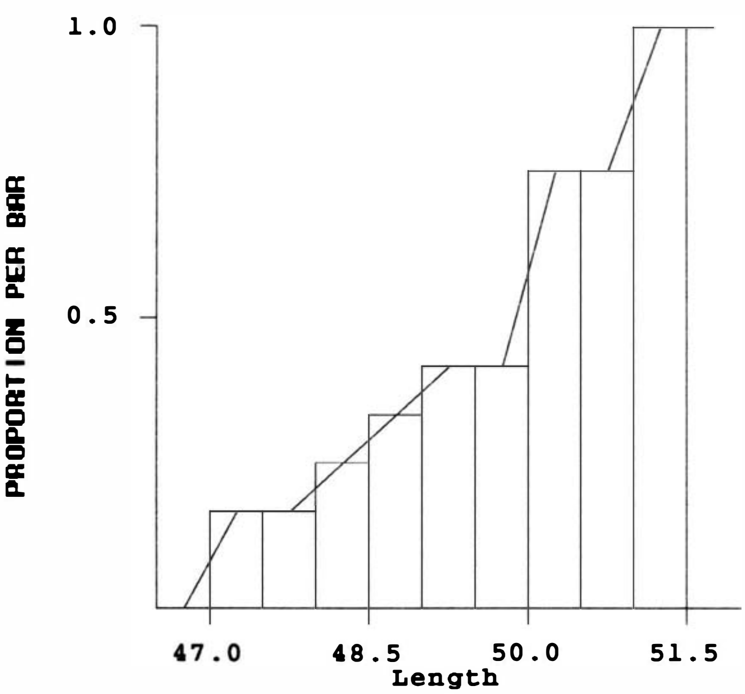

| Percentile | Length |
|---|---|
| 90th | 50.6 |
| 75th | 50.0 |
| 50th | 48.0 |
| 25th | 47.0 |
| 10th | 46.4 |

Figure 28. Length at 35 Weeks



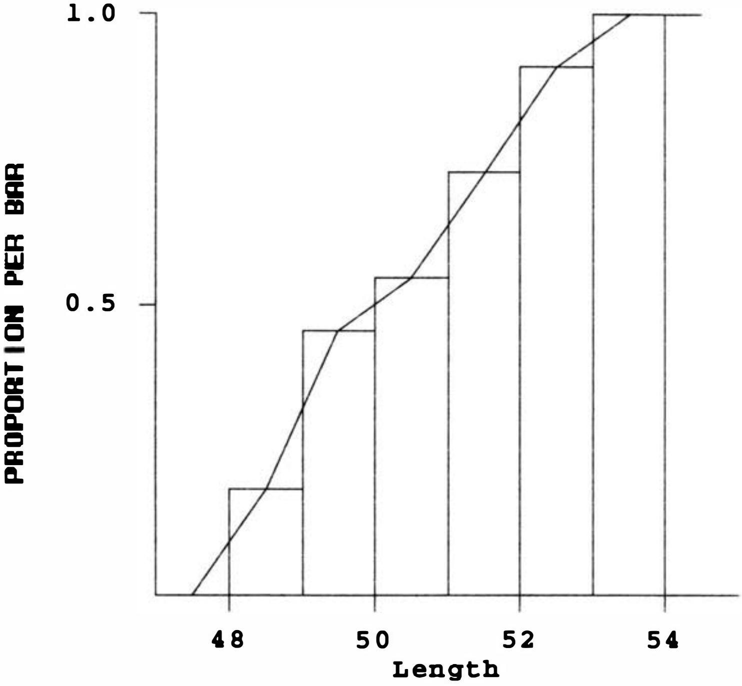

| Percentile | Length |
|---|---|
| 90th | 47.8 |
| 75th | 47.5 |
| 50th | 44.0 |
| 25th | 43.0 |
| 10th | 42.7 |

Figure 29. Length at 36 Weeks



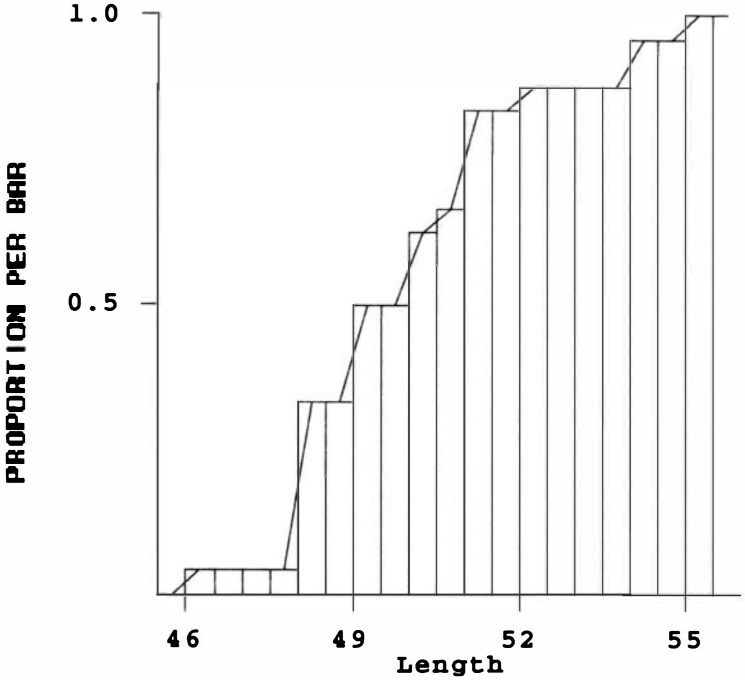

| Percentile | Length |
|---|---|
| 90th | 50.60 |
| 75th | 50.00 |
| 50th | 49.25 |
| 25th | 48.00 |
| 10th | 46.80 |

Figure 30. Length at 37 Weeks



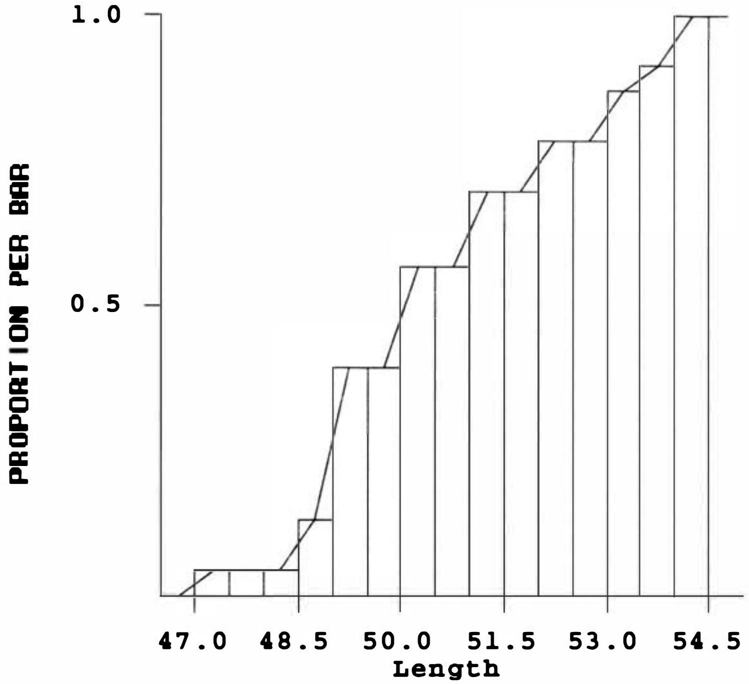

| Percentile | Length |
|---|---|
| 90th | 51.90 |
| 75th | 51.10 |
| 50th | 49.50 |
| 25th | 48.25 |
| 10th | 47.60 |

Figure 31. Length at 38 Weeks



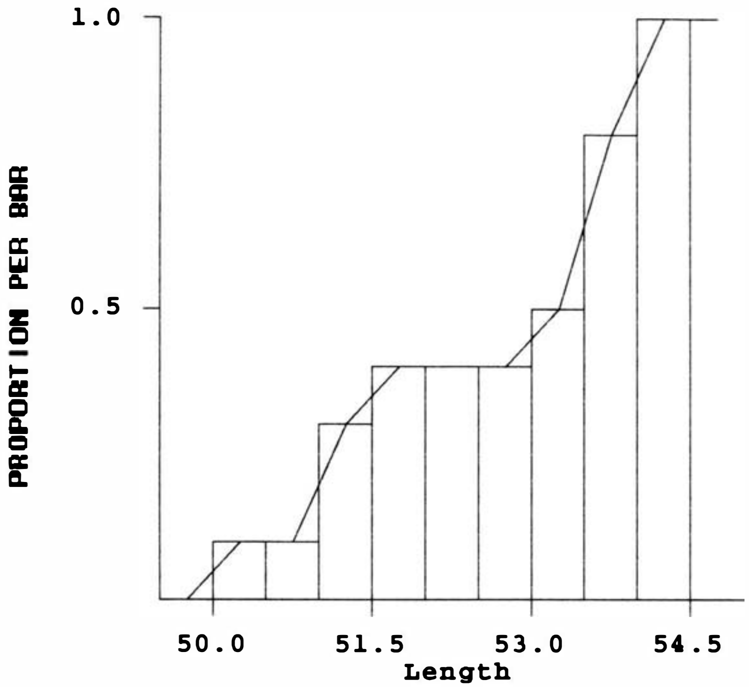

| Percentile | Length |
|---|---|
| 90th | 52.60 |
| 75th | 50.75 |
| 50th | 49.00 |
| 25th | 47.50 |
| 10th | 46.40 |

Figure 32. Length at 39 Weeks




| Percentile | Length |
|---|---|
| 90th | 53.25 |
| 75th | 51.50 |
| 50th | 49.80 |
| 25th | 48.75 |
| 10th | 48.0 |

Figure 33. Length at 40 Weeks




| Percentile | Length |
|---|---|
| 90th | 53.75 |
| 75th | 53.40 |
| 50th | 53.00 |
| 25th | 50.75 |
| 10th | 50.00 |

Figure 34. Length at 41 Weeks

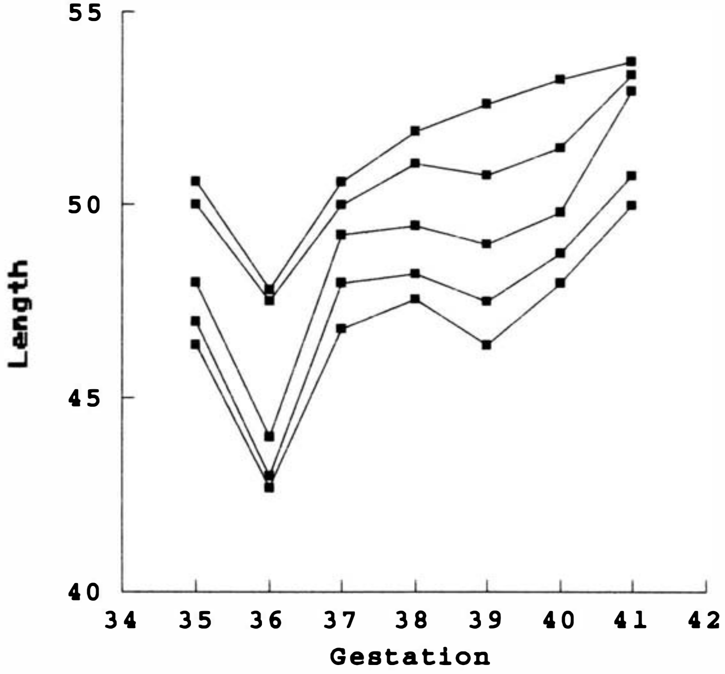



Figure 35. Length Unsmoothed Percentiles

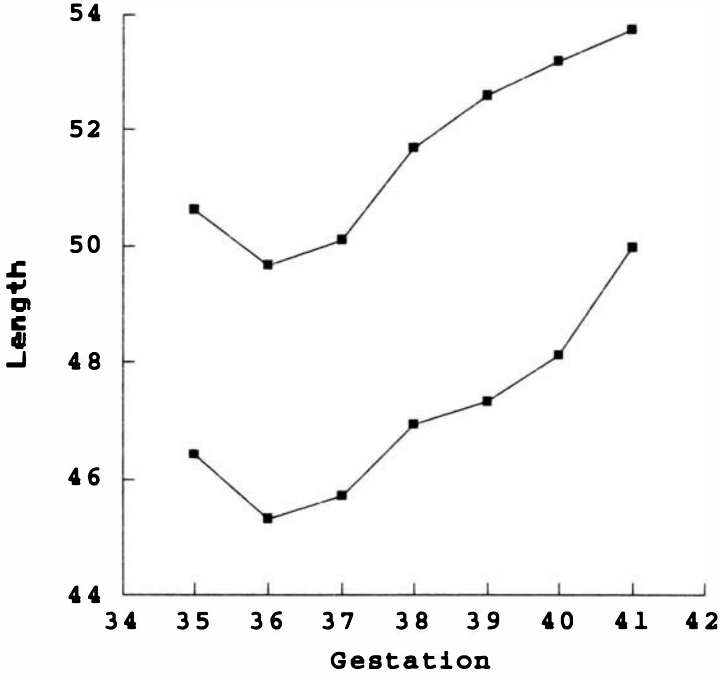



Figure 36. Length 10th and 90th Percentiles After One Smoothing

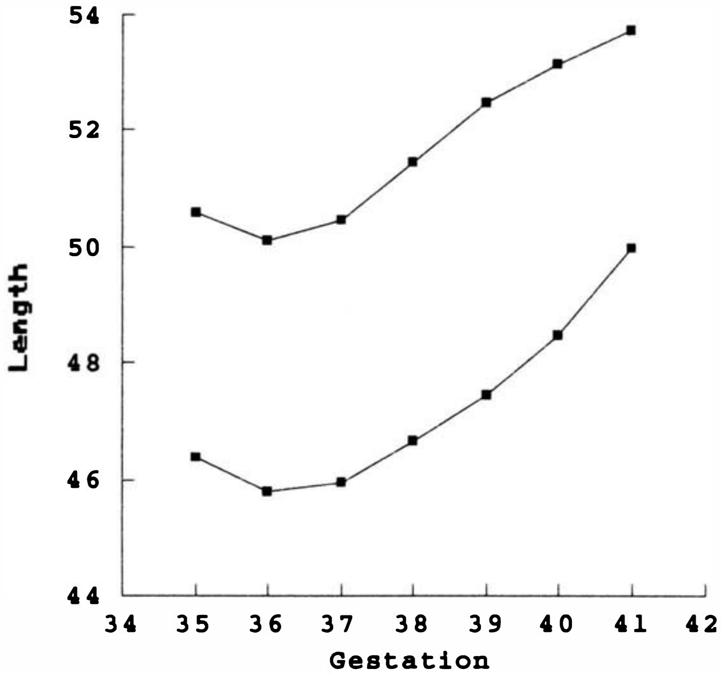



Figure 37. Length 10th and 90th Percentiles Ends Smoothed

Table 37

Length Smoothed

**Ends unsmoothed**

| Gestational Age | Patients | Mean Length | Smoothed Percentiles | |
|---|---|---|---|---|
| | | | 10 | 90 |
| 35 | 4 | 49.0 | 46.40 | 50.60 |
| 36 | 4 | 45.6 | 45.80 | 50.12 |
| 37 | 12 | 49.4 | 45.98 | 50.49 |
| 38 | 11 | 50.2 | 46.66 | 51.46 |
| 39 | 24 | 49.9 | 47.47 | 52.49 |
| 40 | 23 | 50.5 | 48.49 | 53.18 |
| 41 | 10 | 52.5 | 50.00 | 53.75 |

Table 38 lists the percentiles after the ends are smoothed and figure 38 is a graph of these smoothed percentiles with the ends smoothed. Smoothing the ends decreased the 10th and 90th percentiles at both 35 and 41 weeks gestation.

In figure 39 smoothed Richmond lengths are graphed against the Colorado lengths. Table 39 lists both the Richmond and Colorado smoothed percentiles. The distance between the 10th and 90th percentile is shorter for the Richmond data. The 10th percentile for the Richmond data is larger for all gestational ages. The 90th percentile for the Richmond data is larger than the 90th percentile for the Colorado data for infants from 39 to 41 weeks gestation. The 90th percentile for the Richmond data is smaller than the 90th percentile for the Colorado data for infants from 35 to 38 weeks gestation.

Table 40 shows the classification of infants length measurements using the Colorado graph.

Table 40 Length and the Colorado Graphs

| Weeks | 35 | 36 | 37 | 38 | 39 | 40 | 41 | Total |
|---|---|---|---|---|---|---|---|---|
| SGA | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 2 |
| LGA | 0 | 0 | 0 | 2 | 1 | 6 | 4 | 13 |

Table 38

Length Smoothed

**Ends smoothed**

| Gestational Age | Patients | Mean Length | Smoothed Percentiles | |
|---|---|---|---|---|
| | | | 10 | 90 |
| 35 | 4 | 49.0 | 46.06 | 50.03 |
| 36 | 4 | 45.6 | 45.80 | 50.12 |
| 37 | 12 | 49.4 | 45.98 | 50.49 |
| 38 | 11 | 50.2 | 46.66 | 51.46 |
| 39 | 24 | 49.9 | 47.47 | 52.49 |
| 40 | 23 | 50.5 | 48.49 | 53.18 |
| 41 | 10 | 52.5 | 49.67 | 53.60 |

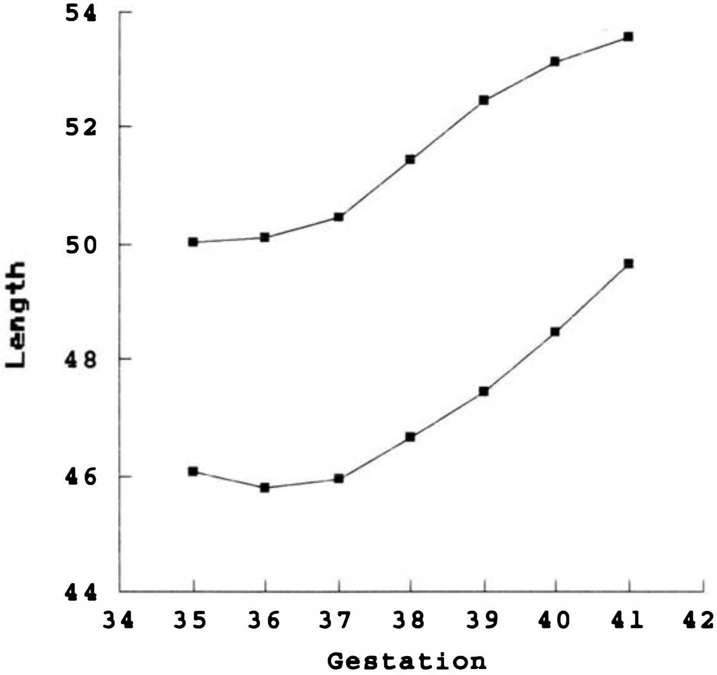



Figure 38. Length 10th and 90th Percentiles Ends Smoothed

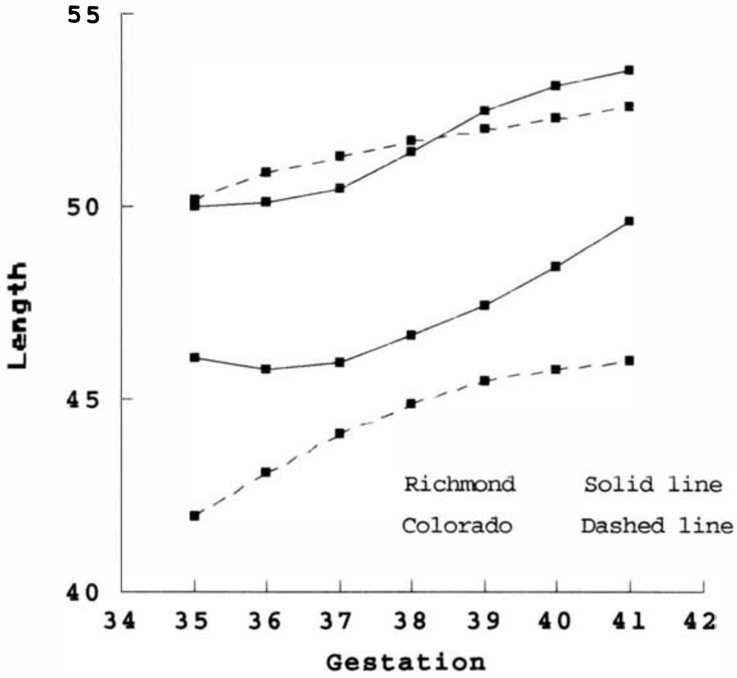



Figure 39. Length Richmond and Colorado
10th and 90th Percentiles

Table 39

Length for Richmond and Colorado

Smoothed Percentiles
Richmond *Colorado*

| Gestational Age | Patients | Mean Length | Smoothed Percentiles 10 | 90 |
|---|---|---|---|---|
| 35 | 4 | 49.0 | 46.06 | 50.03 |
| | | *46.8* | *42.0* | *50.2* |
| 36 | 4 | 45.6 | 45.80 | 50.12 |
| | | *47.5* | *43.1* | *50.9* |
| 37 | 12 | 49.4 | 45.98 | 50.49 |
| | | *47.8* | *44.1* | *51.3* |
| 38 | 11 | 50.2 | 46.66 | 51.46 |
| | | *48.5* | *44.9* | *51.7* |
| 39 | 24 | 49.9 | 47.47 | 52.49 |
| | | *48.9* | *45.5* | *52.0* |
| 40 | 23 | 50.5 | 48.49 | 53.18 |
| | | *49.4* | *45.8* | *52.3* |
| 41 | 10 | 52.5 | 49.67 | 53.60 |
| | | *49.6* | *46.0* | *52.6* |

Two infants are identified as SGA with respect to length. All of the infants identified as LGA with respect to length are between 38 and 41 weeks gestation.

Table 41 shows the length classification of the infants using the Richmond graphs.

Table 41 Length and the Richmond Graphs

| Weeks | 35 | 36 | 37 | 38 | 39 | 40 | 41 | Total |
|---|---|---|---|---|---|---|---|---|
| SGA | 2 | 2 | 0 | 0 | 2 | 6 | 3 | 15 |
| LGA | 0 | 0 | 1 | 2 | 1 | 4 | 2 | 10 |

Using the Richmond graphs, 13 more infants are identified as SGA than when the Colorado graphs are used. Three of these infants are at 35 and 36 weeks gestation where the percentiles are suspect because of small sample size. The remaining infants classified as SGA using the Richmond graph are between 39 and 41 weeks gestation. Classification using the Richmond graphs results in 3 fewer infants being identified as LGA. For both methods, the LGA infants are between 37 and 41 weeks gestation.

Head Circumference

The head circumference measurements ranged from 29.5 centimeters to 37 centimeters with a mean of 34.1 centimeters. The head circumferences by gestational age are plotted in figure 40. As expected the head circumference

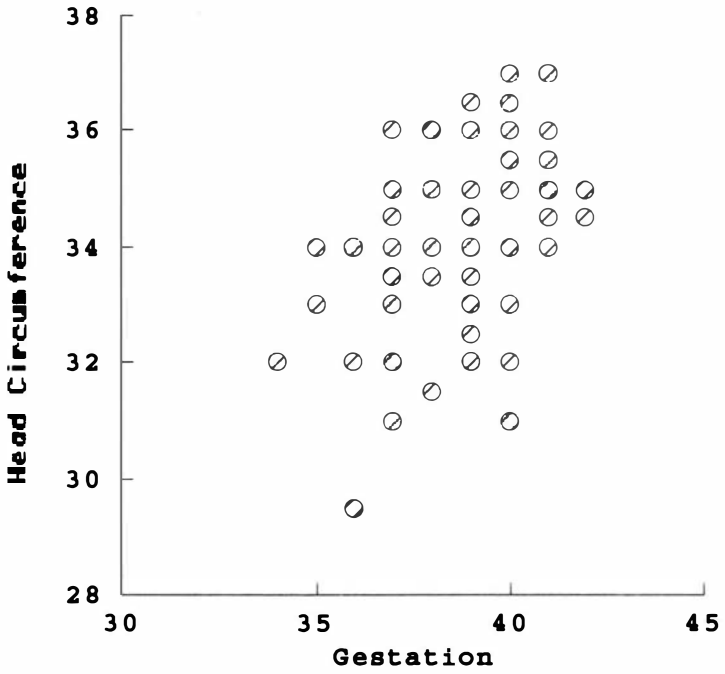



Figure 40. Head Circumference and Gestational Age

seems to increase as the gestational age increases. The points appear clustered together except for one value at 36 weeks gestation. That measurement is below 30 centimeters and is smaller than the other head circumference measurements.

The method of head circumference measurement is the same for both the Lubchenco study and the current data. The head circumference is measured with a disposable tape at the largest occipital frontal circumference (Lubchenco et al, 1966).

The method used to develop the head circumference graph using the current data is the same method as described in section 4.3 for the development of the length graph. Like the length measurements, the head circumference measurements are not grouped.

Table 42 lists the cumulative frequency tables for head circumference by gestational age. Figures 41-47 show the ogives for the cumulative frequency tables. The calculated percentiles are listed at the bottom of each ogive. Table 43 lists the precentiles prior to any smoothing and the percentiles are graphed in figure 48. As seen from the graph, the percentiles for 36 weeks gestation are smaller than the percentiles for 35 and 37 weeks gestation. This is the result of the one head circumference measurement below 30

Table 42

Cumulative Frequencies for Head Circumference

THE FOLLOWING RESULTS ARE FOR:
G = 34.000

| COUNT | CUM COUNT | PCT | CUM PCT | HEAD |
|---|---|---|---|---|
| 2 | 2 | 100.0 | 100.0 | 32.000 |

THE FOLLOWING RESULTS ARE FOR:
G = 35.000

| COUNT | CUM COUNT | PCT | CUM PCT | HEAD |
|---|---|---|---|---|
| 3 | 3 | 75.0 | 75.0 | 33.000 |
| 1 | 4 | 25.0 | 100.0 | 34.000 |

THE FOLLOWING RESULTS ARE FOR:
G = 36.000

| COUNT | CUM COUNT | PCT | CUM PCT | HEAD |
|---|---|---|---|---|
| 1 | 1 | 25.0 | 25.0 | 29.500 |
| 2 | 3 | 50.0 | 75.0 | 32.000 |
| 1 | 4 | 25.0 | 100.0 | 34.000 |

THE FOLLOWING RESULTS ARE FOR:
G = 37.000

| COUNT | CUM COUNT | PCT | CUM PCT | HEAD |
|---|---|---|---|---|
| 1 | 1 | 8.3 | 8.3 | 31.000 |
| 1 | 2 | 8.3 | 16.7 | 32.000 |
| 2 | 4 | 16.7 | 33.3 | 33.000 |
| 2 | 6 | 16.7 | 50.0 | 33.500 |
| 3 | 9 | 25.0 | 75.0 | 34.000 |
| 1 | 10 | 8.3 | 83.3 | 34.500 |
| 1 | 11 | 8.3 | 91.7 | 35.000 |
| 1 | 12 | 8.3 | 100.0 | 36.000 |

Table 42—*Continued*

THE FOLLOWING RESULTS ARE FOR:
G = 38.000

| COUNT | CUM COUNT | PCT | CUM PCT | HEAD |
|---|---|---|---|---|
| 1 | 1 | 9.1 | 9.1 | 31.500 |
| 1 | 2 | 9.1 | 18.2 | 33.500 |
| 2 | 4 | 18.2 | 36.4 | 34.000 |
| 5 | 9 | 45.5 | 81.8 | 35.000 |
| 2 | 11 | 18.2 | 100.0 | 36.000 |

THE FOLLOWING RESULTS ARE FOR:
G = 39.000

| COUNT | CUM COUNT | PCT | CUM PCT | HEAD |
|---|---|---|---|---|
| 3 | 3 | 12.5 | 12.5 | 32.000 |
| 1 | 4 | 4.2 | 16.7 | 32.500 |
| 3 | 7 | 12.5 | 29.2 | 33.000 |
| 1 | 8 | 4.2 | 33.3 | 33.500 |
| 4 | 12 | 16.7 | 50.0 | 34.000 |
| 3 | 15 | 12.5 | 62.5 | 34.500 |
| 6 | 21 | 25.0 | 87.5 | 35.000 |
| 2 | 23 | 8.3 | 95.8 | 36.000 |
| 1 | 24 | 4.2 | 100.0 | 36.500 |

THE FOLLOWING RESULTS ARE FOR:
G = 40.000

| COUNT | CUM COUNT | PCT | CUM PCT | HEAD |
|---|---|---|---|---|
| 1 | 1 | 4.3 | 4.3 | 31.000 |
| 1 | 2 | 4.3 | 8.7 | 32.000 |
| 4 | 6 | 17.4 | 26.1 | 33.000 |
| 3 | 9 | 13.0 | 39.1 | 34.000 |
| 7 | 16 | 30.4 | 69.6 | 35.000 |
| 1 | 17 | 4.3 | 73.9 | 35.500 |
| 4 | 21 | 17.4 | 91.3 | 36.000 |
| 1 | 22 | 4.3 | 95.7 | 36.500 |
| 1 | 23 | 4.3 | 100.0 | 37.000 |

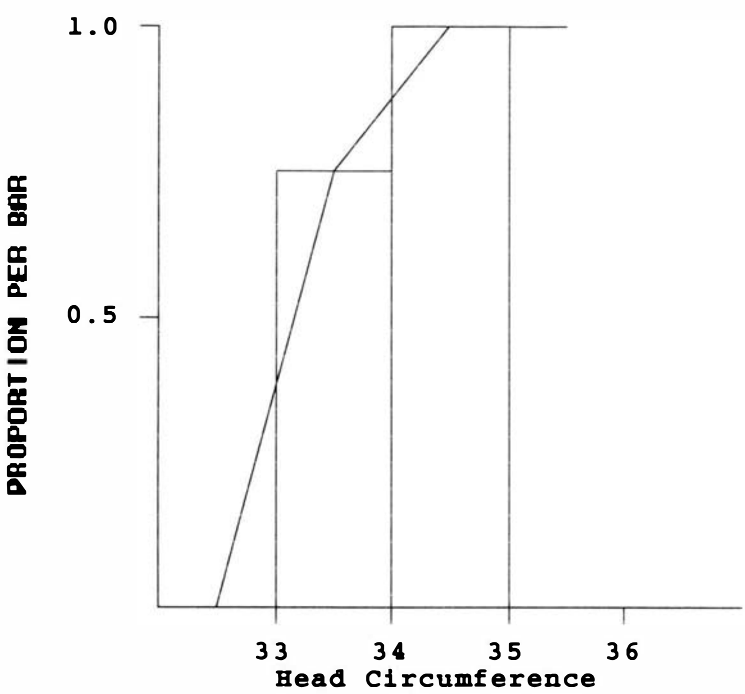
Table 42—*Continued*

THE FOLLOWING RESULTS ARE FOR:
G = 41.000

| COUNT | CUM COUNT | PCT | CUM PCT | HEAD |
|---|---|---|---|---|
| 2 | 2 | 20.0 | 20.0 | 34.000 |
| 1 | 3 | 10.0 | 30.0 | 34.500 |
| 4 | 7 | 40.0 | 70.0 | 35.000 |
| 1 | 8 | 10.0 | 80.0 | 35.500 |
| 1 | 9 | 10.0 | 90.0 | 36.000 |
| 1 | 10 | 10.0 | 100.0 | 37.000 |

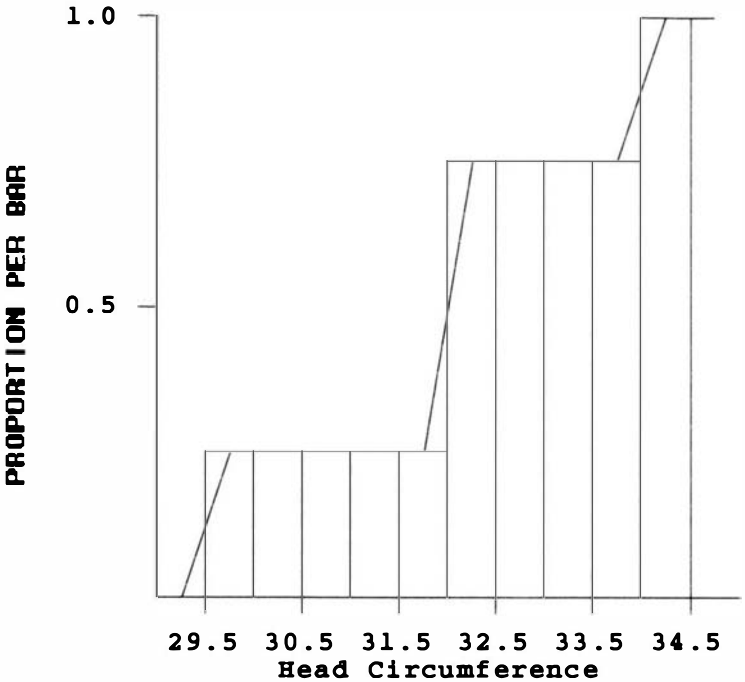
THE FOLLOWING RESULTS ARE FOR:
G = 42.000

| COUNT | CUM COUNT | PCT | CUM PCT | HEAD |
|---|---|---|---|---|
| 1 | 1 | 50.0 | 50.0 | 34.500 |
| 1 | 2 | 50.0 | 100.0 | 35.000 |



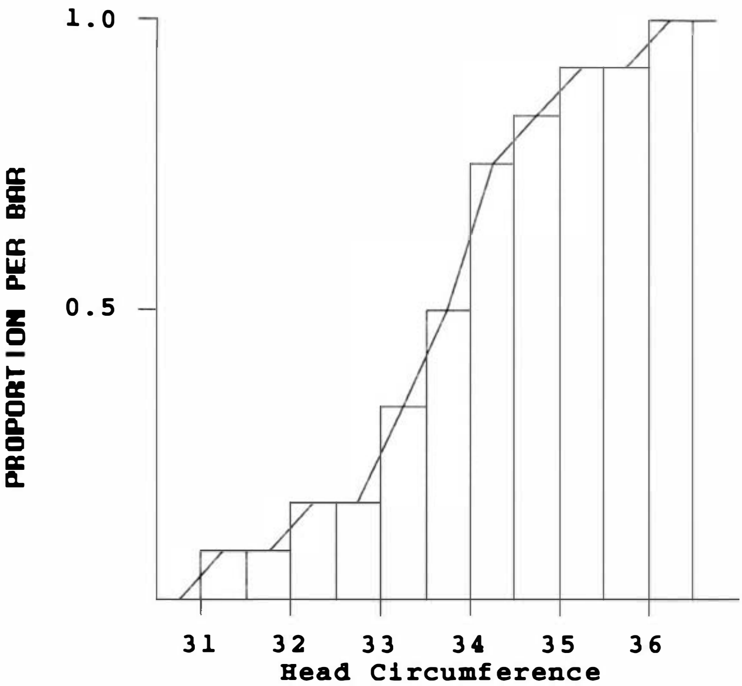

| Percentile | Length |
|---|---|
| 90th | 33.60 |
| 75th | 33.00 |
| 50th | 32.70 |
| 25th | 32.30 |
| 10th | 32.15 |

Figure 41. Head Circumference at 35 Weeks



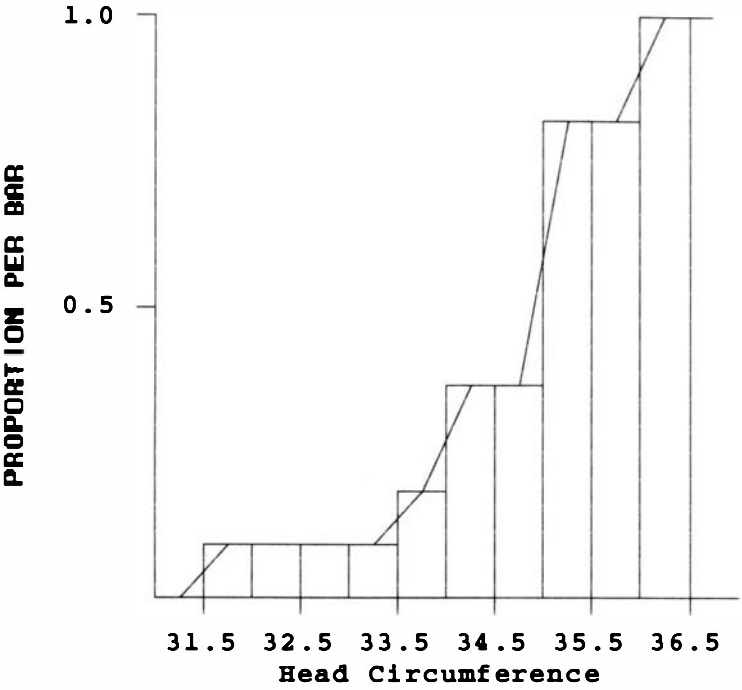

| Percentile | Length |
|---|---|
| 90th | 33.20 |
| 75th | 32.00 |
| 50th | 30.75 |
| 25th | 29.50 |
| 10th | 29.20 |

Figure 42. Head Circumference at 36 Weeks



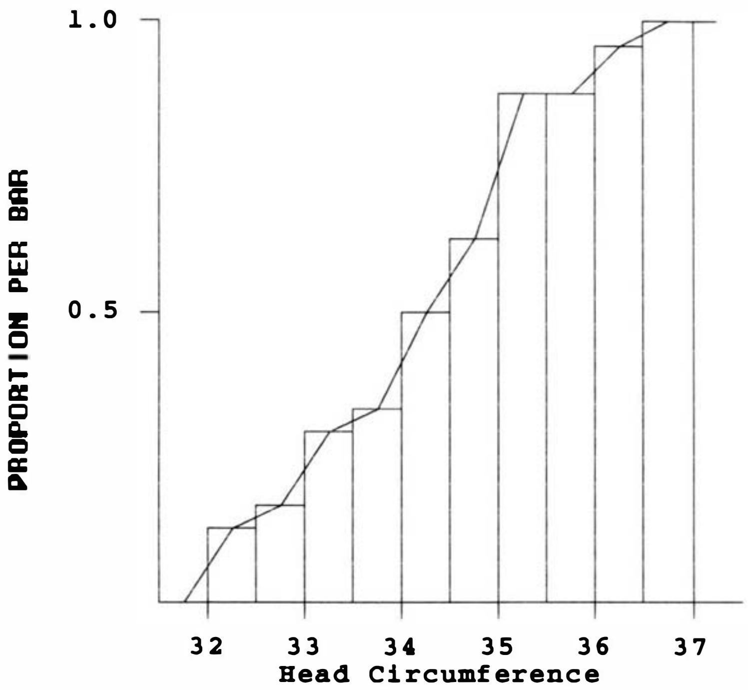

| Percentile | Length |
|---|---|
| 90th | 35.00 |
| 75th | 34.00 |
| 50th | 33.50 |
| 25th | 32.50 |
| 10th | 31.00 |

Figure 43. Head Circumference at 37 Weeks



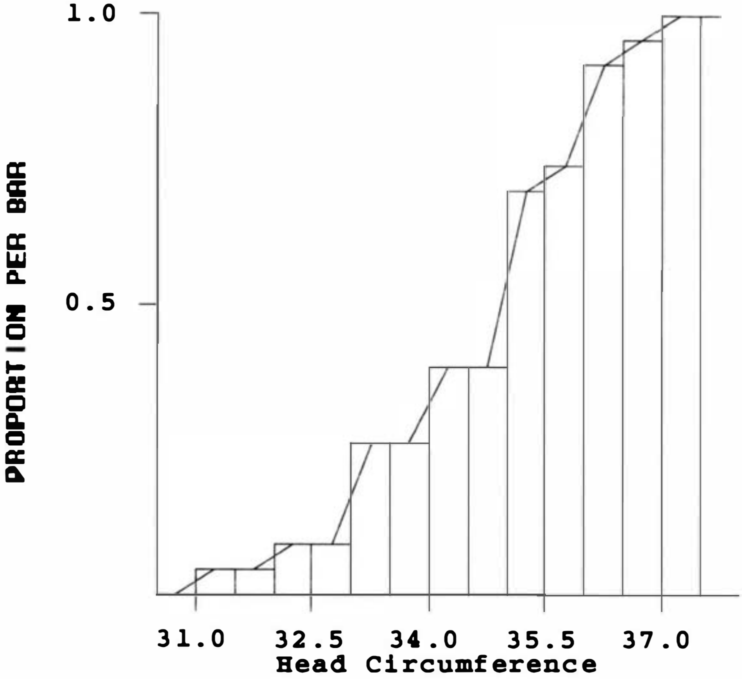

| Percentile | Length |
|---|---|
| 90th | 35.5 |
| 75th | 34.8 |
| 50th | 34.3 |
| 25th | 33.7 |
| 10th | 31.5 |

Figure 44. Head Circumference at 38 Weeks



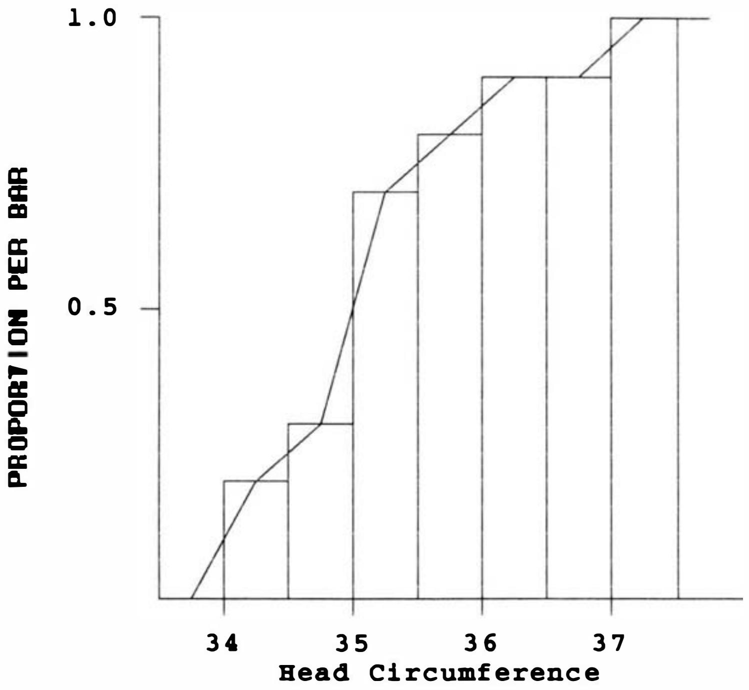

| Percentile | Length |
|---|---|
| 90th | 35.40 |
| 75th | 34.75 |
| 50th | 34.00 |
| 25th | 32.85 |
| 10th | 31.85 |

Figure 45. Head Circumference at 39 Weeks




| Percentile | Length |
|---|---|
| 90th | 35.90 |
| 75th | 35.55 |
| 50th | 34.30 |
| 25th | 32.85 |
| 10th | 32.00 |

Figure 46. Head Circumference at 40 Weeks




| Percentile | Length |
|---|---|
| 90th | 36.25 |
| 75th | 35.25 |
| 50th | 34.75 |
| 25th | 34.25 |
| 10th | 33.65 |

Figure 47. Head Circumference at 41 Weeks

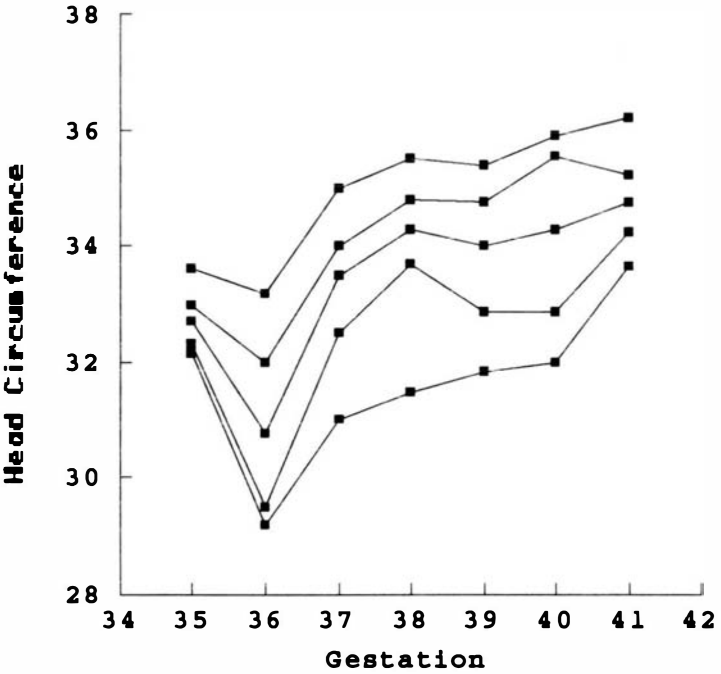



Figure 48. Head Circumference Unsmoothed Percentiles

centimeters at 36 weeks. Head circumference does not decrease from 35 to 36 weeks gestation. There are only four infants in the 35 and 36 week groups. Because of these small group sizes, it is unclear which, if either, represents the true distribution of head circumference. More measurements are needed in these two groups to obtain accurate percentiles for 35 and 36 weeks gestation.

Figures 49 and 50 show the 10th and 90th percentiles after a first and second smoothing. Figure 51 shows the 10th and 90th percentiles with the ends smoothed. The 10th percentile at 35 weeks has been lowered by the end smoothing. Table 44 lists the values of the final smoothed percentiles.

Table 45 lists the 10th and 90th percentiles for Richmond and Colorado. The largest difference between the Richmond and Colorado percentiles is at the extremes of the 10th percentile. There is a difference of 2.15 centimeters at 35 weeks and a difference of 1.65 centimeters at 41 weeks. Figure 52 shows the graph of these measurements. The head circumference for Richmond infants at the 90th percentile is smaller than the Colorado infants for 35 to 39 weeks gestation. The head measurements for the Richmond infants at the 10th percentile are smaller than the Colorado infants at 37 and 38 weeks gestation.

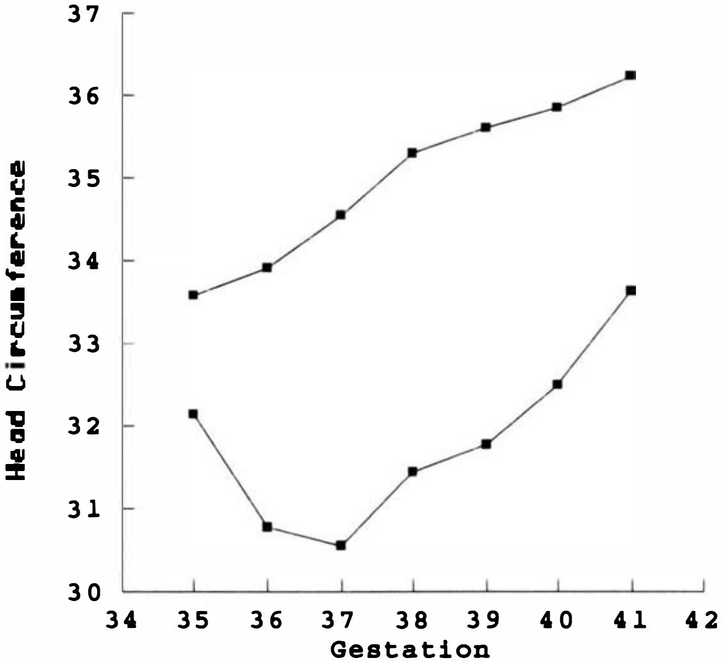



Figure 49. Head Circumference 10th and 90th Percentiles
After One Smoothing

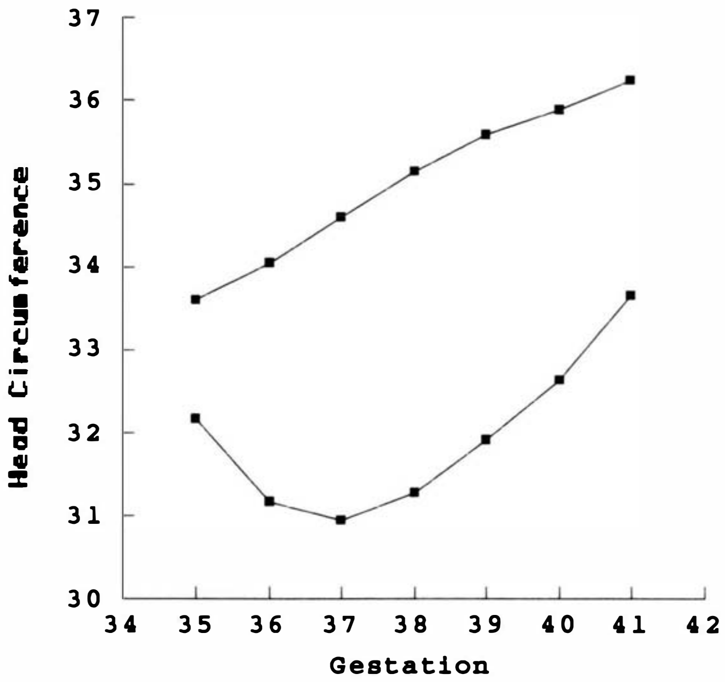



Figure 50. Head Circumference 10th and 90th Percentiles After Two Smoothings

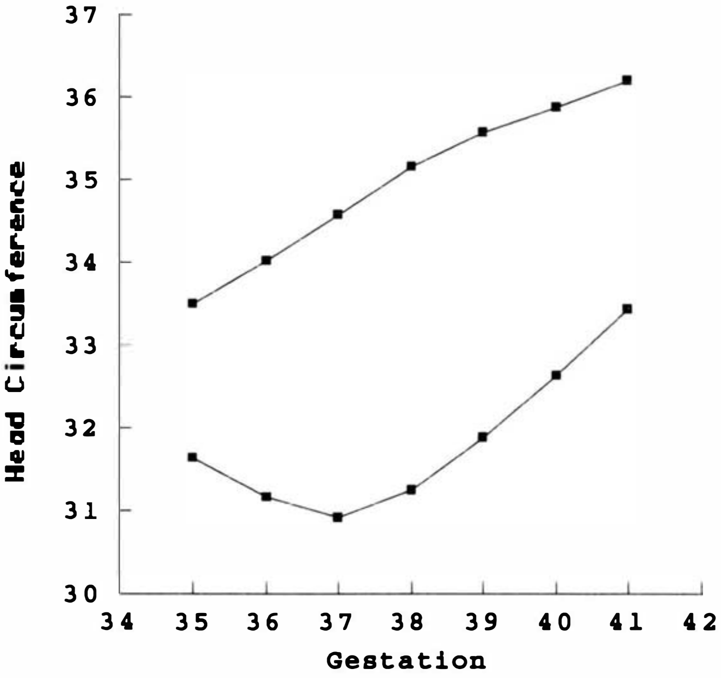



Figure 51. Head Circumference 10th and 90th Percentiles
Ends Smoothed

Table 44

Head Circumference Smoothed

**Ends unsmoothed**

| Gestational Age | Patients | Mean Head Circumference | Smoothed Percentiles 10 | 90 |
|---|---|---|---|---|
| 35 | 4 | 33.25 | 32.15 | 33.60 |
| 36 | 4 | 31.88 | 31.17 | 34.03 |
| 37 | 12 | 33.63 | 30.93 | 34.60 |
| 38 | 11 | 34.55 | 31.27 | 35.16 |
| 39 | 24 | 34.13 | 31.91 | 35.58 |
| 40 | 23 | 34.56 | 32.64 | 35.90 |
| 41 | 10 | 35.10 | 33.65 | 36.25 |

**Ends smoothed**

| Gestational Age | Patients | Mean Head Circumference | Smoothed Percentiles 10 | 90 |
|---|---|---|---|---|
| 35 | 4 | 33.25 | 31.66 | 33.51 |
| 36 | 4 | 31.88 | 31.17 | 34.03 |
| 37 | 12 | 33.63 | 30.93 | 34.60 |
| 38 | 11 | 34.55 | 31.27 | 35.16 |
| 39 | 24 | 34.13 | 31.91 | 35.58 |
| 40 | 23 | 34.56 | 32.64 | 35.90 |
| 41 | 10 | 35.10 | 33.46 | 36.23 |

Table 45

Head Circumference for Richmond and Colorado

Smoothed Percentiles

Richmond *Colorado*

| Gestational Age | Patients | Mean Head Circumference | Smoothed Percentiles 10 | Smoothed Percentiles 90 |
|---|---|---|---|---|
| 35 | 4 | 33.25 | 32.15 | 33.60 |
| | | *32.4* | *30.0* | *34.5* |
| 36 | 4 | 31.88 | 31.17 | 34.03 |
| | | *32.9* | *30.6* | *34.9* |
| 37 | 12 | 33.63 | 30.93 | 34.60 |
| | | *33.2* | *31.1* | *35.2* |
| 38 | 11 | 34.55 | 31.27 | 35.16 |
| | | *33.4* | *31.4* | *35.4* |
| 39 | 24 | 34.13 | 31.19 | 35.58 |
| | | *33.6* | *31.6* | *35.7* |
| 40 | 23 | 34.56 | 32.64 | 35.90 |
| | | *33.8* | *31.8* | *35.9* |
| 41 | 10 | 35.10 | 33.65 | 36.25 |
| | | *34.1* | *32.0* | *36.0* |

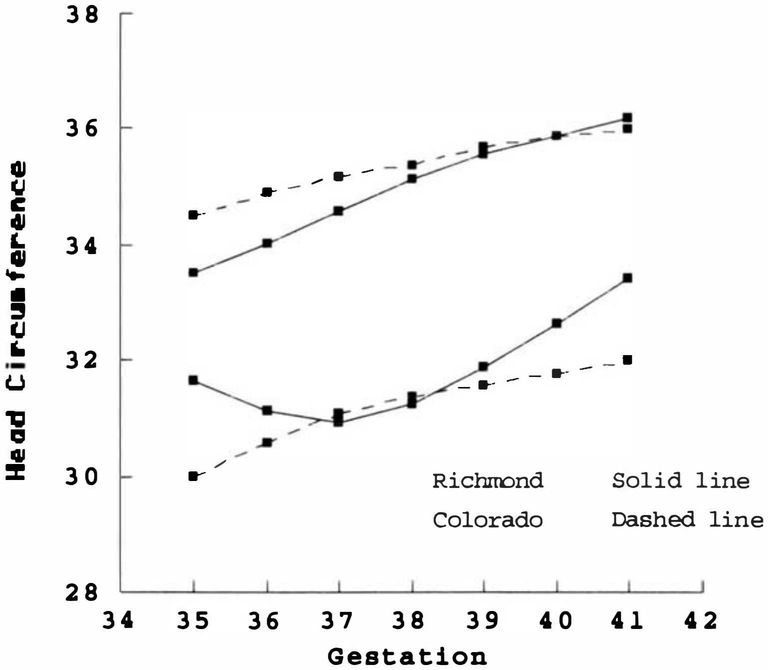



Figure 52. Head Circumference Richmond and Colorado 10th and 90th Percentiles

Table 46 lists the classification of the infants using the Colorado graphs.

Table 46 Head Circumference and the Colorado Graphs

| Weeks | 35 | 36 | 37 | 38 | 39 | 40 | 41 | Total |
|---|---|---|---|---|---|---|---|---|
| SGA | 0 | 1 | 0 | 0 | 2 | 1 | 1 | 5 |
| LGA | 0 | 0 | 0 | 2 | 2 | 6 | 1 | 11 |

Five infants are identified as SGA compared to 11 infants identified as LGA. All of the infants identified as LGA are between 38 and 41 weeks gestation.

Table 47 shows the classification of infants using the Richmond graphs.

Table 47 Head Circumference and the Richmond Graphs

| Weeks | 35 | 36 | 37 | 38 | 39 | 40 | 41 | Total |
|---|---|---|---|---|---|---|---|---|
| SGA | 2 | 1 | 0 | 0 | 1 | 2 | 4 | 8 |
| LGA | 0 | 0 | 0 | 2 | 2 | 6 | 1 | 11 |

These results are similar to the results obtained using the Colorado graphs. This method identifies three more infants as SGA. The same number of infants are identified as LGA by both the Richmond and Colorado graphs.

## Characteristics of Mothers and Infants

This section examines some of the other variables collected for the first 98 infants in the final study. The purpose of examining these variables is to develop some understanding of the characteristics of this sample and to identify data collection concerns.

Of the 98 infants, 51 are female and 47 male. There are 64 black infants and 34 white infants. The pilot study data suggested that male infants were larger. Examination of weight, length, and head circumference by sex shows that the mean of all three of these variables is larger for the male group. The mean chest circumference and mid arm circumference were larger for the female infants. There were 69 vaginal deliveries and 29 Cesearean section deliveries.

The mean age of the mothers is 24 years. Examination of weight gain showed the mean gain to be 30 pounds. Forty-four of the mothers had fewer than 10 prenatal visits. Eight of the mothers had been hospitalized sometime during their pregnancy.

Twenty-six of the mothers had no complications. Sixty-one of the patients had at least one complication. The most frequent complication was smoking, with 20 mothers reporting cigarette use. Preterm labor was reported for nine of the mothers. Eight of the patients had pregnancy induced hypertension.

Complete socioeconomic data were collected for 28 of the mothers. This indicates a problem with collecting the information necessary to use the Hollingshead tool. A Hollingshead score may be calculated for only 29 percent of the patients.

Examination of these variables shows this sample to be similar to the pilot study data. There is still a problem collecting the information necessary to obtain a Hollingshead score.

# Chapter 5

# Conclusions and Recommendations

## Conclusions

Analysis of the pilot study data indicated no problems with measurement reliability for length, head circumference, and Ballard score. There was a significant difference between chest measurements between rater 1 and rater 2. The chest measurements for rater 1 were larger than the chest measurements of rater 2. The middle values of the mid arm measurements were larger for rater 1 compared to rater 2.

Analysis of the data from the first 98 infants in the final study indicates differences between Richmond and Colorado infants in weight, length, and head circumference. On the weight graphs the 10th percentile for Richmond infants is larger than the 10th percentile for the Colorado infants for 35-42 weeks gestation. At 40 and 41 weeks, the 90th percentile for the Richmond infants is larger than the 90th percentile for the Colorado infants. These differences result in fewer Richmond infants being classified as SGA and more infants being classified as LGA when the Colorado graphs are used.

Using the graph produced using two standard deviations from the mean, fewer infants are identified as SGA or LGA compared to use of the Richmond or Colorado graphs using percentiles.

The distance from the 10th to the 90th percentile for length is shorter for the Richmond infants. The 10th percentile is larger at all gestational ages for the Richmond infants. Fewer infants are classified as SGA in length when the Colorado graphs are used.

The head circumference graph for Richmond was similar to the head circumference graph for Colorado. Head circumference measurements for the Richmond infants are larger at the 10th percentile for all gestational ages except at 37 and 38 weeks.

Recommendations

The method used to classify infants in the nurseries as SGA, AGA, or LGA at the Medical College of Virginia should be modified from the current practice. Classification should be made using weight and gestational age only. Length and head circumference should be examined but should not determine how the infant is classified.

Instead of the current graphs, a table of the actual 10th and 90th percentile measurements should be used when classifying infants. It is difficult to make very fine distinctions between classifications when using the graph. The computer system currently used in the hospital could be modified to generate infant classification. The infant's weight and length are already entered in the computer system. The head circumference and Ballard score could be added to the current screens.

Collection of some of the variables needs modification. Gestational age should be collected in weeks and days. This would be more accurate than rounding to the nearest week. The collection of EDC should also include whether this is a sure or unsure date. This could help explain discrepancies between gestational age estimates and measurements. Use of the Hollingshead score needs further study and evaluation. Currently there are too many missing values to make the score meaningful.

Although there are differences in the weight, length, and head circumference graphs between Richmond and Colorado, it is unclear which graphs are better at identifying high risk infants. If data collection continues and graphs specific to

MCVH produced, there is nothing to guarantee these graphs would identify high risk infants more accurately than the current graphs.

The issue of identifying high risk infants needs to be studied in a prospective study where infant morbidity and mortality could be compared with initial nursery classification. Infant and maternal factors associated with morbidity and mortality could be collected. Using these variables, a model could be built which would accurately identify high risk infants.

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# BIBLIOGRAPHY

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# APPENDIX

Table 48

Data From Final Study

| NUMBER | SEX | RACE | WEIGHT | LENGTH | HEAD | CHEST | MIDARM | BALLARD | EDC | METHOD |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | F | B | 2670.0 | 49.0 | 33.0 | 31.0 | 9.0 | 41.0 | 39.0 | 2.0 |
| 2 | M | W | 2980.0 | 48.0 | 34.0 | 29.0 | 10.0 | 37.0 | 36.0 | 1.0 |
| 3 | F | B | 2840.0 | 48.0 | 32.0 | 29.0 | 10.5 | 39.0 | 39.0 | 2.0 |
| 4 | M | W | 3330.0 | 51.0 | 34.0 | 33.0 | 10.5 | 41.0 | 39.0 | 2.0 |
| 5 | F | W | 3180.0 | 48.0 | 35.0 | 31.0 | 11.0 | 39.0 | 39.0 | 1.0 |
| 6 | M | W | 2430.0 | 46.0 | 32.0 | 29.0 | 9.0 | 35.0 | 34.0 | 1.0 |
| 7 | M | W | 2330.0 | 46.0 | 32.0 | 27.0 | 9.0 | 35.0 | 34.0 | 1.0 |
| 8 | M | B | 3460.0 | 54.0 | 35.0 | 33.0 | 11.0 | 40.0 | 40.0 | 1.0 |
| 9 | F | W | 3280.0 | 51.0 | 34.0 | 33.0 | 11.0 | 39.0 | 39.0 | 2.0 |
| 10 | F | W | 3420.0 | 51.0 | 35.0 | 32.0 | 11.0 | 40.0 | 40.0 | 1.0 |
| 11 | F | B | 2220.0 | 46.0 | 32.0 | 28.0 | 9.0 | 40.0 | 39.0 | 2.0 |
| 12 | F | B | 3190.0 | 49.0 | 35.0 | 33.0 | 11.0 | 40.0 | 40.0 | 2.0 |
| 13 | M | W | 3080.0 | 50.0 | 34.0 | 30.0 | 10.0 | 39.0 | 38.0 | 2.0 |
| 14 | M | B | 3430.0 | 53.0 | 36.0 | 32.5 | 12.0 | 41.0 | 38.0 | 2.0 |
| 15 | F | B | 3260.0 | 49.0 | 35.0 | 32.0 | 11.0 | 40.0 | 38.0 | 1.0 |
| 16 | F | W | 3300.0 | 51.0 | 36.0 | 34.0 | 11.5 | 41.0 | 39.0 | 1.0 |
| 17 | F | W | 3500.0 | 50.0 | 34.0 | 34.0 | 11.0 | 39.0 | 40.0 | 1.0 |
| 18 | F | B | 2950.0 | 51.0 | 34.0 | 32.0 | 10.0 | 41.0 | 41.0 | 2.0 |
| 19 | M | B | 2950.0 | 51.0 | 33.0 | 31.0 | 10.5 | 38.0 | 35.0 | 1.0 |
| 20 | M | W | 2710.0 | 50.0 | 33.0 | 30.0 | 9.0 | 38.0 | 40.0 | 2.0 |
| 21 | M | B | 3230.0 | 50.0 | 34.0 | 31.0 | 10.0 | 39.0 | 37.0 | 1.0 |
| 22 | M | W | 2830.0 | 50.0 | 34.0 | 30.0 | 10.0 | 40.0 | 37.0 | 2.0 |
| 23 | F | B | 2960.0 | 49.0 | 35.0 | 30.0 | 10.5 | 40.0 | 40.0 | 1.0 |
| 24 | F | B | 2540.0 | 43.0 | 30.0 | 29.0 | 9.5 | 39.0 | . | 1.0 |

Table 48—*Continued*

Data From Final Study

| NUMBER | SEX | RACE | WEIGHT | LENGTH | HEAD | CHEST | MIDARM | BALLARD | EDC | METHOD |
|---|---|---|---|---|---|---|---|---|---|---|
| 25 | M | B | 4370.0 | 53.0 | 37.0 | 35.0 | 12.0 | 38.0 | 40.0 | 2.0 |
| 26 | F | W | 3000.0 | 50.0 | 34.0 | 30.0 | 10.0 | 40.0 | 39.0 | 1.0 |
| 27 | M | B | 3480.0 | 49.0 | 36.0 | 32.0 | 10.5 | 40.0 | 40.0 | 2.0 |
| 28 | F | B | 3070.0 | 47.0 | 31.0 | 34.0 | 11.5 | 40.0 | 40.0 | 2.0 |
| 29 | F | B | 2190.0 | 44.0 | 32.0 | 28.0 | 8.5 | 36.0 | 36.0 | 1.0 |
| 30 | M | B | 2650.0 | 48.0 | 33.0 | 29.0 | 9.5 | 40.0 | 39.0 | 2.0 |
| 31 | M | W | 2600.0 | 48.0 | 34.0 | 29.0 | 9.0 | 40.0 | 39.0 | 1.0 |
| 32 | M | B | 3000.0 | 49.0 | 33.0 | 32.0 | 11.0 | 40.0 | 40.0 | 2.0 |
| 33 | M | B | 3720.0 | 51.0 | 35.0 | 35.0 | 11.0 | 42.0 | 42.0 | 2.0 |
| 34 | F | W | 3320.0 | 50.0 | 36.0 | 32.0 | 12.0 | 40.0 | 40.0 | 2.0 |
| 35 | M | W | 3650.0 | 51.0 | 35.0 | 33.0 | 11.0 | 38.0 | 40.0 | 2.0 |
| 36 | M | B | 2660.0 | 48.0 | 32.0 | 31.0 | 10.0 | 39.0 | 37.0 | 2.0 |
| 37 | F | B | 2750.0 | 47.0 | 33.0 | 32.0 | 10.0 | 40.0 | 37.0 | 2.0 |
| 38 | F | B | 3280.0 | 50.0 | 34.0 | 32.0 | 11.0 | 41.0 | 40.0 | 2.0 |
| 39 | M | W | 3940.0 | 52.0 | 36.0 | 36.0 | 13.0 | 40.0 | 40.0 | 1.0 |
| 40 | M | W | 2870.0 | 49.0 | 33.0 | 32.0 | 10.0 | 38.0 | 40.0 | 1.0 |
| 41 | M | W | 2650.0 | 49.0 | 32.0 | 31.0 | 9.0 | 38.0 | 40.0 | 1.0 |
| 42 | F | B | 3170.0 | 51.0 | 34.0 | 32.0 | 11.0 | 39.0 | 38.0 | 2.0 |
| 43 | F | W | 3870.0 | 54.0 | 36.0 | 34.0 | 11.0 | 40.0 | 39.0 | 1.0 |
| 44 | F | B | 2410.0 | 47.0 | 31.0 | 30.0 | 9.0 | 42.0 | 37.0 | 2.0 |
| 45 | F | B | 2980.0 | 48.0 | 35.0 | 32.0 | 10.0 | 39.0 | 38.0 | 1.0 |
| 46 | M | B | 3750.0 | 53.0 | 35.0 | 34.0 | 11.0 | 40.0 | 41.0 | 1.0 |
| 47 | M | B | 3170.0 | 50.0 | 35.0 | 31.0 | 11.0 | 39.0 | 39.0 | 1.0 |
| 48 | F | W | 3090.0 | 49.0 | 33.0 | 32.0 | 10.0 | 37.0 | . | . |

## Table 48—*Continued*

### Data From Final Study

| NUMBER | SEX | RACE | WEIGHT | LENGTH | HEAD | CHEST | MIDARM | BALLARD | EDC | METHOD |
|---|---|---|---|---|---|---|---|---|---|---|
| 49 | M | B | 3540.0 | 54.0 | 35.0 | 33.0 | 10.0 | 42.0 | 41.0 | 2.0 |
| 50 | M | B | 3230.0 | 53.0 | 35.0 | 33.0 | 10.0 | 41.0 | . | . |
| 51 | F | B | 3110.0 | 50.0 | 35.0 | 33.0 | 10.5 | 39.0 | 37.0 | 1.0 |
| 52 | F | B | 3550.0 | 50.0 | 35.0 | 35.0 | 11.0 | 41.0 | 41.0 | 2.0 |
| 53 | F | B | 3570.0 | 51.0 | 35.0 | 33.0 | 11.0 | 41.0 | 38.0 | 2.0 |
| 54 | F | B | 3420.0 | 51.0 | 35.0 | 32.0 | 11.0 | 39.0 | 40.0 | 1.0 |
| 55 | M | B | 3120.0 | 48.0 | 35.0 | 31.0 | 12.0 | 40.0 | 39.0 | 2.0 |
| 56 | F | B | 3340.0 | 49.0 | 33.5 | 32.0 | 40.0 | 41.0 | 38.0 | 1.0 |
| 57 | F | B | 3120.0 | 49.0 | 35.0 | 31.0 | 10.5 | 39.0 | 38.0 | 2.0 |
| 58 | F | B | 3080.0 | 53.0 | 34.0 | 32.0 | 10.0 | 40.0 | 40.0 | 1.0 |
| 59 | M | B | 4500.0 | 53.5 | 37.0 | 36.5 | 12.0 | 42.0 | 41.0 | 1.0 |
| 60 | F | B | 2523.0 | 47.0 | 34.0 | 29.0 | 9.0 | 37.0 | 35.0 | 2.0 |
| 61 | F | B | 4260.0 | 52.0 | 36.0 | 35.0 | 12.5 | 40.0 | 38.0 | 1.0 |
| 62 | M | B | 3170.0 | 50.0 | 34.5 | 31.5 | 10.0 | 39.0 | 39.0 | 1.0 |
| 63 | F | B | 2930.0 | 48.0 | 32.5 | 31.0 | 10.0 | 41.0 | 39.0 | 1.0 |
| 64 | F | B | 3330.0 | 51.0 | 33.0 | 32.0 | 10.5 | 40.0 | 37.0 | 1.0 |
| 65 | M | B | 2840.0 | 50.0 | 33.0 | 29.5 | 9.5 | 40.0 | 35.0 | 2.0 |
| 66 | M | B | 2770.0 | 49.0 | 34.5 | 30.5 | 9.5 | 40.0 | 39.0 | 1.0 |
| 67 | F | B | 3175.0 | 49.0 | 34.5 | 32.0 | 11.0 | 38.0 | 39.0 | 1.0 |
| 68 | F | W | 3770.0 | 51.0 | 34.5 | 34.5 | 11.5 | 37.0 | 37.0 | 1.0 |
| 69 | F | B | 4760.0 | 54.0 | 36.5 | 39.0 | 12.5 | 41.0 | 39.0 | 1.0 |
| 70 | F | B | 2840.0 | 49.0 | 33.0 | 30.0 | 10.0 | 39.0 | 39.0 | 1.0 |
| 71 | F | W | 3320.0 | 49.0 | 33.5 | 31.0 | 10.0 | 38.0 | 37.0 | 1.0 |
| 72 | M | B | 3110.0 | 52.0 | 33.0 | 32.0 | 9.5 | 39.0 | 40.0 | 1.0 |
| 73 | F | B | 3420.0 | 52.0 | 33.5 | 32.0 | 10.0 | 41.0 | 39.0 | 1.0 |

Table 48—*Continued*

Data From Final Study

| NUMBER | SEX | RACE | WEIGHT | LENGTH | HEAD | CHEST | MIDARM | BALLARD | EDC | METHOD |
|---|---|---|---|---|---|---|---|---|---|---|
| 74 | F | W | 3110.0 | 51.0 | 35.0 | 33.0 | 9.0 | 39.0 | 39.0 | 2.0 |
| 75 | F | W | 3830.0 | 51.0 | 34.5 | 33.0 | 11.0 | 39.0 | 41.0 | 1.0 |
| 76 | M | B | 2930.0 | 48.5 | 35.0 | 31.5 | 10.0 | 40.0 | 40.0 | 2.0 |
| 77 | F | W | 2720.0 | 48.0 | 33.0 | 30.5 | 9.5 | 36.0 | 35.0 | 2.0 |
| 78 | M | W | 3900.0 | 54.0 | 36.0 | 33.5 | 10.5 | 39.0 | 40.0 | 1.0 |
| 79 | F | B | 2790.0 | 47.5 | 32.0 | 30.0 | 9.5 | 37.0 | 36.0 | 2.0 |
| 80 | F | W | 3780.0 | 50.5 | 35.0 | 35.0 | 11.5 | 39.0 | 39.0 | 2.0 |
| 81 | M | B | 2740.0 | 48.0 | 31.5 | 30.5 | 9.0 | 39.0 | 38.0 | 1.0 |
| 82 | M | B | 3610.0 | 51.0 | 34.0 | 33.5 | 10.5 | 40.0 | 37.0 | 2.0 |
| 83 | M | B | 3530.0 | 51.5 | 35.0 | 32.5 | 11.0 | 41.0 | . | . |
| 84 | M | W | 3790.0 | 53.5 | 35.0 | 35.0 | 10.0 | 40.0 | 41.0 | 1.0 |
| 85 | M | B | 2070.0 | 43.0 | 29.5 | 27.5 | 8.5 | 36.0 | 36.0 | 1.0 |
| 86 | F | W | 4300.0 | 53.5 | 36.5 | 36.0 | 11.5 | 38.0 | 40.0 | 2.0 |
| 87 | F | B | 3490.0 | 52.0 | 34.5 | 34.0 | 10.0 | 39.0 | 42.0 | 2.0 |
| 88 | F | B | 4090.0 | 51.5 | 34.0 | 35.5 | 13.0 | 40.0 | 41.0 | 1.0 |
| 89 | M | B | 3190.0 | 52.0 | 35.0 | 31.0 | 10.0 | 39.0 | 38.0 | 2.0 |
| 90 | M | W | 3180.0 | 48.5 | 35.5 | 32.0 | 10.0 | 39.0 | 40.0 | 2.0 |
| 91 | M | B | 2551.0 | 46.5 | 32.0 | 30.0 | 9.0 | 39.0 | . | . |
| 92 | F | B | 3030.0 | 48.5 | 33.5 | 32.5 | 10.0 | 39.0 | 37.0 | 1.0 |
| 93 | M | B | 4140.0 | 55.0 | 35.0 | 34.5 | 11.0 | 42.0 | 39.0 | 1.0 |
| 94 | M | B | 4000.0 | 50.0 | 36.0 | 33.5 | 12.0 | 39.0 | 37.0 | 1.0 |
| 95 | M | W | 3630.0 | 54.0 | 35.5 | 33.0 | 10.0 | 41.0 | 41.0 | 1.0 |
| 96 | M | W | 4320.0 | 53.5 | 36.0 | 35.5 | 12.0 | 40.0 | 41.0 | 1.0 |
| 97 | F | B | 2800.0 | 48.0 | 32.0 | 31.5 | 9.5 | 39.0 | 39.0 | 1.0 |
| 98 | M | W | 2680.0 | 47.5 | 33.0 | 30.5 | 9.0 | 37.0 | . | . |

Table 48—*Continued*

Data from Final Study

| NUMBER | DEL$ | AGE | G | P | AB | COMP$ | COMP | GAIN | SOCIO1 | SOCIO2 | PNC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SVD | 25.0 | 5.0 | 4.0 | 1.0 | F | 1.0 | 25.0 | . | 5.0 | B |
| 2 | CS | 37.0 | 5.0 | 2.0 | 3.0 | E | 5.0 | 20.0 | . | . | D |
| 3 | SVD | 18.0 | 3.0 | 2.0 | 1.0 | | . | 40.0 | . | 5.0 | E |
| 4 | SVD | 24.0 | 2.0 | 2.0 | .0 | F | 2.0 | 42.0 | 6.0 | 5.0 | C |
| 5 | CS | 40.0 | 7.0 | 1.0 | 6.0 | B | 1.0 | 26.0 | . | 3.0 | E |
| 6 | CS | 35.0 | 4.0 | 4.0 | .0 | GEN | 1.0 | 30.0 | 6.0 | 4.0 | C |
| 7 | CS | 35.0 | 4.0 | 4.0 | .0 | GEN | 1.0 | 30.0 | 6.0 | 4.0 | C |
| 8 | CS | 23.0 | 2.0 | 1.0 | 1.0 | G | 1.0 | 22.0 | 7.0 | . | C |
| 9 | CS | 24.0 | 2.0 | 1.0 | 1.0 | F | 2.0 | 45.0 | 7.0 | 5.0 | B |
| 10 | SVD | 18.0 | 1.0 | 1.0 | . | | . | 31.0 | 7.0 | . | C |
| 11 | SVD | 18.0 | 4.0 | 4.0 | .0 | F | 1.0 | 25.0 | . | 6.0 | B |
| 12 | CS | 27.0 | 3.0 | 2.0 | 1.0 | F | 1.0 | 23.0 | 7.0 | 4.0 | B |
| 13 | SVD | 20.0 | 1.0 | 1.0 | .0 | | . | 35.0 | . | 4.0 | C |
| 14 | SVD | 22.0 | 3.0 | 3.0 | .0 | K | 22.0 | 20.0 | . | 3.0 | B |
| 15 | SVD | 23.0 | 3.0 | 3.0 | .0 | B | 2.0 | . | . | 5.0 | E |
| 16 | SVD | 30.0 | 3.0 | 3.0 | .0 | D | . | 30.0 | 6.0 | 4.0 | C |
| 17 | SVD | 22.0 | 2.0 | 2.0 | .0 | A | . | 50.0 | . | 4.0 | C |
| 18 | CS | 20.0 | 1.0 | 1.0 | .0 | C | . | . | . | 5.0 | B |
| 19 | SVD | 20.0 | 2.0 | 1.0 | 1.0 | K | 48.0 | 20.0 | 26.0 | 4.0 | C |
| 20 | SVD | 27.0 | 4.0 | 4.0 | .0 | F | 2.0 | 23.0 | . | 2.0 | C |
| 21 | CS | 32.0 | 2.0 | 2.0 | . | A | . | 40.0 | . | . | C |
| 22 | SVD | 30.0 | 3.0 | 2.0 | 1.0 | FG | 31.0 | . | . | . | B |
| 23 | SVD | 21.0 | 2.0 | 1.0 | 1.0 | C | . | 32.0 | . | 2.0 | C |
| 24 | SVD | 28.0 | 5.0 | 4.0 | 1.0 | IG | 1.0 | . | . | 4.0 | A |

Table 48—*Continued*

Data from Final Study

| NUMBER | DEL$ | AGE | G | P | AB | COMP$ | COMP | GAIN | SOCIO1 | SOCIO2 | PNC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | SVD | 28.0 | 3.0 | 2.0 | 1.0 | | . | . | . | 4.0 | C |
| 26 | SVD | 21.0 | 3.0 | 3.0 | .0 | F | 1.0 | 18.0 | . | . | C |
| 27 | CS | 26.0 | 4.0 | 2.0 | 2.0 | B | 2.0 | . | 5.0 | . | E |
| 28 | LSF | 29.0 | 5.0 | 5.0 | .0 | | . | . | . | . | |
| 29 | SVD | 20.0 | 1.0 | 1.0 | .0 | I | . | 5.0 | . | 2.0 | B |
| 30 | SVD | 24.0 | 3.0 | 3.0 | .0 | F | 2.0 | 36.0 | . | . | C |
| 31 | SVD | 26.0 | 4.0 | 3.0 | 1.0 | F | 2.0 | 28.0 | . | 5.0 | B |
| 32 | SVD | 23.0 | 1.0 | 1.0 | .0 | A | . | 40.0 | 7.0 | 4.0 | B |
| 33 | SVD | 21.0 | 2.0 | 1.0 | 1.0 | A | . | 45.0 | . | 4.0 | B |
| 34 | SVD | 19.0 | 1.0 | 1.0 | .0 | F | 1.0 | 22.0 | 6.0 | 6.0 | B |
| 35 | SVD | 23.0 | 3.0 | 3.0 | .0 | | . | 24.0 | . | . | B |
| 36 | SVD | 20.0 | 2.0 | 1.0 | 1.0 | F | 1.0 | . | . | . | B |
| 37 | SVD | 33.0 | 3.0 | 2.0 | 1.0 | F | 1.0 | 28.0 | . | 4.0 | C |
| 38 | SVD | 21.0 | 2.0 | 2.0 | .0 | B | 2.0 | 42.0 | 6.0 | 4.0 | C |
| 39 | CS | 20.0 | 2.0 | 1.0 | 1.0 | A | . | 100.0 | . | . | B |
| 40 | CS | 22.0 | 3.0 | 3.0 | .0 | FN | 1.0 | 60.0 | 7.0 | 4.0 | B |
| 41 | CS | 22.0 | 3.0 | 3.0 | .0 | FN | 1.0 | 60.0 | 7.0 | 4.0 | B |
| 42 | SVD | 34.0 | 3.0 | 2.0 | 1.0 | A | . | 38.0 | 7.0 | 3.0 | B |
| 43 | CS | 32.0 | 2.0 | 2.0 | .0 | EF | 2.0 | 3.0 | . | . | B |
| 44 | SVD | 20.0 | 5.0 | 3.0 | 2.0 | FG | 1.0 | 15.0 | . | 6.0 | B |
| 45 | SVD | 19.0 | 3.0 | 3.0 | .0 | A | . | 10.0 | 7.0 | 4.0 | B |
| 46 | CS | 24.0 | 4.0 | 2.0 | 2.0 | HI | . | 35.0 | 7.0 | 6.0 | C |
| 47 | SVD | 22.0 | 2.0 | 1.0 | 1.0 | A | . | 35.0 | 7.0 | 4.0 | B |
| 48 | SVD | 19.0 | 2.0 | 2.0 | .0 | | . | . | . | . | |

Table 48—*Continued*

Data from Final Study

| NUMBER | DEL$ | AGE | G | P | AB | COMP$ | COMP | GAIN | SOCIO1 | SOCIO2 | PNC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 49 | SVD | 28.0 | 2.0 | 2.0 | .0 | | . | . | 3.0 | 3.0 | C |
| 50 | SVD | 17.0 | 1.0 | 1.0 | .0 | | . | . | 7.0 | 5.0 | A |
| 51 | SVD | 28.0 | 3.0 | 3.0 | .0 | D | . | 25.0 | 7.0 | 5.0 | B |
| 52 | SVD | 31.0 | 7.0 | 5.0 | 2.0 | F | 2.0 | 20.0 | 7.0 | . | C |
| 53 | SVD | 34.0 | 3.0 | 2.0 | 1.0 | FI | 2.0 | 30.0 | 7.0 | 3.0 | B |
| 54 | SVD | 25.0 | 1.0 | 1.0 | .0 | | . | 30.0 | 6.0 | 4.0 | C |
| 55 | CS | 19.0 | 2.0 | 2.0 | .0 | | . | 24.0 | 7.0 | 4.0 | C |
| 56 | SVD | 25.0 | 5.0 | 3.0 | 2.0 | A | . | 12.0 | 4.0 | . | C |
| 57 | SVD | 15.0 | 1.0 | 1.0 | .0 | C | . | 30.0 | 7.0 | 6.0 | B |
| 58 | SVD | 21.0 | 3.0 | 2.0 | 1.0 | G | 1.0 | 14.0 | 7.0 | . | B |
| 59 | SVD | 22.0 | 4.0 | 4.0 | .0 | A | . | 35.0 | 7.0 | . | B |
| 60 | CS | 20.0 | 1.0 | 1.0 | .0 | DBN | 14.0 | . | . | . | |
| 61 | CS | 36.0 | 4.0 | 3.0 | 1.0 | D | . | 15.0 | . | . | C |
| 62 | SVD | 26.0 | 1.0 | 1.0 | .0 | FCM | 2.0 | 45.0 | . | . | BE |
| 63 | SVD | 30.0 | 5.0 | 3.0 | 2.0 | G | 1.0 | 35.0 | 6.0 | 4.0 | C |
| 64 | SVD | 32.0 | 2.0 | 2.0 | .0 | DB | 2.0 | 25.0 | 6.0 | 4.0 | B |
| 65 | SVD | 20.0 | 2.0 | 2.0 | .0 | B | 2.0 | 12.0 | . | . | C |
| 66 | SVD | 16.0 | 1.0 | 1.0 | .0 | A | . | 23.0 | . | 5.0 | |
| 67 | CS | 25.0 | 3.0 | 2.0 | 1.0 | FG | 21.0 | 35.0 | . | . | B |
| 68 | CS | 23.0 | 1.0 | 1.0 | .0 | A | . | 19.0 | . | . | B |
| 69 | CS | 23.0 | 2.0 | 2.0 | .0 | A | . | 20.0 | . | . | CE |
| 70 | SVD | 21.0 | 3.0 | 2.0 | 1.0 | A | . | 20.0 | . | . | B |
| 71 | SVD | 24.0 | 2.0 | 2.0 | .0 | F | 2.0 | . | . | . | B |
| 72 | SVD | 17.0 | 1.0 | 1.0 | .0 | A | . | 20.0 | . | . | B |
| 73 | SVD | 36.0 | 10.0 | 3.0 | 7.0 | E | 1.0 | 22.0 | 2.0 | 3.0 | C |

Table 48—*Continued*

Data from Final Study

| NUMBE | DEL$ | AGE | G | P | AB | COMP$ | COMP | GAIN | SOCIO1 | SOCIO2 | PNC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 74 | SVD | 19.0 | 2.0 | 1.0 | 1.0 | F | 2.0 | 19.0 | 3.0 | . | C |
| 75 | SVD | 23.0 | 3.0 | 2.0 | 1.0 | A | . | 28.0 | . | 3.0 | B |
| 76 | SVD | 23.0 | 5.0 | 4.0 | 1.0 | F | 2.0 | 25.0 | 6.0 | . | CE |
| 77 | SVD | 19.0 | 2.0 | 2.0 | .0 | A | . | 32.0 | 6.0 | . | C |
| 78 | SVD | 24.0 | 4.0 | 3.0 | 1.0 | LF | 2.0 | 34.0 | . | 6.0 | C |
| 79 | CS | 28.0 | 5.0 | 2.0 | 3.0 | A | . | 31.0 | . | 4.0 | CE |
| 80 | CS | 25.0 | 2.0 | 1.0 | 1.0 | A | . | 69.0 | 4.0 | 4.0 | C |
| 81 | SVD | 31.0 | 3.0 | 1.0 | 2.0 | F | 1.0 | 35.0 | . | 2.0 | C |
| 82 | CS | 23.0 | 1.0 | 1.0 | .0 | C | . | . | . | 4.0 | B |
| 83 | SVD | 22.0 | 5.0 | 5.0 | .0 | A | . | . | . | 5.0 | B |
| 84 | SVD | 22.0 | 2.0 | 1.0 | 1.0 | A | . | 33.0 | 2.0 | 5.0 | C |
| 85 | SVD | 25.0 | 4.0 | 4.0 | .0 | B | 2.0 | . | . | 6.0 | B |
| 86 | CS | 18.0 | 2.0 | 2.0 | .0 | A | . | 47.0 | 4.0 | . | C |
| 87 | CS | 22.0 | 1.0 | 1.0 | .0 | A | . | 20.0 | . | 4.0 | C |
| 88 | SVD | 29.0 | 5.0 | 5.0 | .0 | A | 1.0 | 20.0 | . | . | B |
| 89 | LSF | 14.0 | 1.0 | 1.0 | .0 | C | . | 17.0 | . | . | B |
| 90 | CS | 29.0 | 4.0 | 2.0 | 2.0 | F | 2.0 | . | . | . | B |
| 91 | SVD | 28.0 | 5.0 | 5.0 | .0 | F | 1.0 | . | . | . | |
| 92 | SVD | 19.0 | 3.0 | 1.0 | 2.0 | F | 1.0 | 35.0 | . | . | C |
| 93 | SVD | 21.0 | 3.0 | 3.0 | .0 | B | . | 30.0 | . | 5.0 | C |
| 94 | SVD | 17.0 | 2.0 | 2.0 | .0 | A | . | 7.0 | . | . | |
| 95 | CS | 27.0 | 2.0 | 1.0 | 1.0 | A | . | 55.0 | . | 3.0 | A |
| 96 | CS | 17.0 | 2.0 | 2.0 | .0 | FE | 21.0 | 45.0 | . | 6.0 | B |
| 97 | SVD | 12.0 | 1.0 | 1.0 | .0 | C | . | 27.0 | . | 6.0 | C |
| 98 | SVD | 25.0 | 6.0 | 4.0 | 2.0 | CE | 1.0 | . | . | . | |

# Vita

[redacted]