WEIGHING WET DIAPERS: A NEW APPROACH TO MEASURING INFANT OUTPUT

by

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A thesis submitted to the faculty of the University of
Utah in partial fulfillment of the requirements
for the degree of

Master of Science

College of Nursing

University of Utah

June 1971

This Thesis for the

Master of Science Degree

by

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ACKNOWLEDGEMENTS

I wish to gratefully acknowledge those individuals who unselfishly gave their time and efforts to assist in the preparation of this study. To the Latter-Day Saints Hospital, Salt Lake City, Utah, for allowing the data collection to be done there. To Mrs. Ester Anderson and her staff, a special thanks for their help and cooperation in the data collection; to Proctor and Gamble Manufacturing Company and Kimberly - Clark Corporation, my sincere gratitude for supplying the Pampers and Kimbies used in this study; to the members of my supervisory committee, Dr. Mark Snow, chairman, Miss Tomiye Ishimatsu and Dr. Miriam James, my deepest appreciation for their valuable suggestions and guidance in the preparation of the manuscript; and to my husband, Robert, for his understanding, encouragement and assistance.

The helpful suggestions of my friends and classmates were also greatly appreciated.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Accurate measurement of fluid losses is important in infant patients, especially in burn cases. Indwelling catheters, urine collection bags and other commonly used methods of continuous urine collection and measurement have several disadvantages including trauma, danger of infection, skin irritation, need for restraints, and use of expensive devices.

The present study was designed to ascertain if weighing wet diapers can be used as a method of measuring infant urine output.

This study utilized disposable diapers to measure urine output in a group of 14 bottle-fed neonates. Careful handling kept fluid losses at a minimum without requiring special equipment or disturbing normal ward routine.

A significant correlation between fluid intake and diaper weights indicated that diaper weights can be used as a measure of urine output.

A follow up of this study is recommended to compare weighing wet diapers as a method of measuring urine output with either the indwelling catheter or the polythene urine collection bag.

To further test the efficacy of this method, it is recommended that a larger group of infants be tested with several nurses collecting and weighing the diapers.

CHAPTER I

INTRODUCTION

Infants are vulnerable to fluid volume deficits because of their greater body fluid content (prematures - 90 per cent and infants - 70 to 80 per cent), and because of a greater exchange of their extracellular fluid (1/2 per day for infants compared to 1/6 per day for adults) (Metheny & Snively, 1967, p. 250). Due to the greater fluid turnover, dehydration and overhydration are much more critical in an infant. The infant's difficulty in dealing with fluid imbalances stems from a large surface area, a higher metabolic rate, and an immature renal performance (Guyton, 1971, p. 997).

The infant's functionally immature kidneys are called upon to excrete a large amount of metabolic waste products, which in turn requires the formation of a proportionately large volume of urine (Mikal, 1967, p. 373). The young kidney is unable to excrete sodium, chloride, and other ions, or to reabsorb water with any efficiency, thus producing a hypotonic urine of relatively large volume. Also, the kidney cannot rapidly excrete large volumes of ion-free water. This fixed volume and solute excretion makes the infant susceptible to problems of overloading and dehydration (Artz, 1969, p. 262).

The kidney is the body's final adjustment mechanism in the maintenance of fluid balance. It is important to determine the amount of urine output in infants to prevent the excessive loss and load of fluids before they reach critical levels. Urine volume measurement is especially important in the treatment of burns in children, where the aim of therapy is to maintain an adequate urine output. Immediately following a burn, urine reduction and sometimes renal shutdown have been observed due to the decreased extracellular fluid volume resulting from the fluid shift into the burn areas. An increased secretion of antidiuretic hormone has also been mentioned by Artz (1969, p. 129) as a possible contributor to the altered renal excretion. Metcoff, Buchman, Jackson, Richter, Bloomenthal, and Zacharias (1961) have observed a reduction of 30 to 60 per cent in renal blood flow and about 40 to 50 per cent decrease of glomerular filtration during the early burn period. The transition from the depressed urine flow the first 24 to 48 hours to the increased urine volume during the reabsorption of edema fluid occurring the second to the fifth day after the burn can best be determined by the measurement of urine output. If this transition period does not take place, renal damage must be considered (Metheny & Snively, 1967, p. 168).

The measurement of urine output is the best single index of the adequacy of fluid therapy in burns (Abramson, 1966, p. 859; Artz, 1969, p. 137; & Crews, 1967, p. 22-23.

Quantitative measurement of urine volume is important in many other phases of pediatric nursing, such as in post-operative care, when, during the first few days, renal output is decreased due to stress reaction and remains such regardless of the amount of fluid given (Metheny & Snively, 1967, pp. 147-148). Knowing the urine volume is also important in the early recognition of congenital urinary tract obstruction above the bladder, where symptoms referable to the urinary tract are absent except for instances where there may be intermittent periods in which large quantities of urine are voided owing to the release of an obstructed and greatly distended ureter or hydronephrosis (Nelson, Vaughan, & McKay, eds., 1969, p. 1116). In addition, urine volume should be measured in disorders involving the posterior pituitary gland and the adrenal cortex; here the secretion of antidiuretic hormone and aldosterone is greatly altered, and affects the rate of water reabsorption in the renal tubules (Guyton, 1971, p. 420).

Commonly used methods of collection and measurement of urine output on a continuous basis include indwelling catheters, polythene urine collection bags, modified isolettes and cribs. When these methods cannot be used, the only record of urine output is the number of wet diapers (Hill, 1958, p. 570).

Research showed the danger of the indwelling catheter as a source of infection (Beeson, 1958; Hildebrant, 1964; Levin, 1964; & Lireman, 1969). Kass and Sossen (1959) reported that after 24 hours with a retention catheter bacteriuria occurred in 50 per cent of the patients, and that after four days 98 to 100 per cent of the patients had 100,000 bacteria per cubic centimeter of urine. This hazard is increased in the infant female with a short urethra. The trauma caused by the insertion of the catheter cannot be overemphasized. For the above reasons, the avoidance of retention catheters in burn patients would be desirable; nevertheless, they are used for lack of a safer method because of the importance of measuring the urinary output. Many burn patients survive the shock phase and the edema resorption phase, but succumb to later hazards such as sepsis (Weisburg, 1962, p. 378).

Urine collection bags with tubing attachments, despite various modifications (Clifton, 1969; Hsi-Yen & Anderson, 1967; & Wilkinson, & Baldwin, 1969) have various limitations. The necessity of an intact skin makes them unusable in patients with burns and severe rashes involving the perineal area. Both legs must be restrained to prevent interference with the drainage tube. The bags may tear or the adhesive material may become moist with urine and fail to adhere, thus requiring reapplication. Frequent reapplication of these bags causes irritation with erythema and even excoriation of the perineal skin. At such times the collections must be discontinued to allow the skin to heal (Sato, 1969, p. 804). The data of Braude, Forfar, Gould,and Mcleod (1967) suggested contamination of urine during the application of the bags. Cell and bacterial counts for both sexes were significantly increased in such urine samples.

Modified isolettes and cribs have been introduced as a method of collecting urine (Winter, Baker, Eberlein, 1967). The problem with such modified incubators and cribs are related to the drainage of other liquids, such as milk and bath water, into the urine collection bottles. In addition, the modified crib used for toddlers requires many devices for keeping the child warm when he wears nothing but a restraint jacket (Sato, 1969, p. 805).

Counting the number of wet diapers as a gauge of infant urine output is widely used in pediatric wards. This is inaccurate, as infants may void two or more times in one diaper and have only one voiding recorded. This investigator decided to test the possibility of weighing wet diapers as a method for measuring quantitatively the urine output of infants. This method has advantages over the previous ones mentioned in that it does not require restraints, can be used for both sexes, does not require the use of expensive equipment and can be used in the home.

The literature includes no studies on the use of weighing diapers as a method for measuring infant urine output. Kooh and Metcoff (1963, p. 120) described a technique of weighing diapers to approximate stool losses in infantile diarrhea. There has been no follow-up or evaluation of this technique. The possible use of diaper weight as a means of measuring urine output has also been suggested by Metheny and Snively (1967, pp. 253-254).

The intent of this study was to ascertain if weighing wet diapers can be used as a measure of urine output in infants. An attempt was made to demonstrate a direct relationship between fluid intake and urine output obtained by this method during a 24 hour period of time.

CHAPTER II

METHOD

A preliminary trial of the method was made prior to the actual study in order to keep it as practical as possible and to make modifications in the method as needed.

As a result of the pretest several alterations were made in the method: 1) Diaper liners were necessary to separate the stools from the urine instead of tearing off the flow-through linings of the disposable diapers. 2) Vinyl-covered "Time Tape" was used to keep the diapers in place instead of safety pins. 3) Plastic garbage bags with "Twist-to-Seals" were used to collect the wet diapers due to the number of infants used in the study. Step cans could be used equally well.

Subjects of the study were 14 bottle-fed infants. They were one- and two-day-old Caucasian infants of 38 to 40 weeks gestation with a birth weight of six pounds and over. Excluded from the study were breast-fed infants, those with birth anomalies, those with inherited metabolic disorders, those with temperatures over 100 degrees Fahrenheit and those who vomited any portion of their feedings which could not be contained within the maternity liners. Vomiting was defined as an active, forceful expulsion of emesis (Godfrey, 1968, p. 11).

The subjects each had a cotton shirt, a disposable diaper, and two receiving blankets. Each occupied an open bassinet with a mattress and sheet.

The infants were born in a large hospital in Salt Lake City, Utah. The patient population of the hospital was considered by hospital personnel to come from the middle socioeconomic group. In 1970, this hospital had a birth rate of 4670 infants. 4416 were full term and 254 were premature. Approximately 375 babies were born per month, with an average of 47 infants in the nursery on any one day: 35 full term and 12 premature.

The hospital nursery is composed of an "admit" nursery which receives infants directly from the delivery rooms, two full-term nurseries for infants one day old and over (second nursery is used mainly as an overflow nursery), and three smaller areas: the premature nursery, the intensive care unit and an isolation facility for sick infants.

A central control unit regulated the temperature both in the nursery and in the mothers' ward between 76 and 78 degrees. In both areas the humidity was maintained between 48 and 50 per cent. Silverman (1965, p. 83) stated that there is rarely any difficulty in controlling the infants' temperature if nurseries are kept at 75 degrees Fahrenheit and relative humidity at 50 per cent.

The data were collected during two 24-hour periods: from 7 A. M. September 16, 1970 to 7 A. M. September 17, 1970, and from 7 A. M. September 23, 1970 to 7 A. M. September 24, 1970. All the data concerned with handling the diapers were collected by present author. Feedings were given by other nursery personnel and mothers, with specific instructions and under the direct supervision of this investigator.

The equipment used in the data collection included a Harvard Trip Balance plus the following for each infant; 1) one dozen disposable diapers (Kimbies or Pampers), weighed; 2) one dozen diaper liners; 3) six plastic garbage bags with "Twist-to-Seals", weighed (two for each eight hour time period); 4) one roll of vinyl covered "Time Tape"; 5) one dozen maternity liners, weighed.

Before data collection all the infants were put together in one area of the nursery. Each bassinet was labeled and all the needed equipment was placed underneath each bassinet. Each subject was bathed and dried, then the first disposable diaper put on. The diaper was put on by laying the diaper down with the inner flow-through lining on top. The diaper liner was opened and laid on top of the diaper, making sure that it covered the entire inner part of the diaper to the point where the outer waterproof covering overlapped with the inner lining. The baby's buttocks were raised and the diaper slipped under, making sure that the diaper liner extended as far as the diaper. The diaper was held together with a piece of tape at the top portion near the waist on both sides and by another piece of tape near the thigh on both sides. The tapes were placed in such a way that evaporation from the thigh areas was prevented.

During the study the usual nursery routine was observed. All babies went out to their mothers for feedings, and returned to the nursery at the same time. Mothers used the maternity liners as bibs and for burping. Therefore, if the infant vomited an accurate fluid intake was still obtained. As soon as the baby vomited on the maternity liner it was folded and placed in a plastic bag with "Twist-to-Seal", the bag was weighed and the original weight of the bag and liner subtracted from the weight obtained. The difference in grams was calculated as the amount of fluid intake lost. This was converted to cubic centimeters and subtracted from the total eight hour fluid intake. Male infants were circumcised as scheduled with this investigator assisting in the procedure. Circumcision was done soon after the infant had voided. Daily weights were taken at midnight.

Diapers were removed by a standardized procedure as soon as a yellowish color was seen through the waterproof outer lining. Tapes were removed completely and discarded. The nurse's right palm was placed between the thighs with the thumb on top of the bladder area and the four fingers behind the buttocks. With the left hand holding the edge of the diaper liner the wet diaper was removed by sliding it off the baby so the inside areas remained facing each other. The diaper liner was left on the baby to be discarded. The exposed waterproof outer lining extended one inch beyond the wet inside area, providing protection from evaporation. The wet diaper, with the inner area unexposed, was placed in a plastic bag and closed with a "Twist-to-Seal". Diapers were used as needed during the 24 hour period.

The fluid intake was totalled at the end of each eight hour time period, and the 24 hour total was obtained by adding the three eight hour totals. Each plastic bag containing the wet diapers was weighed after each eight hour time period. The number of diapers used was determined by counting the remaining clean diapers. Their weight was subtracted from that of the original dozen. The average weight of the clean diapers equivalent in number to those used plus the weight of the plastic bag with "Twist-to-Seal" was subtracted from the weight of the plastic bag with the wet diapers. The difference represented the weight in grams of the urine absorbed in the diapers for the eight hour time period. The urine output in grams for the three eight hour time periods was totalled to obtain the 24 hour output.

CHAPTER III

RESULTS

Fluid intake was measured in cubic centimeters per infant. Urine output in grams per eight hour time period was obtained by subtracting the average weight of clean diapers equal in number to those used plus the weight of the plastic bag with "Twist-to-Seal" closure from the weight of the plastic bag containing the wet diapers. Eight hour time periods ran from 7 A. M. to 3 P. M., 3 P. M. to 11 P. M., and 11 P. M. to 7 A. M.

Individual fluid intake and urine output of all 14 subjects were recorded for each eight hour time interval. The three eight hour values were then added to obtain the 24 hour scores.

A Pearson product-moment correlation (*r*) between fluid intake and urine output was done on each eight hour collection period and on the total 24 hour period, in order to measure the linear relationship between fluid intake and urine output scores.

Table 1 shows the total volumes of fluid intake and urine output, mean, standard deviation, and standard error of estimate for the entire sample.

Table 2 shows the correlation coefficients obtained between the fluid intake and urine output for each eight hour period and for the entire 24 hours. It also shows the corresponding levels of significance for each Pearson *r*.

TABLE 1

Fluid Intake and Urine Output Collection Data

Time Interval	Total Volume	Mean	Standard Deviation	Standard error of estimate
7 AM to 3 PM				
Intake[a]	935	66.79	30.48	8.15
Output[b]	551.36	39.38	25.92	6.92
3 PM to 11 PM				
Intake	1120	80	33.28	8.90
Output	740.5	52.89	36.35	9.72
11 PM to 7 AM				
Intake	1120	80	31.44	8.40
Output	905.29	64.66	47.60	12.72
24 Hour Sample				
Intake	3175	226.79	84.84	22.68
Output	2197	156.95	92.95	24.84

a Intake in cubic centimeters

b Output in grams

TABLE 2

Pearson r and Corresponding Level of Significance for the Entire Sample

Time Interval of Fluid Intake and Urine Output	r	P
7 A.M. to 3 P.M.	.63	less than .02
3 P.M. to 11 P.M.	.50	more than .05
11 P.M. to 7 A.M.	.61	.02
24 Hour Sample	.80	less than .01

A direct relationship between fluid intake and urine output obtained by weighing wet diapers was shown by the four correlation coefficients (.63, .50, .61, and .80) obtained for the entire sample.

The strongest relationship between fluid intake and urine output is shown in the 24 hour sample. 64 per cent of the variations in the fluid intake can be accounted for by the urine output and vice versa, compared to 40 per cent, 25 per cent, and 37 per cent for the three eight hour samples.

Figure 1 shows a scatter diagram indicating the relationship between fluid intake and urine output using the 24 hour sample. The ordinate indicates fluid intake and the abscissa urine output.

The weight of one dozen dry diapers used in the study varied from 318.2 grams to 429.6 grams. The average weight for one Pamper varied between 26.5 and 27.4 grams and for one Kimbie between 28.4 and 36.1 grams.

Table 3 shows the number of disposable diapers used by each infant during each eight hour time period. The average number used were two per eight hours for both 7 A. M. to 3 P. M. and 3 P. M. to 11 P. M. time periods, and three for the 11 P. M. to 7 A. M. time interval.

Figure 1. Scatter Diagram of the 24 Hour Sample Showing Relationship Between Fluid Intake and Urine Output

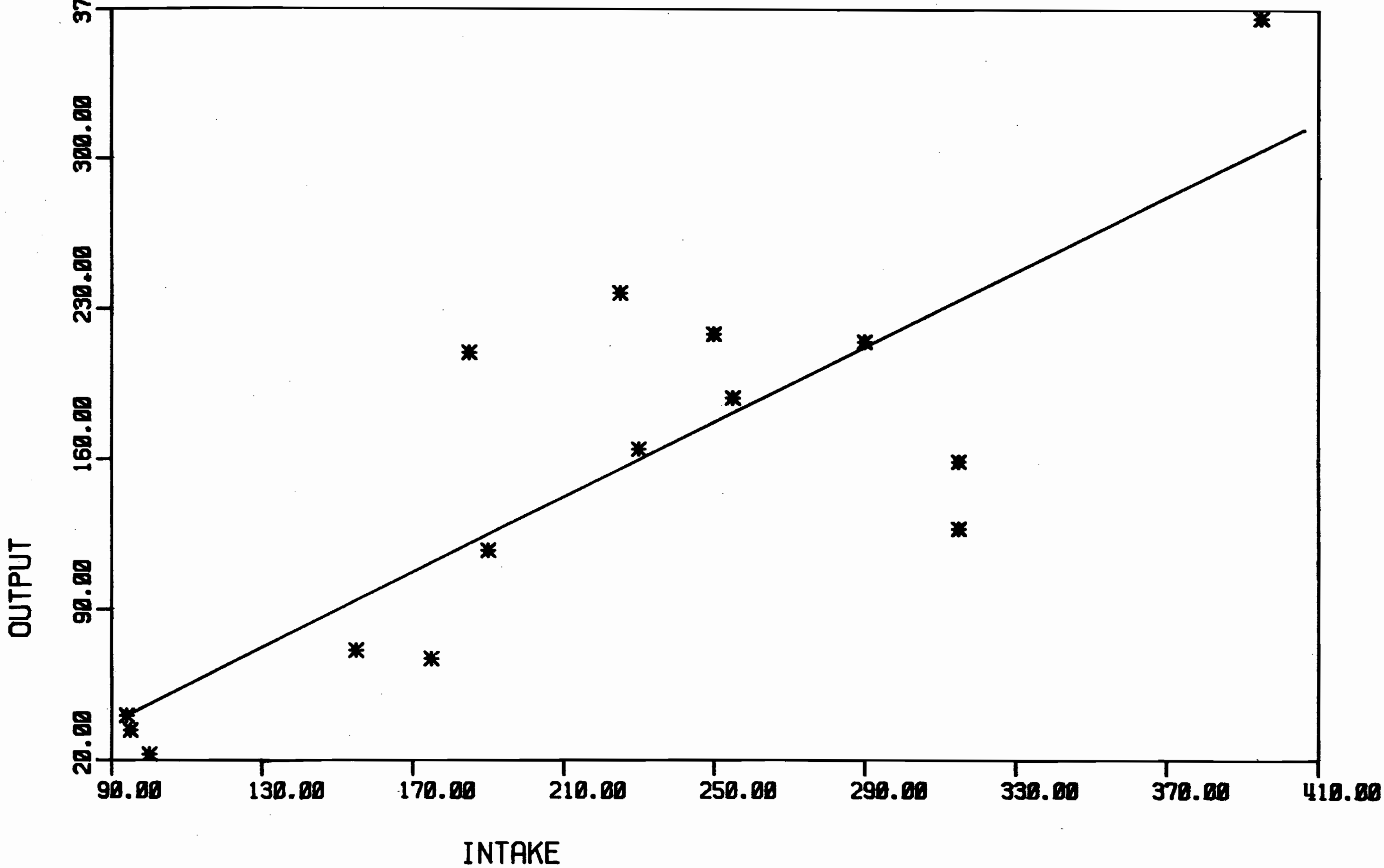

TABLE 3

Number of Diapers Used Per Eight Hour Period

N	7-3	3-11	11-7	Total
1	2	2	6	10
2	1	3	2	6
3	2	3	2	7
4	1	2	5	8
5	2	1	2	5
6	4	3	4	11
7	2	2	2	6
8	3	3	2	8
9	3	2	3	8
10	2	2	3	7
11	3	3	3	9
12	2	3	4	9
13	3	2	4	9
14	2	2	4	8

CHAPTER IV

DISCUSSION

The lower correlation coefficient obtained on the eight hour samples may be accounted for in part by the feeding schedule for infants in the hospital. The last oral feedings for the 7 A. M. to 3 P. M. time interval were given to the subjects between 2:00 P. M. and 2:30 P. M. and totalled with the fluid intake obtained for that eight hour time period. However, the urine output that followed the feedings was not collected until after 3:00 P. M. and thus was included with the 3 P. M. to 11 P. M. urine output scores. The same was true with the 6:00 A. M. and 10:00 P. M. feedings. Urine output that followed both feedings was measured and totalled with the succeeding eight hour period.

Urine evaporation from the wet diapers was kept at a minimum by the waterproof covering of the disposable diapers, by the use of vinyl covered "Time Tape" to keep the diapers in place and eliminate gaps between the diapers and the thighs, by handling wet diapers so the inner wet surfaces were left unexposed, and by keeping the soiled diapers in a plastic bag with "Twist-to-Seal" closures.

No attempt was made to measure insensible losses from the lungs and skin.

Diaper liners effectively separated the stool from the urine. The investigator did not collect any wet diaper contaminated with stool during the study.

The need for weighing maternity liners used to catch fluid intake losses through vomiting happened only twice during the data collection. In both cases the infants had to be dropped from the study because the mothers decided to feed the infants by breast instead of the bottle.

The number of diapers used by each subject suggests that one dozen disposable diapers are adequate for use during an entire 24 hour period.

Routine procedures such as circumcision, bathing, and taking of daily weights were done during the data collection without loss of urine. Three infant males were circumcised during the study and all 14 subjects were bathed and weighed. There was no interruption of the routine nursery activities while the study was being done.

Results of this study were found significant in relation to the question posed.

1. There is a significant direct relationship between fluid intake and urine output obtained by weighing wet disposable diapers.

2. Urine volume in a wet diaper can be determined by weighing it.

3. Collecting and weighing wet disposable diapers can be done without interruption of ward routine.

To further test the efficacy of this method, it is recommended that a larger group of infants be tested with several nurses collecting and weighing the diapers. A follow up to this study is also suggested to compare this method of measuring urine output with other methods now being used, such as polythene collection bags and catheters.

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