ASSESSMENT OF THE RELATIONSHIP BETWEEN CHANGE IN WEIGHT AND THE DIFFERENCE BETWEEN INTAKE AND OUTPUT

by

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A Thesis

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CHAPTER I

INTRODUCTION

Water in the body serves several important functions. Extracellular water is the fluid environment surrounding cells. Maintenance of both the composition and volume of extracellular fluid is necessary to maintain cell life. The water of blood is the solvent for dissolving oxygen and nutrients transported to cells, as well as waste products transported away from cells. It is also necessary for storage and removal of heat. Intracellular water is the solvent for all of the chemicals that react in cellular metabolic functions. Thus, it is clear that maintenance of normal body fluid volume is essential for maintaining homeostasis (Phipps, Long & Woods, 1979; Vander, Sherman & Luciano, 1980).

As long as individuals are healthy and have access to drinking water, fluid balance will be maintained by ingesting water at a rate that balances water loss. However, when a person becomes acutely or chronically ill, it may be difficult to maintain water homeostasis. When water imbalance occurs, either an excess or deficit of total body fluid volume results. Hospitalized patients often exhibit abnormalities in fluid balance. They may be unable to ingest adequate amounts of fluid or their kidneys may excrete too much or too little urine. The patient may also lose abnormally large amounts of fluid as diarrhea, nasogastric or wound drainage. Excessive amounts of fluid may be given inadvertently during therapy. Thus, there are many ways that water imbalance can be generated.

Assessment of the status of fluid balance can be one of the most difficult and challenging responsibilities of clinicians. This difficulty exists because body water is not confined to a single space or compartment to which we have access. Rather, the water is distributed to three separate compartments. Sixty per cent of adult human body weight is water. Thirty-three per cent of this water is extracellular fluid of which one-fifth to one-quarter is plasma and three-quarters composes the interstitial fluid. The other forty per cent of the total body weight is intracellular fluid (Shires & Canizaro, 1979). Figure 1 illustrates these relationships.

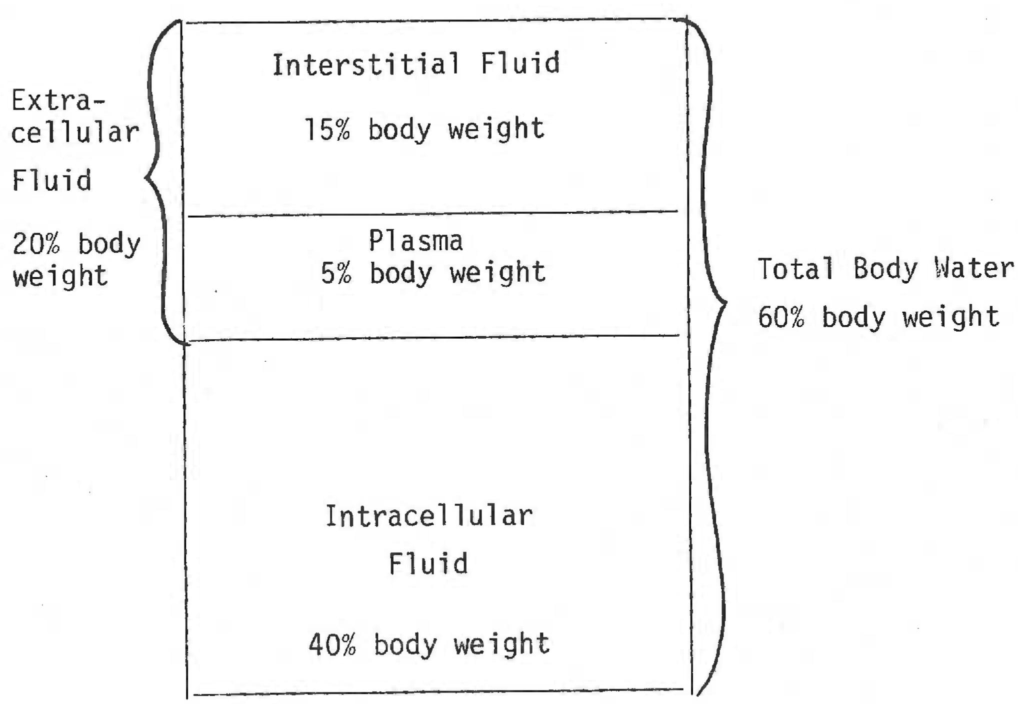


Figure 1. Distribution of total body water in the adult.

When it becomes necessary to assess fluid and electrolyte balance, we can obtain a sample from the plasma compartment for analysis, but we do not have direct access to either the interstitial or intracellular fluid compartments. The composition of the sample of plasma may be determined very precisely via chemical analysis. If one assumes that the protein concentration of interstitial fluid is negligible compared to plasma, the composition of interstitial fluid can be inferred from that of the plasma. The composition of intracellular fluid cannot be estimated in this fashion. Without a suitable marker, the plasma volume cannot be determined from chemical analysis. Further, since there is no direct access to the interstitial and intracellular compartments, direct measurement of the volume of these spaces is impossible. Therefore, some other indirect method is necessary for assessment of fluid volume.

A balance of fluid volume means that gains in body water equal losses in body water volume. In the discussion that follows, the term fluid balance connotes the balance of fluid volume. In the healthy adult, the body gains fluid from the ingestion of food and drink, plus water produced as a byproduct of metabolism. Fluid is lost in urine, sweat, feces and insensibly. Water is excreted insensibly as water vapor through the pores of the skin and also by the lungs during exhalation. Table I shows the average amount of fluid gained and lost by an adult each day.

Table 1. Normal routes of water gain and loss in adults. (Adapted from Vander, 1975).

Intake Source	Amount
Orally ingested	1,200 ml.
In food	1,000 ml.
Metabolically produced	350 ml.
Total water intake per 24 hours	2,550 ml.
Output	
Urine	1,500 ml.
Insensible (skin and lungs)	900 ml.
Sweat	50 ml.
In feces	100 ml.
Total water output per 24 hours	2,550 ml.

In the hospital setting, volume of intake and output is recorded forany patient who may be suspected of developing a fluid imbalance. These data are frequently called intake and output records, I & O records, or simply, intake and output. Historically, intake and output has been used to aid assessment of fluid balance. Nurses working in hospitals spend a great deal of time measuring and recording intake and output. Recently, the value of intake and output as a measure of fluid balance has been questioned. Some authors believe that daily change in body weight is a much better, and perhaps the only accurate, indicator of fluid balance (Gillis, 1978; Grant & Kubo, 1975; Valtin, 1979).

At present, weight gain over a 24-hour period is interpreted clinically to mean a gain in extracellular fluid alone (Valtin, 1979).

On the other hand, studies have shown that daily weight changes in patients receiving hyperalimentation may indicate changes in lean body mass (Spanier & Shizgal, 1977). In this latter case, change in daily weight may not indicate change in extracellular water alone. Thus, the relationship between body weight changes and difference between recorded intake and output needs to be more clearly defined in the clinical setting. The purpose of this study is to compare the changes in body weight with changes in recorded intake and output and determine what correlation, if any, exists between these two methods of assessing fluid balance. In addition, the relationship between the calculated unmeasured water loss (insensible loss plus perspiration) and (1) body surface area, (2) body temperature, and (3) caloric intake will be examined.

In order to evaluate the relationship between daily body weight changes and difference in recorded intake and output, the following model is used.

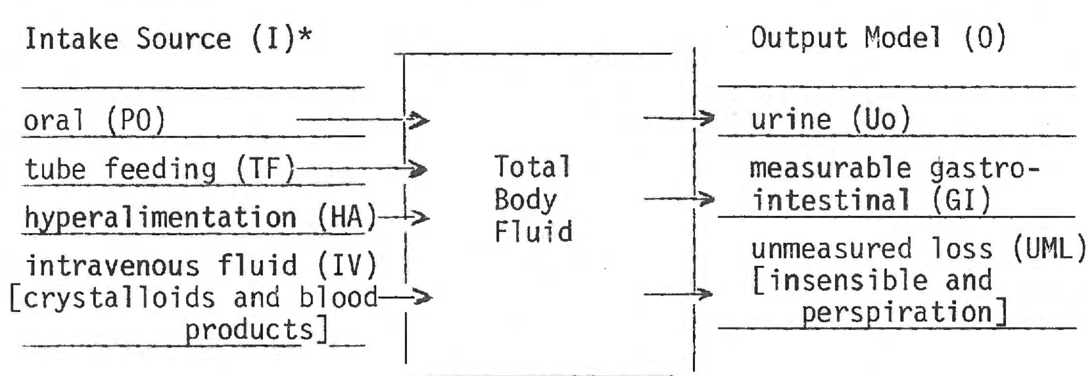


Figure 2. Usual modes of fluid intake and output of the hospitalized patient.

*Patients receiving nebulized oxygen gain up to 300 ml. per day via their respiratory system. This has not been shown to be consistent from patient to patient (Moore, 1972).

The following equations are based on the Fick principle.

$$I-O = \Delta wt^{\circ} \qquad (1)$$

if

$$I= PO+TF+HA+IV \text{ and} \qquad (2)$$

$$O= Uo+GI+WD+UML \qquad (3)$$

then

$$(PO+TF+HA+IV)-(Uo+GI+WD+UML)= \Delta wt \qquad (4)$$

since in this study

$$WD = 0 \qquad (5)$$

then

$$[(PO+TF+HA+IV)-(Uo+GI)] - \Delta wt = UML \qquad (6)$$

and

$$(I-O) - \Delta wt = UML. \qquad (7)$$

$^{\circ}\Delta wt$ = daily change in body weight.

WD = wound drainage

LITERATURE REVIEW

Most of the controversy surrounding the use of intake and output as an accurate indicator of fluid balance centers around the issue of accuracy of the records themselves. Many factors influence the accuracy of intake and output records. The nurse must remember to measure and record all fluid given to the patient. Visitors must not give the patient an extra glass of water without telling the nurse. Urine, diarrhea and emesis must not be discarded before the volume is measured. Large amounts of wound drainage must be measured and counted as output. Lastly, care must be taken to add up daily intake and output records correctly. Failure to carry out any of these measures would make the intake and output records an invalid tool in the assessment of fluid balance.

In a study involving thirty hospitalized patients, Pflaum (1979) examined the issue of accuracy of intake and output records. Each patient was weighed once and then weighed again twenty-four hours later. A record of fluid intake and output was kept for this twenty-four hour period. Weights were then converted into liters using the assumption that 1 kg. change in weight is equivalent to 1 liter. The change in body weight (in liters) minus the difference between intake and output was determined to be an error on the part of those recording intake and output. The reported mean error was 733.30 ml. However, using the data reported by Pflaum, this investigator found a mean error of 752.69 ml. with a standard deviation of 546.38 ml. Pflaum concluded that the majority of intake and output records are inaccurate. The element that Pflaum did not consider in her study was that of insensible water loss. Insensible water loss must be added into the intake and output record in order to determine fluid balance (see Table 1). Without the addition of this loss, the computed daily fluid balance would be in error by 600 to 900 ml. (Shires & Canizaro, 1979; Trunkey, 1975).

Several factors are said to influence insensible loss. These include increased body heat due to increased metabolic rate, fever and changes in ambient air temperature. Studies have shown a strong correlation between basal energy metabolism and insensible water loss. Other studies have shown that intravenous hyperalimentation increases metabolic rate (Marks, Farrell, Friedman & Maisels, 1979). Based on the findings of these prior studies, Marks et al. (1979) studied the effect of continuous intravenous hyperalimentation on insensible water loss in low birth weight infants.

Each infant received three separate solution, each infused over a period of three hours. Solution 1 contained 10% dextrose in 0.225% NaCl (low calorie), solution 2 contained 10% dextrose plus amino acids (moderate calorie), and solution 3 contained 10% dextrose, amino acids and commercial intravenous fat emulsion (high calorie). The order in which these three solutions were infused was random and 5% dextrose in water was infused for 30 to 60 minutes between each infusion. Marks et al. used changes in the weight of each infant to estimate insensible water loss. Insensible water loss was determined as the difference between expected weight gain due to infused fluid and measured weight gain.

Marks et al. found that during the infusion of amino acids and fat emulsion, the infants had increased insensible loss which was attributed to increased metabolism and heat production. The higher caloric density of the intravenous fat emulsion is the factor to which the authors attribute the increased insensible loss.

On the basis of this study, Marks et al. could draw no conclusions about the relationship between insensible water loss and energy utilization during prolonged periods of intravenous nutrition. Marks et al. did not measure internal body temperature, but kept abdominal skin temperature at a constant value of 36.5 C. This is in keeping with the findings of other investigators of a positive correlation between patient's body temperature and insensible loss. In adults, for each degree celsius increase in body temperature per day above normal, insensible water loss is usually increased by no more than 250 ml. (Shires & Canizaro, 1979).

Lamke, Nilsson and Reithner (1977) studied the effect of ambient air temperature on water loss from the skin. They also sought to determine whether a small number of measurement points could be used to estimate total cutaneous water loss. Ten healthy volunteer subjects (5 men and 5 women) were placed in a specially constructed climate chamber. Water loss was measured at three different ambient temperatures after a forty minute equilibration time. At each temperature, the mean evaporation rate from nine different sub-regions of the body surface of each subject was estimated from measurements made at a point located within each sub-region. The data obtained showed a positive correlation between insensible water loss and ambient air temperature. Lamke et al. found that this correlation was only significant at ambient temperatures greater than 30 C. This is warmer than most hospital rooms. They also found that an accurate assessment of total cutaneous water loss could not be made on the basis of the evaporation rate measured at any single point. However, the average of the water losses measured at three different sub-regions (forearm, chest and abdomen) closely correlated with total cutaneous water loss (correlation coefficient 0.92).

One of Pflaum's assumptions was that change in body weight is an accurate indicator of fluid balance. Other authors support this assumption (Gillis, 1978; Valtin, 1979). Some believe that day-to-day weight changes are due primarily to accumulation or loss of fluid (del Greco, 1979; Hudak, Gallo & Lohr, 1973; Roberts, 1979). In patients receiving intravenous feedings containing no amino acids or fat emulsions, weight change has been shown to correlate well with changes in fluid balance (Spanier & Shizgal, 1977).

This correlation may not be the case with patients receiving hyperalimentation. Hyperalimentation is the intravenous administration of fat emulsions and/or nitrogen (in the form of amino acids) and other nutrients. The purpose of giving hyperalimentation to a patient is to produce an anabolic state, thus increasing the lean body mass (Elebute, 1974). In a study of 35 critically ill patients, Spanier & Shizgal, (1977) tested the efficacy of hyperalimentation. A multiple isotope dilution technique was used to estimate both body cellular and extra-cellular mass. Body fat and lean body mass were calculated from the total body water and weight measurements.

Fifteen of the patients received hyperalimentation solutions containing less than 46 kcal/kg/day for a period of 13.3 ± 1.2 days. The other 20 patients received a hyperalimentation solution containing at least 46 kcal/kg/day for a period of 16.7 ± 1.8 days. The patients who received less than 46 kcal/kg/day had a slight decrease in body weight over the course of the study. The patients who received greater than 46 kcal/kg/day had an increase in body weight. A positive and statistically significant ($p < 0.001$) correlation was observed between the number of kcal/kg/day infused and the mean daily change in body cell mass. There was no net gain in body fluid of either group. The intercept of the regression line indicated that when calories are infused at a rate of 46 kcal/kg/day, the patient can maintain an anabolic state and body weight balance. Other authors have shown positive correlations between kcal/kg/day infused and mean daily changes in body weight in the range of 32.5 to 60 kcal/kg/day (Wretlind, 1972; Zohrab, McHattie, Jeejeebhoy, 1973).

The best method of assessing fluid balance in the clinical area has yet to be determined. The literature suggests that change in body weight is a good indicator of fluid balance in a patient not receiving hyperalimentation. With the patient receiving hyperalimentation, depending on how many kcal/kg/day the patient receives, weight changes may be due to changes in fluid volume or lean body mass or both.

Problem Statement

From a review of the literature, it can be seen that the relationship between daily changes in body weight and difference between intake and output has not been well defined. Measurement of both weight and intake and output are part of accepted nursing practice. These procedures need to be examined further to assess their usefulness in the clinical setting.

In addition, the role of unmeasured loss in the clinical setting needs to be examined. The effect of body temperature, caloric intake and ambient air temperature on insensible loss has been reported in the literature. Whether these factors play a significant role in clinical assessment of fluid balance needs to be addressed. Lastly, it would be useful to be able to predict a patient's daily unmeasured loss on the basis of body surface area. The questions being asked are:

1) What is the relationship between changes in daily body weight and difference between recorded intake and output?

2) What is the relationship between the calculated unmeasured fluid loss and body surface area?

3) What is the relationship between the calculated unmeasured fluid loss and mean daily body temperature?

4) What is the relationship between the calculated unmeasured fluid loss and daily caloric intake?

CHAPTER II

METHODS

Subjects and Setting

Twenty-six hospitalized patients receiving no solid food by mouth were used as subjects in this study. The subjects were between the ages of 28 and 84 and were selected on the basis of availability. Subjects received one or more of the following types of fluid therapy: (1) intravenous crystalloid solutions, (2) intravenous hyperalimentation, or (3) liquid by mouth or nasogastric tube (NG tube). The number of patients receiving each type of fluid is listed in Table 2.

Table 2. Type of fluid received by Patients.

Number of patients	Type of Fluid Received
10	crystalloid solutions only
13	crystalloid solutions and liquids per mouth or NG tube
3	parenteral hyperalimentation and crystalloid solutions

Only patients with intake and output that was both measurable and recorded were used. Dialysis and burn patients as well as patients who were incontinent of urine or feces or had unmeasurable wound drainage or emesis were excluded. All 26 subjects were followed for a period of 48 hours.

The study took place in the intensive care unit (ICU) of a large metropolitan hospital. This setting was selected because fluid intake and output is measured and recorded routinely for all patients. Most patients are weighed daily. Since these measures were being done as part of the patient's routine care, no patient was subjected to additional procedures because of the study.

Data Collection

The major variables of interest in this study are the difference between intake and output, change in weight and unmeasured loss. Other variables include body surface area, daily caloric intake, mean body temperature and ambient air temperature. Data measured included intake, output, body weight, height, body temperature and ambient air temperature. Calculated data included the difference between intake and output, unmeasured loss, corrected body weight, difference between daily weights, body surface area, caloric intake and mean daily body temperature.

Intake and output was measured and recorded by the staff nurses in the ICU. The amount and type of fluid given to and excreted by the patient was recorded on the intake and output record which is part of the patient's chart. The nurses then summed these amounts every 8-hour shift and also every 24 hours (from 7am to 7pm). Most intravenous fluid was administered via an electronic infusion pump. These pumps display the volume infused. The volume recorded as being received by the patient was read from the pump. Otherwise, the amount of intravenous fluid received by the patient was measured by use of a 100 or 250 ml. graduated infusion set. To estimate the volume of blood infused, the following values were considered standard: (1) 250 ml. per unit of packed red blood cells and (2) 500 ml. per unit of whole blood.

Urine output and chest tube drainage was measured, recorded hourly and summed for every shift. Gastrointestinal drainage was collected in a disposable graduated container, measured and recorded every shift. The volume of liquid stool and emesis was also measured in graduated pitchers and the volumes recorded.

The investigator initially measured each patient's height using a tape measure with the patient supine in a flat bed. Discrepancies of 1 to 3 inches were found between this measurement and the standing measurement obtained at the time of the patient's admission. These differences were most likely due to the soft mattresses that made it difficult to assure that the patient was really flat. Therefore, the heights used to calculate body surface area are those obtained at admission.

Patients were weighed daily in the early morning by a nurse and patient aide. The Scale-tronix brand digital scale was set at a reading of zero before each patient was weighed. The patient's weight was recorded in his/her chart. The time weighed and what type of clothing the patient was wearing when weighed was also recorded.

Body temperature was measured by the nurses using either a glass thermometer or an IMED brand electronic thermometer. All temperatures were taken rectally every one to four hours and recorded in the nurse's notes.

Ambient air temperature was checked by the investigator each day at different times and was found to vary between only 66 and 70 degrees Farenheit. Thus, ambient air temperature was not considered to be a variable in this study.

All of the individual intake and output entries recorded by the nurses between the time of one daily weight measurement and the next were summed by the investigator. This daily output figure was then subtracted from the sum of all of the intake.

The individual daily weights recorded by the nurses were corrected for clothing worn when weighed. Patients were covered with either a drawsheet, towel, bath blanket, pillowcase or gown when weighed. Fifteen of each item were weighed separately by the investigator on the same scale used to weigh the patient. An average weight of each item was calculated by the investigator. This average weight was subtracted from the recorded weight to obtain corrected weight. The corrected weight thus obtained was then subtracted from the following days corrected weight to obtain the change in body weight.

Unmeasured water loss (UML) was calculated by subtracting daily change in body weight (liters) from the difference between intake and output for the same time period.

Body surface area was obtained from a nomogram which correlates height, weight and surface area (Freitag & Miller, 1980).

The number of milliliters of each type of fluid received by the patient was multipled by the caloric concentration (kcal/ml) of that fluid. The number of calories received in the time between each daily weight measurement was then calculated. The number of kilocalories received per day was then divided by the patient's weight in kilograms to determine the rate of caloric intake (kcals/kg/day).

The temperatures recorded by the nurses were averaged for every four-hour period. All of the four-hour average temperatures between the daily weights were then averaged to find a mean daily temperature.

Part of unmeasured loss is that which is lost via the respiratory system. Delivery of nebulized oxygen may affect unmeasured loss. Therefore, mode of oxygen administration was recorded for each patient.

CHAPTER III

RESULTS

Data was analyzed for 26 subjects for two consecutive days (Day I and Day II). Comparisons were made based on two major categories: (1) mean daily body temperature and (2) mode of oxygen delivery. Temperature groups include: (1) all subjects in all body temperature ranges, (2) subjects with mean daily body temperatures between 36.4 and 37.5^{o} C. and (3) subjects with mean daily body temperatures greater than 37.5^{o} C. Subjects in these temperature groups were divided on the basis of mode of oxygen delivery. These subgroups include: (1) subjects receiving continuous mechanical ventilation, (2) subjects receiving heated mist per endotracheal tube or mask and (3) subjects not on ventilators or receiving mist.

All Subjects, All Temperature Ranges

Comparisons between change in daily weight and the calculated difference between intake and output for Day I and Day II are shown in Figures 3 and 6 and Tables 3 and 4. The correlation coefficient, r, for Day I was 0.76 and the slope was 0.97. For Day II, the correlation coefficient was 0.74 and the slope was 1.20. The value of the correlation coefficient (Pearson's r) was low for the following relationships: (1) body surface area and unmeasured loss (UML) (Figures 9 and 10, Table 7), (2) mean daily body temperature and UML (Figures 11 and 12, Table 8) and (3) daily caloric intake and UML (Figures 13 and 14, Table 9) in all temperature ranges. The mean values of UML for all subjects for both days were not different at 0.68 l $\pm$ 1.02 l (Day I) and 0.75 l $\pm$ 1.08 l (Day II) (Tables 5 and 6).

All Subjects with Mean Daily Body Temperatures Between 36.4 and 37.5^{o} C.

The correlation coefficients for change in daily weight and difference between intake and output varied considerably from Day I to Day II in this temperature range. For Day I, the value of r was 0.94 and for Day II, 0.65.

The values of the slopes (determined by linear regression analysis) for the two days was quite similar (Figures 4 and 7, Tables 3 and 4). However, the mean UML for Day I was 0.42 l while that for Day II was 0.16 l (Tables 5 and 6).

All Subjects with Mean Daily Body Temperatures Greater than 37.5^{o} C.

The correlation coefficients obtained from the analysis of change in daily weight and difference between intake and output for Day I and Day II were close in value. For Day I, r was 0.74 while for Day II it was 0.79. The values of the slopes, obtained from regression analysis, were also close in value (Figures 5 and 8, Tables 3 and 4). Mean daily UML was higher in this group than in the other two temperature groups. The mean values for UML was 0.92 l for Day I and 1.02 l for Day II (Tables 5 and 6).

All Temperatures, Different Modes of O_2 Administration

The correlation coefficients relating change in weight and the difference between intake and output for patients on ventilators varied little between Day I and Day II. However, the slopes for this subgroup varied considerably. The correlation coefficient for patients on heated mist was 0.83 for Day I and 0.94 for Day II. The slope was 1.11 on Day I and 0.78 on Day II. Pearson's r for patients not receiving oxygen via mechanical ventilator or heated mist was 0.91 for Day I and 0.82 for Day II. The slope obtained for Day I was 1.24 and 1.36 for Day II. (See Figures 3 and 6, Tables 3 and 4).

Results obtained from comparing the relationship between body surface area and unmeasured loss was not consistent from Day I to Day II within subgroups. Correlation coeficients ranged from -0.11 to 0.68 (Table 7). Slopes ranged between -0.77 and 6.58 (Figures 9 and 10, Table 7). Mean daily unmeasured loss varied considerably from Day I to Day II within subgroups. Means ranged from 0.01 l to 1.25 l (Tables 5 and 6).

Temperatures 36.4 to 37.5^o C., Different Modes of O_2 Administration

Only one person receiving oxygen with heated mist had a normal body temperature, thus no comparisons can be made using this subgroup. Correlation coefficients and slopes varied from Day I to Day II within the other two subgroups (Figures 4 and 7, Tables 3 and 4). Further, the mean daily unmeasured loss varied considerably from Day I to Day II (Tables 5 and 6).

Temperatures Greater than 37.5^o C., Different Modes of O_2 Administration

No consistent correlation or slope was found between daily changes in weight and difference between intake and output from Day I to Day II within each subgroup. Correlation coefficients ranged from 0.52 to 0.96 and slopes varied from 0.78 to 2.80 (Figures 5 and 8, Tables 3 and 4). Values for mean unmeasured loss varied from 0.74 l to 1.25 l in these subgroups (Tables 5 and 6).

Table 3. Correlations Between Weight Change and Difference Between Intake and Output (Day I).

All Body Temperature Ranges

	All Subjects	Ventilator	Heated Mist	Neither
R	0.76	0.75	0.83	0.91
Slope	0.97	0.79	1.11	1.24
Intercept	-0.65	-0.95	-1.33	0.04
N	26	12	5	9

Mean Daily Body Temperatures 36.4 → 37.5°C.

	All Subjects	Ventilator	Heated Mist	Neither
R	0.94	0.95		0.98
Slope	1.34	1.14		1.35
Intercept	-0.28	-0.66		0.21
N	9	5	0	4

Mean Daily Body Temperatures > 37.5°C.

	All Subjects	Ventilator	Heated Mist	Neither
R	0.74	0.52	0.83	0.96
Slope	1.02	1.08	1.11	1.21
Intercept	-0.71	-0.89	-1.33	0.04
N	17	7	5	5

Figure 3. Daily weight change (liters) vs difference between intake and output (liters) for all subjects for Day I.

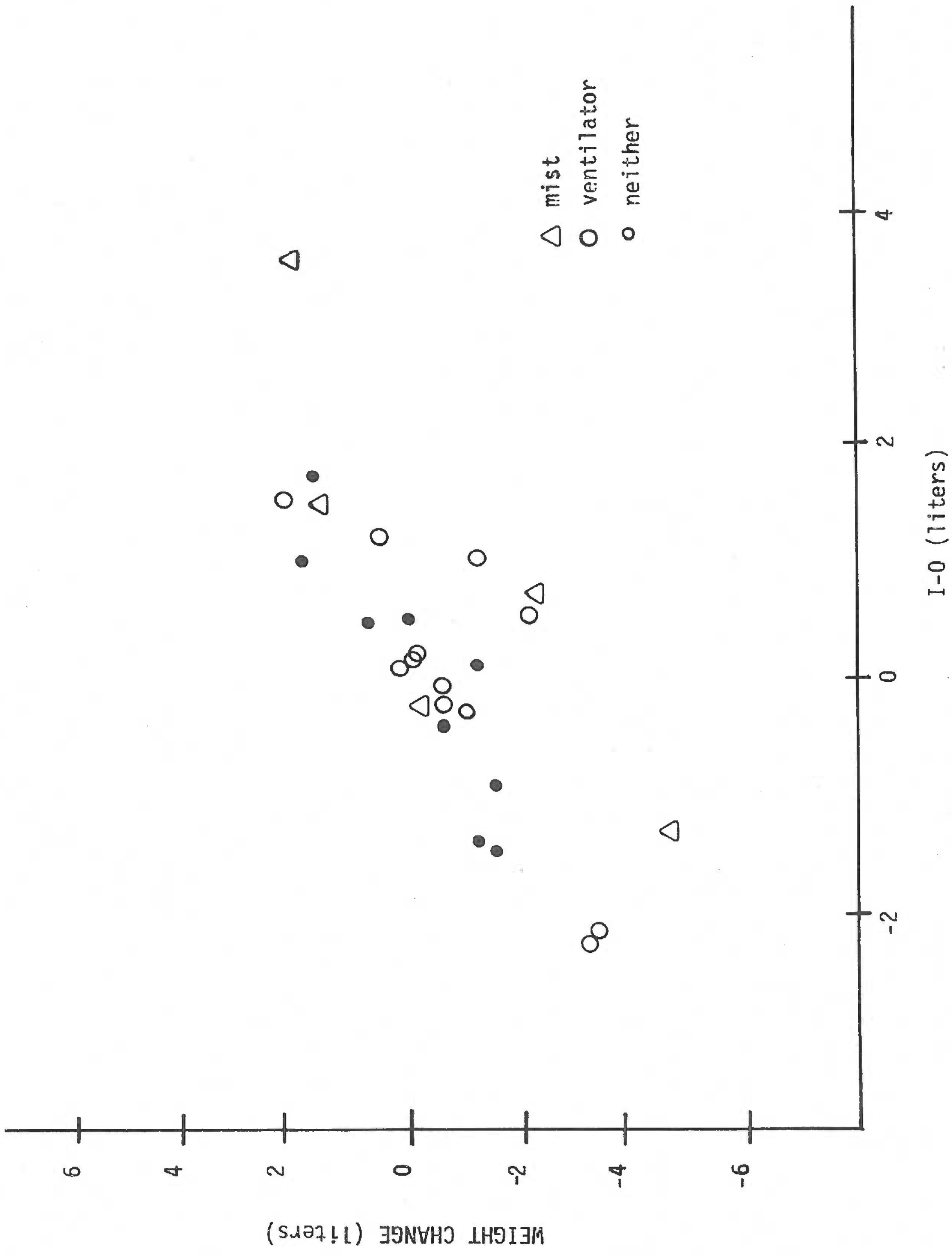
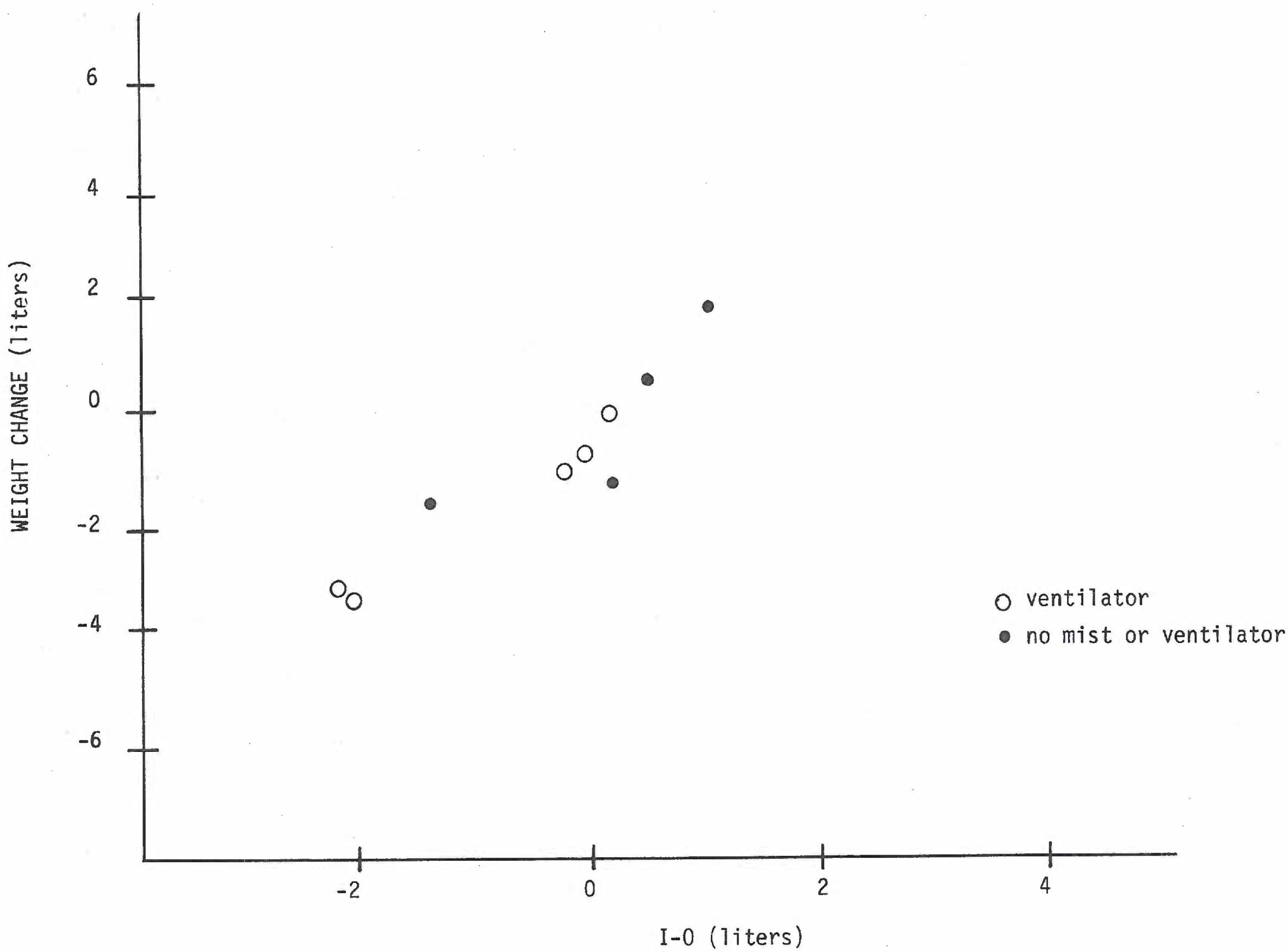
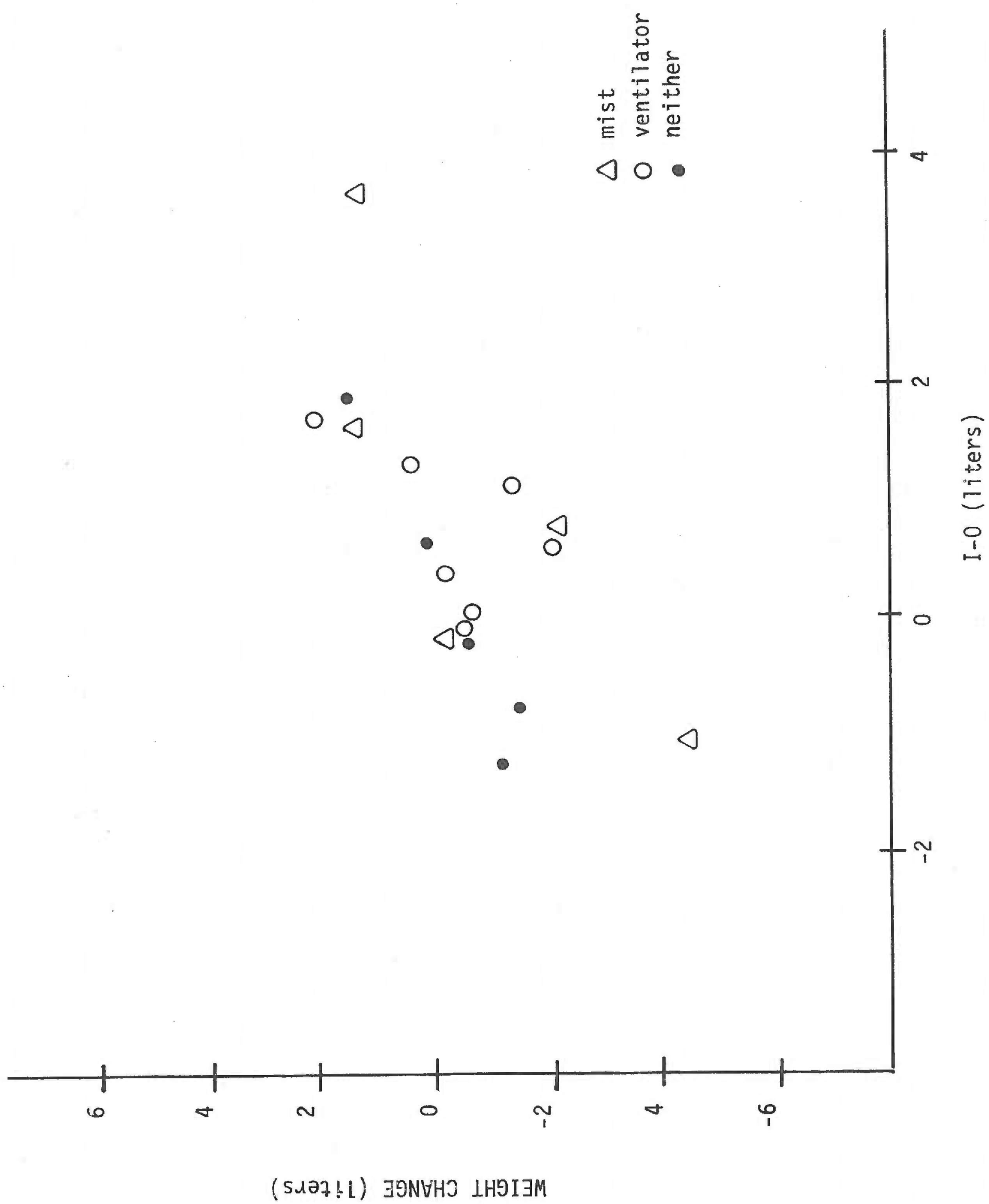

△ mist
○ ventilator
• neither
I-O (liters)
WEIGHT CHANGE (liters)
-2
0
2
4
6
-4
-6

Figure 4. Daily weight change (liters) vs difference between intake and output (liters) for all subjects with mean daily body temperatures between 36.4 and 37.5^{o} C. (Day I).



WEIGHT CHANGE (liters)
6
4
2
0
-2
-4
-6
-2
0
2
4
I-O (liters)
ventilator
no mist or ventilator

Figure 5. Daily weight change (liters) <u>vs</u> difference between intake and output (liters) for all subjects with mean daily body temperatures greater than 37.5^{o} C. Day I).



mist
ventilator
neither
I-O (liters)
-2
0
2
4
WEIGHT CHANGE (liters)
6
4
2
0
-2
4
-6

Table 4. Correlations Between Weight Change and Difference Between Intake and Output (Day II).

All Body Temperature Ranges

	All Subjects	Ventilator	Heated Mist	Neither
R	0.74	0.79	0.94	0.82
Slope	1.20	2.74	0.78	1.36
Intercept	-0.72	-1.03	-1.02	-0.51
N	26	12	5	9

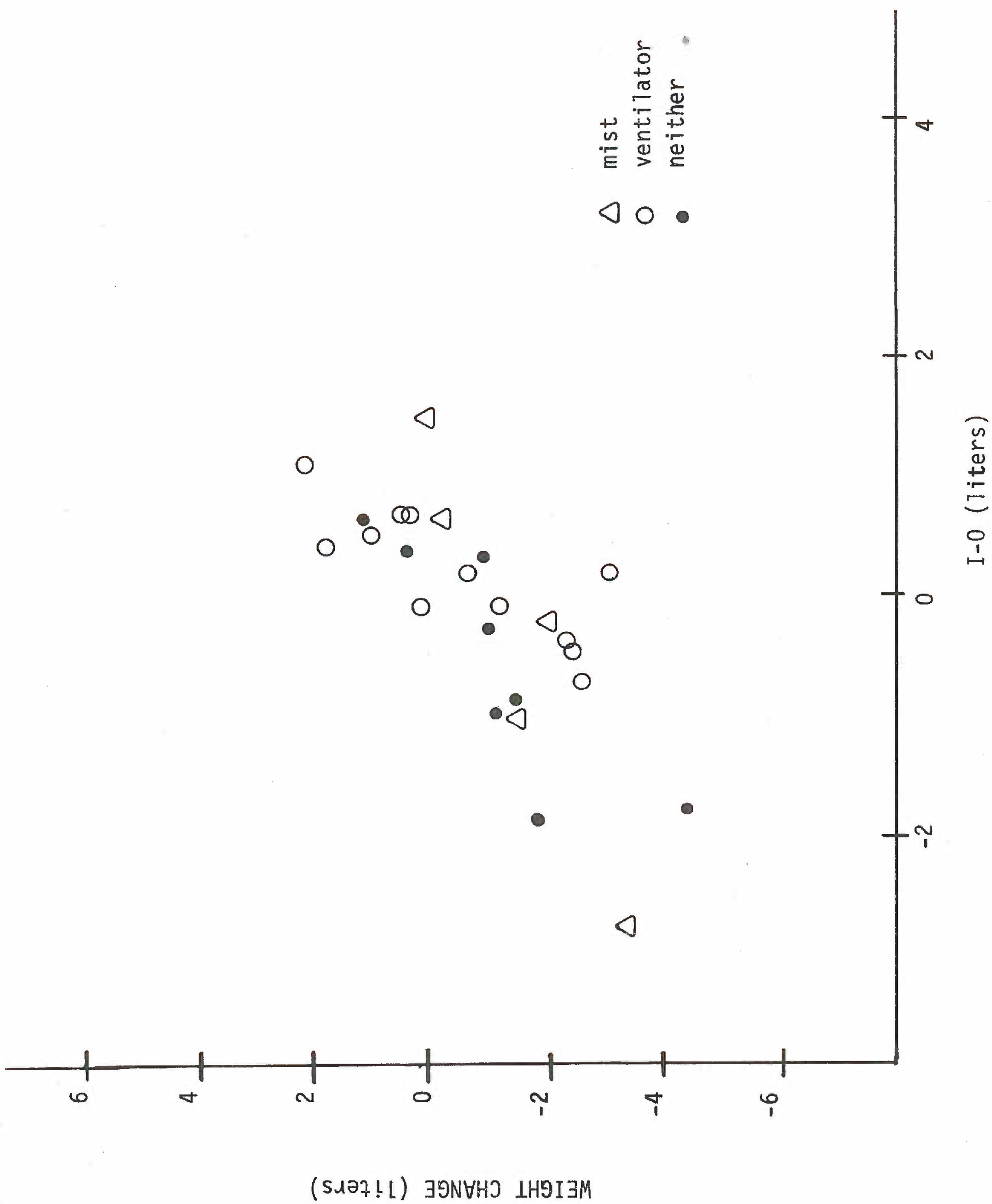
Mean Daily Body Temperatures 36.4 → 37.5°C.

	All Subjects	Ventilator	Heated Mist	Neither
R	0.65	0.79		0.79
Slope	1.30	3.06		1.16
Intercept	-0.33	-0.59		-0.98
N	8	5	1	2

Mean Daily Body Temperatures > 37.5°C.

	All Subjects	Ventilator	Heated Mist	Neither
R	0.79	0.88	0.94	0.87
Slope	1.16	2.80	0.78	1.59
Intercept	-0.98	-1.50	-1.02	-0.72
N	18	7	4	7

Figure 6. Daily weight change (liters) <u>vs</u> difference between intake and output (liters) for all subjects for Day II.



mist
ventilator
neither
WEIGHT CHANGE (liters)
6
4
2
0
-2
-4
-6
I-0 (liters)
-2
0
2
4

Figure 7. Daily weight change (liters) _vs_ difference between intake and output (liters) for all subjects with mean daily body temperatures between 36.4 and 37.5° C. (Day II).

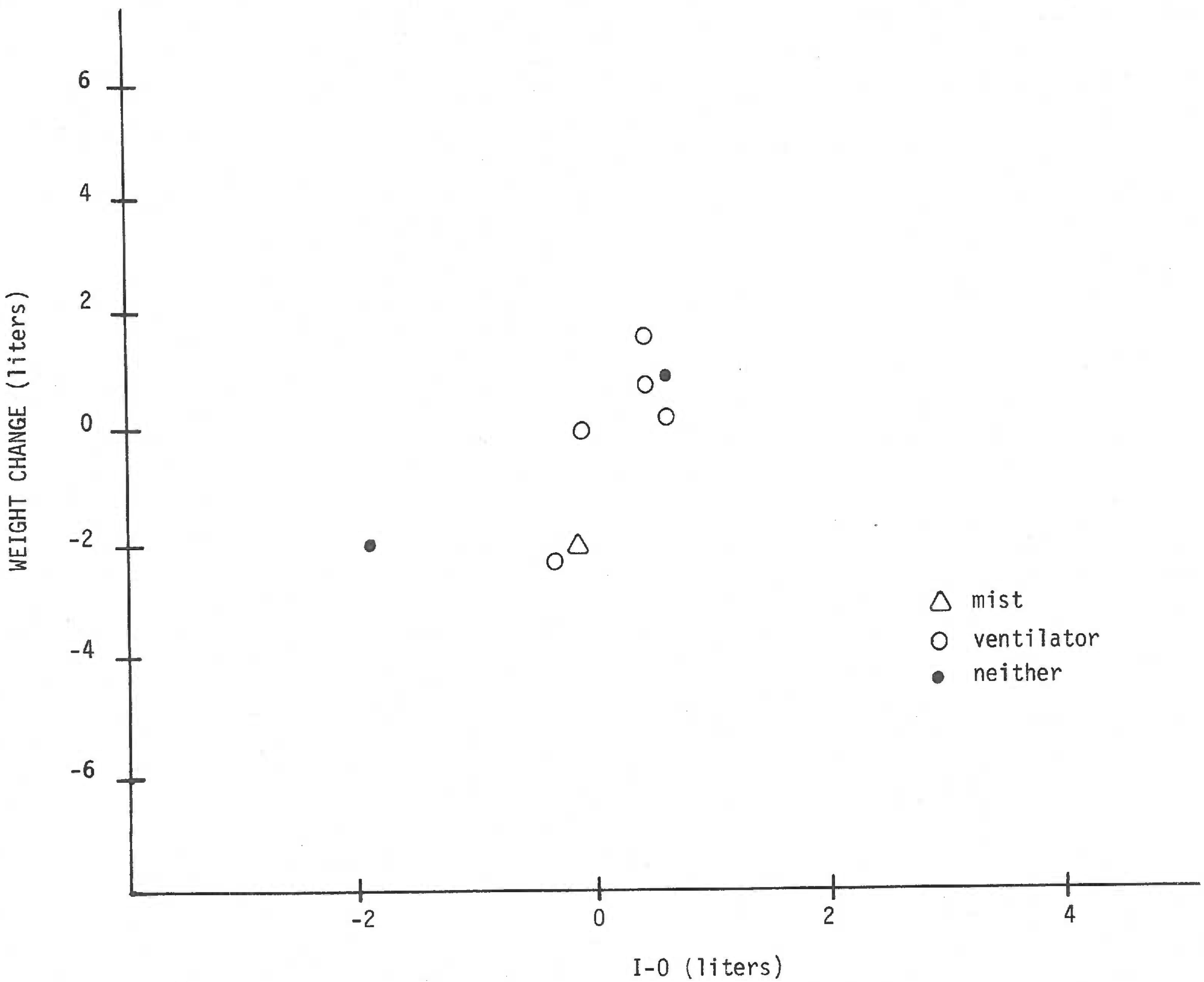

WEIGHT CHANGE (liters)
6
4
2
0
-2
-4
-6
-2
0
2
4
I-0 (liters)
mist
ventilator
neither

Figure 8. Daily weight change (liters) _vs_ difference between intake and output (liters) for all subjects with mean daily body temperatures greater than 37.5^{o} C. (Day II).

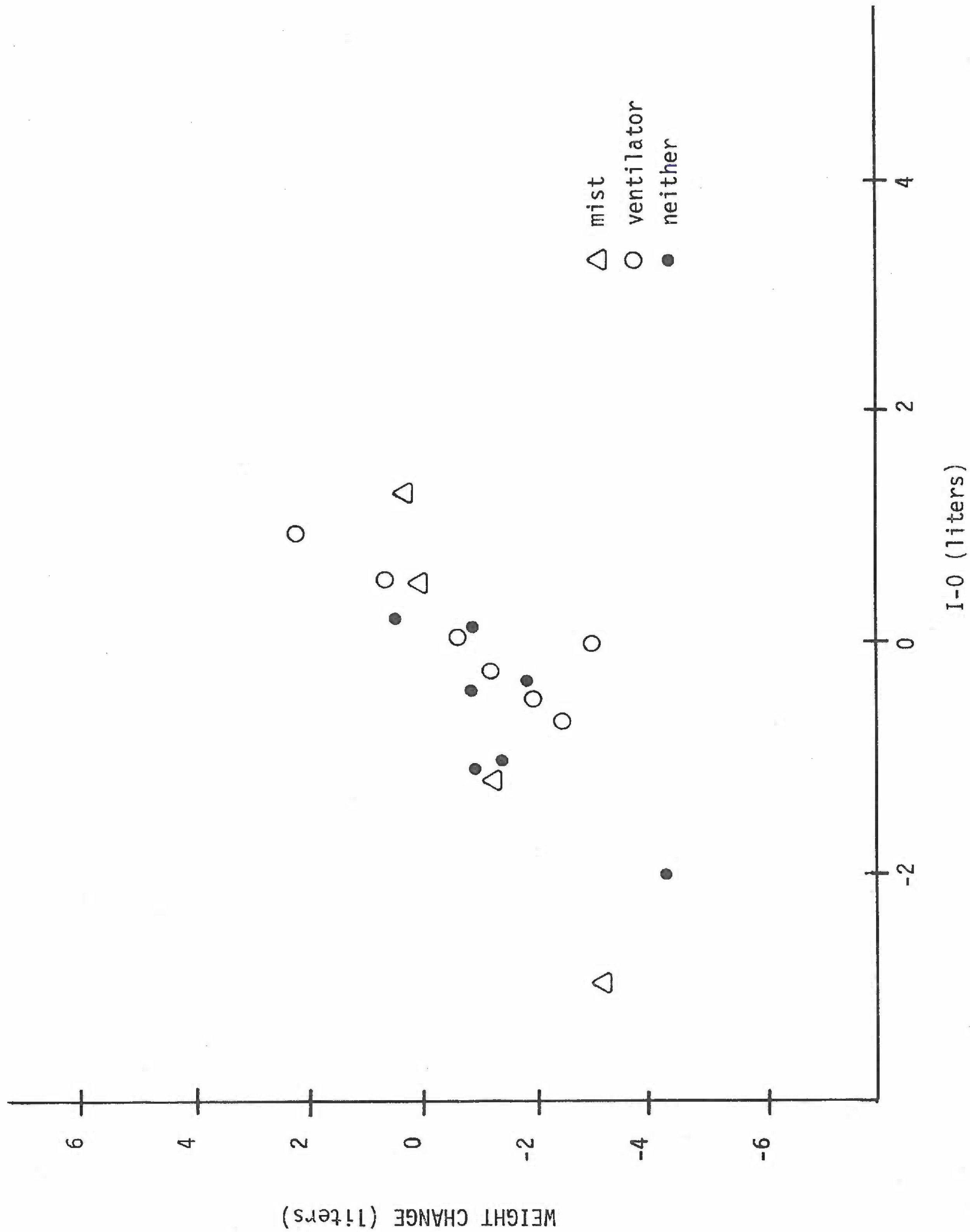

mist
ventilator
neither
I-O (liters)
WEIGHT CHANGE (liters)
-2
0
2
4
6
-4
-6

Table 5. Mean and Standard Deviations of Unmeasured Loss (Day I).

All Body Temperature Ranges

	All Subjects	Ventilator	Heated Mist	Neither
$\bar{X}$	0.68	0.95	1.25	0.01
SD	1.02	0.82	1.44	0.68
N	26	12	5	9

Mean Daily Body Temperatures 36.4 ⟶ 37.5°C.

	All Subjects	Ventilator	Heated Mist	Neither
$\bar{X}$	0.42	0.65		0.13
SD	0.65	0.38		0.90
N	9	5	0	2

Mean Daily Body Temperatures > 37.5°C.

	All Subjects	Ventilator	Heated Mist	Neither
$\bar{X}$	0.92	1.17	1.25	0.74
SD	1.07	0.99	1.44	0.73
N	17	7	5	5

Table 6. Mean and Standard Deviations of Unmeasured Loss (Day II).

All Body Temperature Ranges

	All Subjects	Ventilator	Heated Mist	Neither
$\bar{X}$	0.75	0.70	0.97	0.70
SD	1.08	1.35	0.62	0.96
N	26	12	5	9

Mean Daily Body Temperatures 36.4 ⟶ 37.5°C.

	All Subjects	Ventilator	Heated Mist	Neither
$\bar{X}$	0.16	0.04		
SD	1.14	1.20		
N	8	5	1	2

Mean Daily Body Temperatures > 37.5°C.

	All Subjects	Ventilator	Heated Mist	Neither
$\bar{X}$	1.02	1.15	0.87	1.01
SD	0.97	1.46	0.49	0.84
N	18	7	4	7

Table 7. Correlations between Body Surface Area and Unmeasured Loss for Day I and Day II (All Temperature Ranges).

Day I

	All Subjects	Ventilator	Heated Mist	Neither
R	0.03	0.00	-0.11	0.14
Slope	0.12	-0.01	-0.55	0.64
Intercept	0.45	0.97	1.94	-1.21
N	26	12	5	9

Day II

	All Subjects	Ventilator	Heated Mist	Neither
R	0.37	-0.58	0.68	-0.11
Slope	1.98	3.06	6.58	-0.77
Intercept	-2.91	-4.78	-11.00	2.17
N	26	12	5	9

Figure 9. Unmeasured loss (liters) vs body surface area (m^2) for all subjects for Day I.

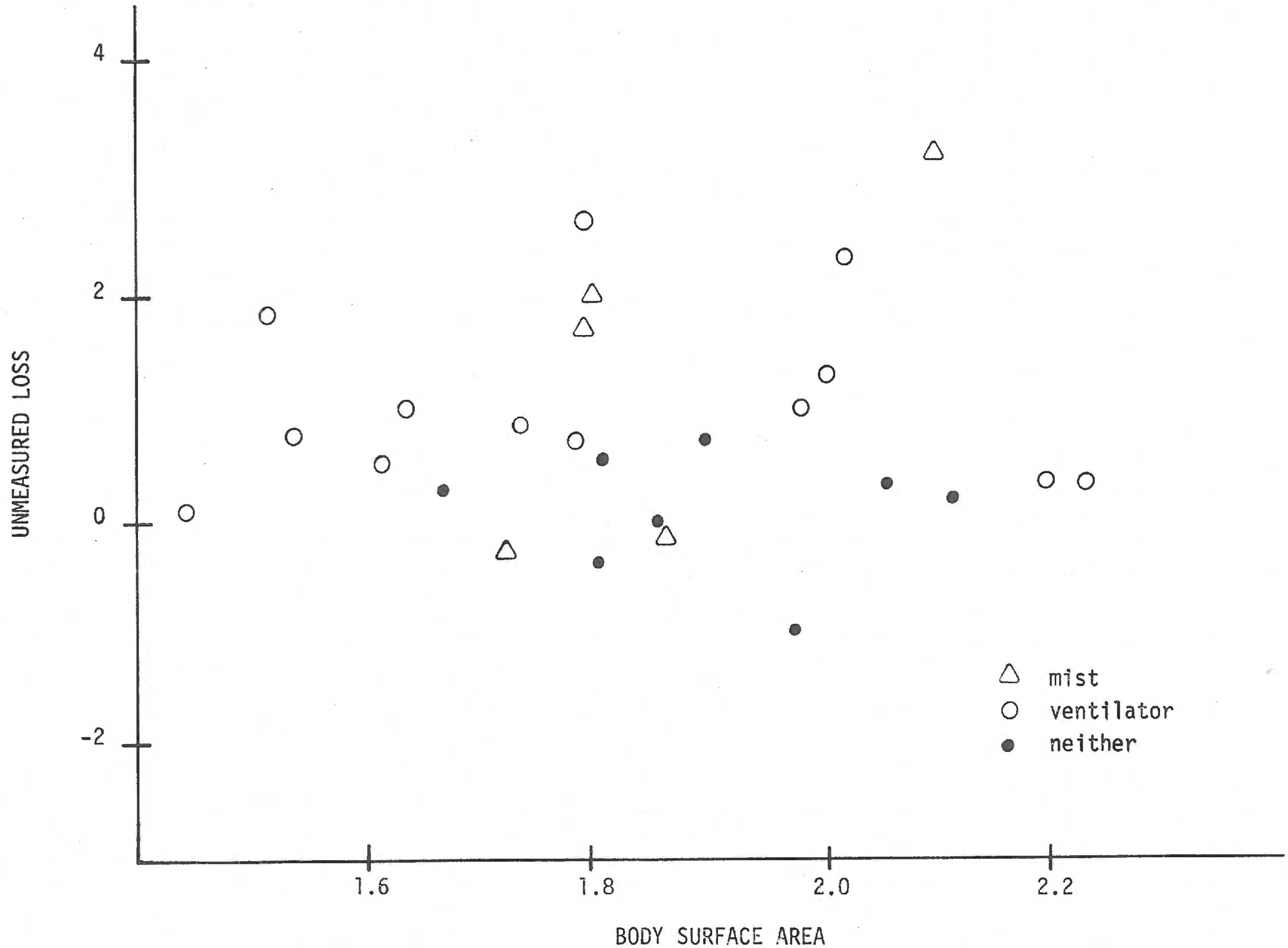

UNMEASURED LOSS
4
2
0
-2
1.6
1.8
2.0
2.2
BODY SURFACE AREA
mist
ventilator
neither

Figure 10. Unmeasured loss (liters) vs body surface area (m^2) for all subjects for Day II.

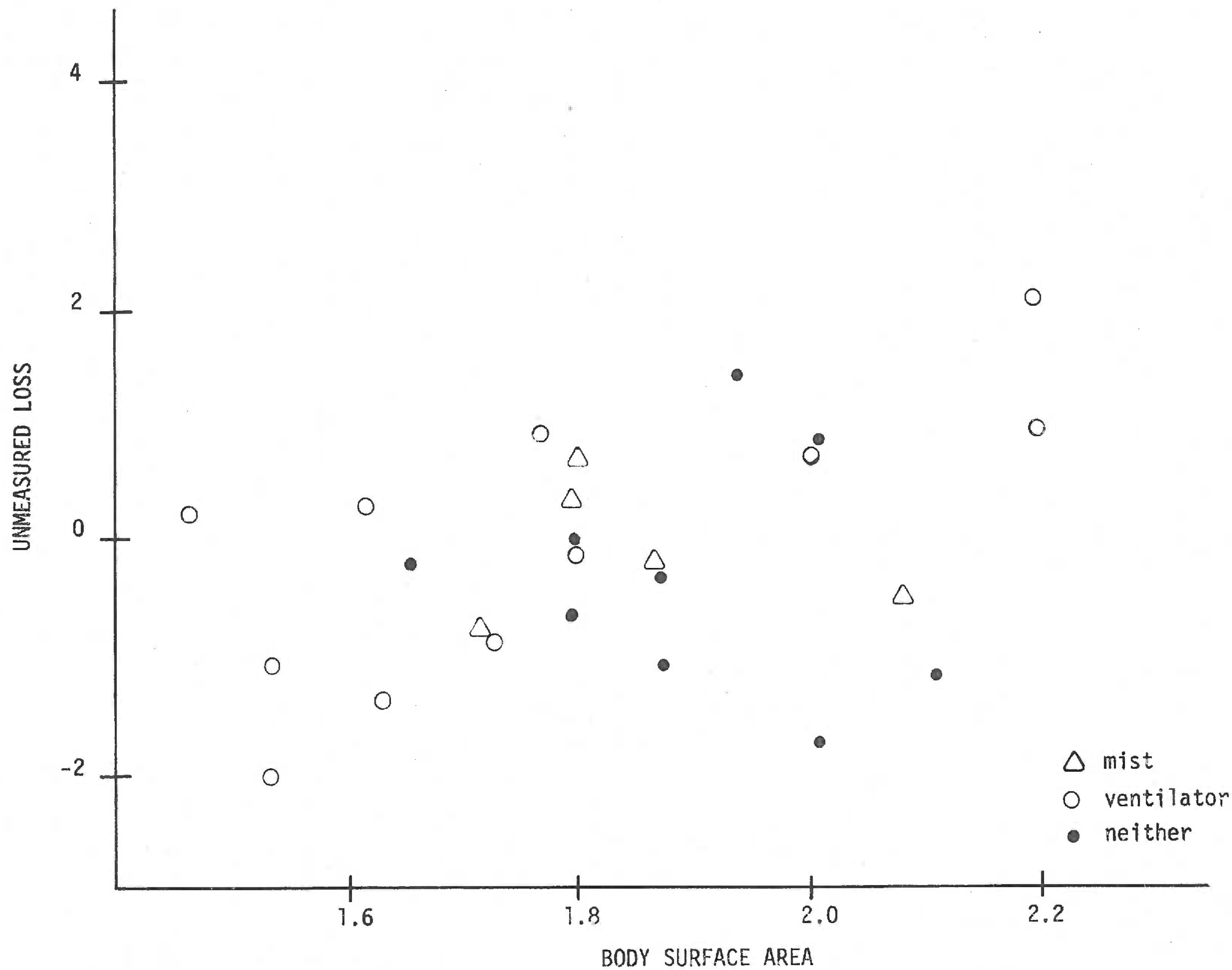

UNMEASURED LOSS
4
2
0
-2
1.6
1.8
2.0
2.2
BODY SURFACE AREA
mist
ventilator
neither

Table 8. Correlations Between Mean Daily Body Temperature and Unmeasured Loss for Day I and Day II (All Temperature Ranges)

Day I

N = 26	Slope = 0.08
R = 0.04	Intercept = -2.23

Day II

N = 26	Slope = 0.41
R = 0.24	Intercept= -14.81

Figure 11. Unmeasured loss (liters) _vs_ mean daily body temperature ($^{o}C.$) for all subjects for Day I.

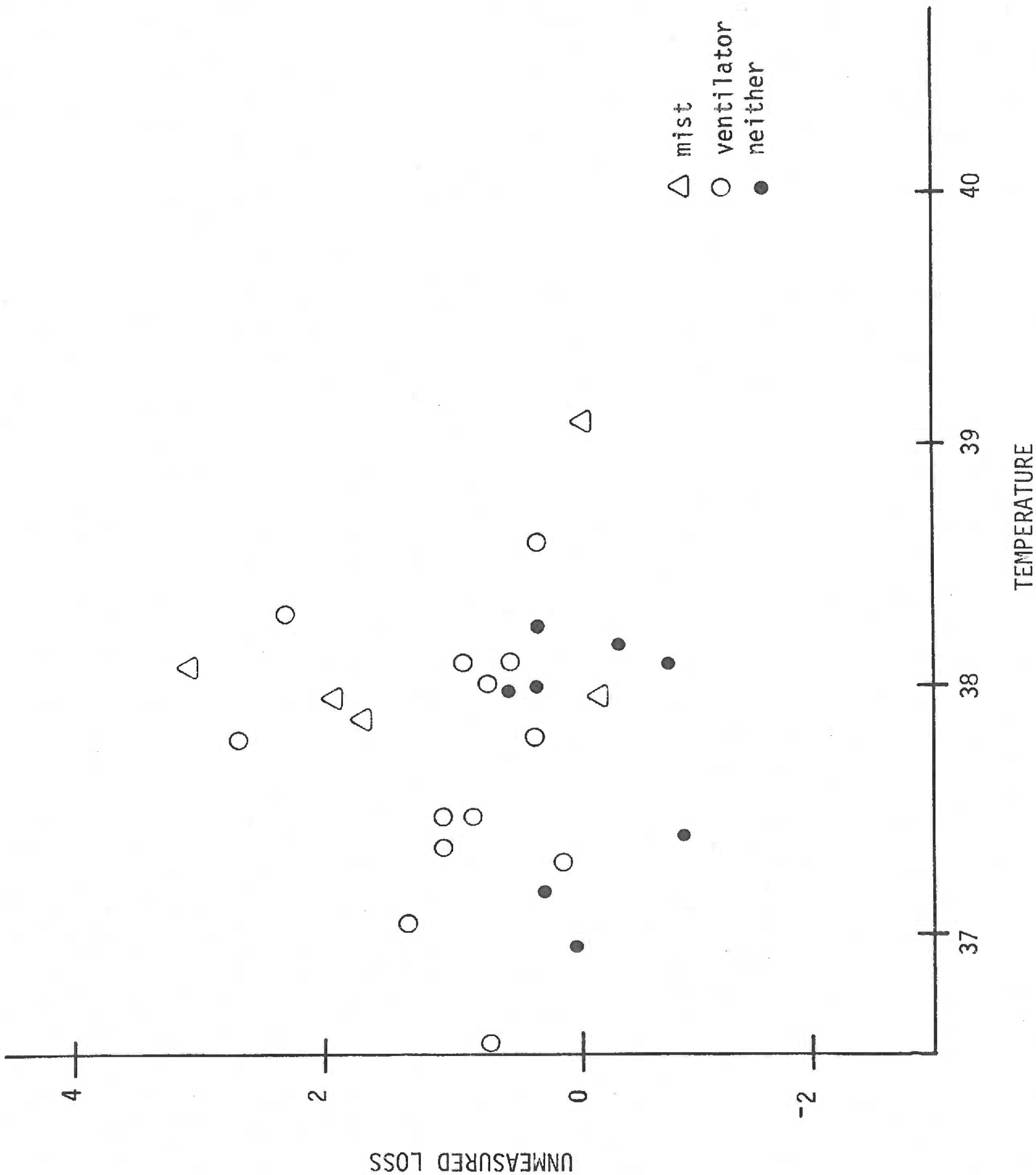

mist
ventilator
neither
TEMPERATURE
37
38
39
40
UNMEASURED LOSS
4
2
0
-2

Table 9. Correlations Between Kcal/kg/day and Un-Measured Loss for Day I and Day II (All Temperature Ranges).

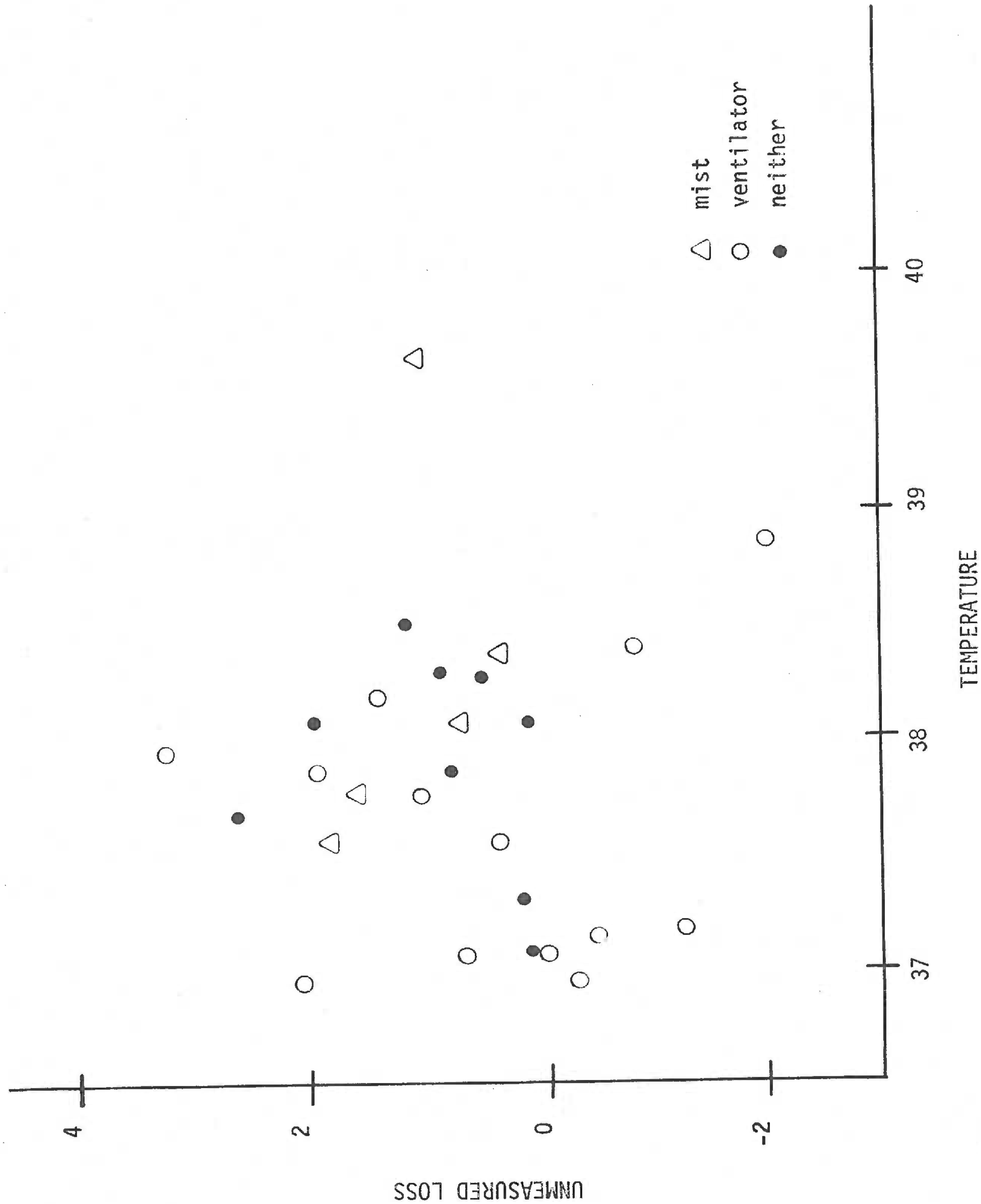
Day I

N = 26		Slope =	0.02
R = 0.26		Intercept =	0.41

Day II

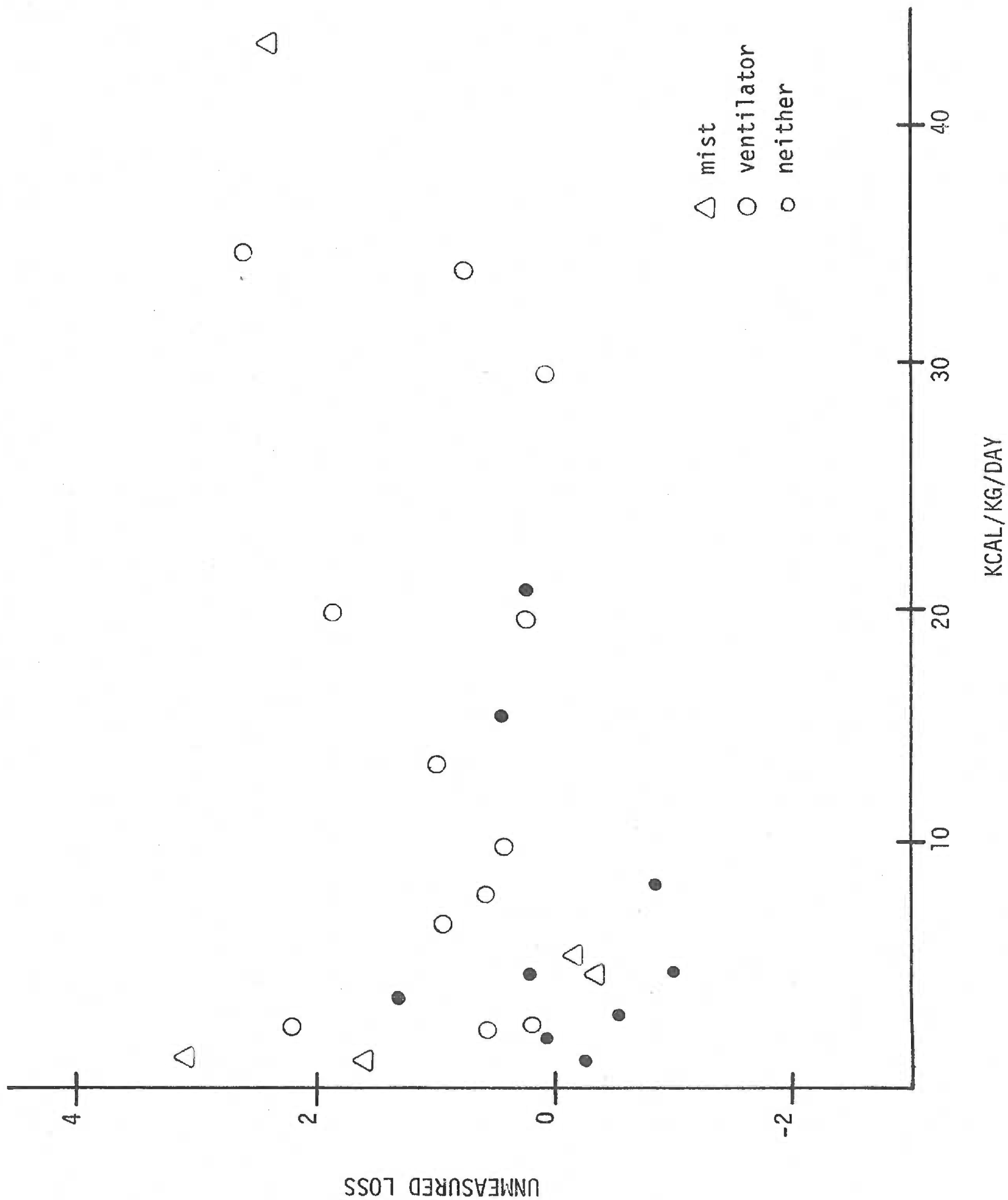
N = 26		Slope =	0.00
R = 0.03		Intercept =	0.79

Figure 12. Unmeasured loss (liters) _vs_ mean daily body temperature (^{o}C.) for all subjects for Day II.



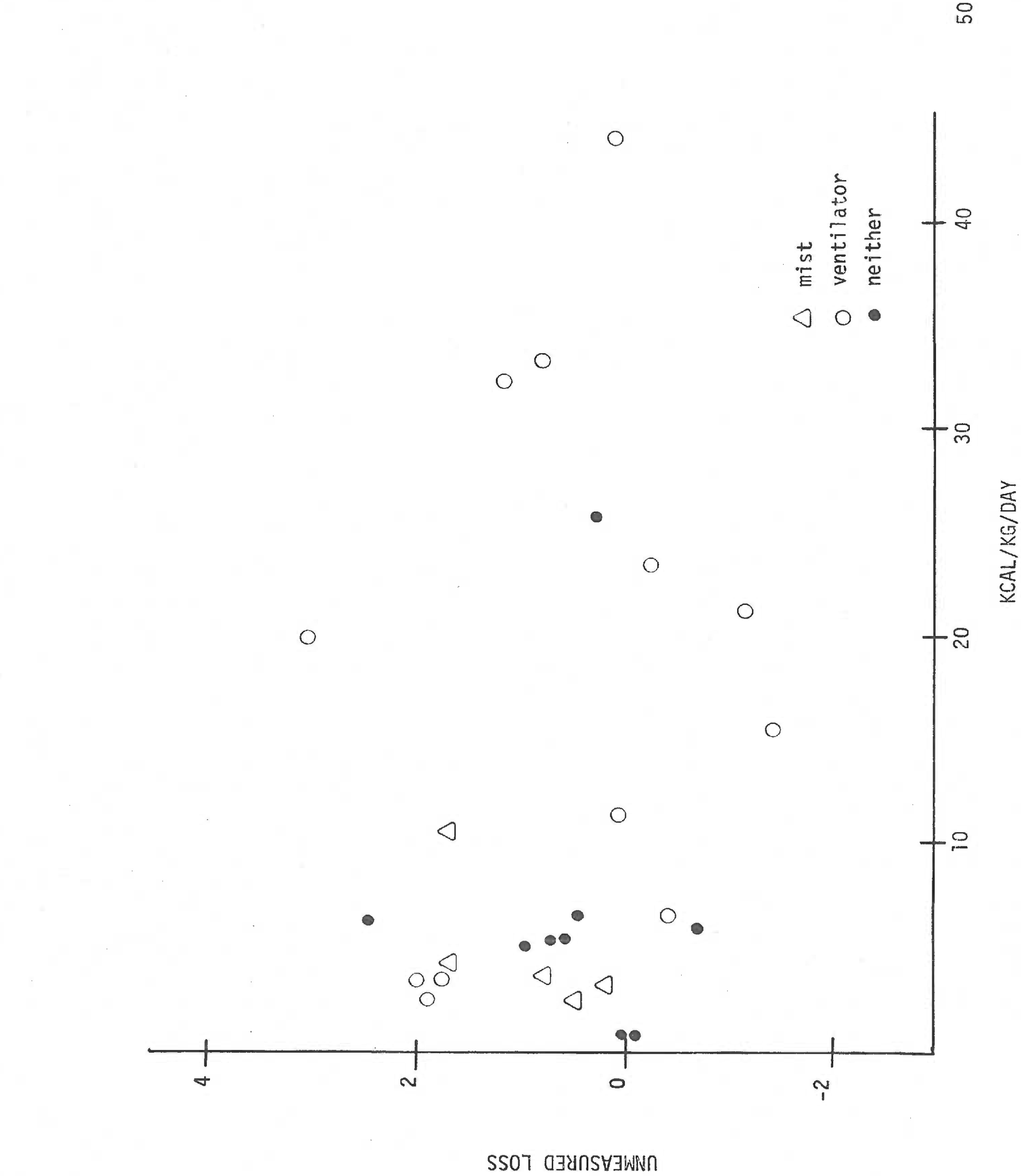
mist
ventilator
neither
TEMPERATURE
37
38
39
40
UNMEASURED LOSS
4
2
0
-2

Figure 13. Unmeasured loss (liters) vs daily caloric intake (kcal/kg/day) for all subjects for Day I.



UNMEASURED LOSS
4
2
0
-2
KCAL/KG/DAY
10
20
30
40
mist
ventilator
neither

Figure 14. Unmeasured loss (liters) vs daily caloric intake (kcal/kg/day) for all subjects for Day II.


UNMEASURED LOSS
KCAL/KG/DAY
4
2
0
-2
10
20
30
40
50
mist
ventilator
neither

CHAPTER IV

DISCUSSION

The findings of this study can be divided into three major groups. First, a positive correlation was found between daily change in body weight and difference in daily intake and output. The correlation coefficients for Day I and Day II were very similar when all subjects were grouped together irrespective of mean daily body temperature (Tables 4 and 5). Second, a low correlation was found in all temperature ranges for the following relationships: (1) body surface area versus unmeasured loss (Table 7), (2) mean daily body temperature versus unmeasured loss (Table 8) and (3) daily caloric intake versus unmeasured loss (Table 9). Lastly, mean daily unmeasured loss for all subjects for both days was within the limits reported in the literature (Tables 5 and 6).

The fact that daily changes in body weight and difference between intake and output correlate positively confirms findings of prior research. In this study, correlation coefficients (Pearson's r) were 0.76 for Day I and 0.74 for Day II (Tables 3 and 4). However, if each subject is looked at individually (as is done in the clinical setting), this correlation is less obvious (Appendix A). For example, subject 8 lost 2.0 kg (equivalent to a 2.0 l fluid loss) while his intake and output record showed a gain of 0.59 l for the same time period. These individual subject variations account for some of the difference in slopes (determined by linear regression) from Day I to Day II.

The low correlations between (1) body surface area and unmeasured loss, (2) mean daily body temperature and unmeasured loss and (3) daily caloric intake and unmeasured loss was unexpected. Since unmeasured loss is thought to consist primarily of insensible loss, a higher positive correlation between body surface area and unmeasured loss was expected. The literature reports that an increase in body temperature produces increased insensible loss (Shires & Canizaro, 1979). Therefore, unmeasured loss and body temperature should correlate in a positive manner. This relationship was not found in this study. Marks et al. found that insensible loss increased with higher caloric intake over a 3-hour period of time. They were unable to show that this relationship held true over a 24-hour period of time. In the present study, essentially no correlation was found between daily caloric intake and unmeasured loss.

Even though daily unmeasured loss (UML) (averaged for all subjects) fell within the clinically accepted range, the individual variation for a given subject was quite marked. Daily UML for an individual subject varied as much as 3.39 l from Day I to Day II. For example, for subject 2, UML for Day I was -1.63 and on Day II UML was +1.76. This is a wide variation and is clearly not within the 0.6 l to 0.9 l range reported in the literature as expected daily insensible loss (Shires & Canizaro, 1979). The fact that a person can have a negative UML (i.e. net gain in body water) is not taken into account in most clinical settings.

There are at least four possible explanations for these discrepancies in calculated UML. These area: (1) errors in measuring and/or recording intake and output, (2) errors in measuring and/or recording daily weight, (3) inaccurate measuring devices, (4) individual differences in daily unmeasured loss. Errors in measuring and/or recording intake, output and body weight can only be minimized by diligence on the part of the person who measures these parameters and records the results obtained.

The accuracy of these measuring devices has not been thoroughly examined and reported in the literature. Calibration of these devices should be done in order to assess the accuracy of this kind of measurement. Since all intake and output was measured using the same brands of measuring devices, it is possible that the error involved was consistent from patient to patient. However, any error in intake and output makes the results of comparisons with change in daily weight more variable. In addition, the scale that was used in this study is reported to have a mean error of $\pm$ .3 kg if used properly. This also makes the results obtained from comparisons more variable. Lastly, it is possible that unmeasured loss is more variable than previously reported. This could account for some of the differences in the findings reported of this study and that reported in others.

Further studies are needed to evaluate the relative importance of these four sources of error. For example, a study where only one trained individual measures and records subject's intake, output, height and weight should be done. This would reduce the variability due to multiple individuals obtaining and recording measurements. In addition, the measuring devices should be calibrated.

Intake and output and daily weight measurements are all subject to a certain amount of human error. It is difficult to predict whether changes in body weight or difference between daily intake and output is the best indicator of the status of fluid balance in patients. It is possible that neither one is sufficiently accurate to use in assessment of fluid balance.

However, measurement of intake and output is useful in evaluating clinical conditions other than fluid balance per se. For example, urine output should be measured in all patients who are in danger of developing shock or other clinical problems such as renal dysfunction. Fluid intake should be monitored whenever there is need to know types and amounts of fluid received by a patient.

In conclusion, even though differences between intake and output and changes in daily weight may not be sufficiently accurate to assess fluid balance, both types of measurements should be continued as a part of nursing assessment. It is imperative that nurses maintain a high degree of accuracy when measuring and recording these parameters. By doing so, the clinician may be able to detect early changes in a patient's condition.

CHAPTER V

SUMMARY

Both changes in body weight and difference between intake and output are used clinically to assess patient's fluid balance. The purpose of this study was to determine what correlation exists between daily changes in body weight and the difference between recorded intake and output. In addition, the relationship between unmeasured water loss and (1) body surface area, (2) mean daily body temperature, and (3) daily caloric intake was examined. The study was undertaken because of the discrepancies in the literature regarding the usefulness of body weight changes and differences between intake and output in the assessment of fluid balance.

Twenty-six hospitalized patients receiving no solid food by mouth were used as subjects in this study. The subjects' ages ranged between 28 and 84 years. All subjects were selected on the basis of availability.

The following results were obtained:

(1) Correlation coefficients (Pearson's r) between changes in daily weight and difference between intake and output for all subjects for Day I was 0.76 and 0.74 for Day II.

(2) Mean unmeasured water loss for all subjects for Day I was 0.68 l $\pm$ 1.02 l and 0.75 l $\pm$ 1.08 l for Day II.

(3) The value of the correlation coefficient (Pearson's r) was low for the following relationships: (a) body surface area <u>vs</u> unmeasured loss, (b) mean daily body temperature <u>vs</u> unmeasured loss, and (c) daily caloric intake <u>vs</u> unmeasured loss.

Even though mean unmeasured loss for all subjects was within accepted ranges, individual subjects showed a wide day-to-day variation. This finding plus all others listed above may be greatly influenced by errors in measuring and recording necessary parameters. Therefore, neither difference between intake and output or changes in daily weight may be sufficiently accurate to use in assessment of fluid balance. Nonetheless, both practices should be continued as a part of nursing assessment. By practicing a high degree of accuracy when measuring and recording these parameters, the clinician may be able to detect an early change in a patient's condition.

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APPENDIX A

SUMMARY TABLE

SUMMARY TABLE

ALL SUBJECTS

Subject	Day	Daily Intake (l)	Output (l)	I-O (l)	Weight (kg)	Δ Weight (l)	UML (l)	BSA(m^2)	kcal/kg/day	Route of fluid Administered	Ventilator	Mist	Temperature o C.
1					84.1								
	I	2.46	1.86	0.58	84.7	0.60	-0.02	1.88	1.8	IV			37.0
	II	1.69	1.30	0.39	85.1	0.40	-0.01	1.88	1.8	IV			38.0
2					70.3								
	I	3.37	3.64	-0.27	68.4	-1.90	-1.63	1.80	1.9	IV		X	37.9
	II	1.96	1.90	0.06	66.7	-1.70	1.76	1.80	5.0	IV		X	37.6
3					65.3								
	I	2.54	1.32	1.23	65.9	0.60	0.63	1.73	8.9	IV/TF	X		38.0
	II	2.55	1.87	0.68	66.4	0.54	0.18	1.73	11.9	IV/TF	X		37.7
4					80.0								
	I	3.84	2.75	1.09	82.0	2.00	-0.91	1.94	5.5	IV			37.4
	II	3.06	4.93	-1.87	77.7	-4.30	2.43	1.94	6.7	IV			37.6
5					92.8								
	I	2.30	3.38	-1.08	88.6	-4.20	3.12	2.09	2.02	IV		X	38.1
	II	1.62	4.40	-2.78	85.3	-3.30	0.52	2.09	3.23	IV		X	38.0
6					89.3								
	I	4.19	3.60	0.59	89.6	0.30	0.29	2.02	21.5	IV/PO			38.3
	II	2.71	2.81	-0.10	87.7	-1.90	1.80	2.02	11.2	IV/PO			38.0
7					71.3								
	I	2.30	2.58	-0.28	70.8	-0.50	0.22	1.66	5.5	IV			38.0
	II	2.42	2.68	-0.26	69.8	-1.00	0.74	1.66	5.7	IV/PO			38.2
8					65.3								
	I	3.00	2.40	0.59	63.3	-2.00	2.59	1.80	36.3	IV/TF	X		37.8
	II	2.76	2.55	0.21	62.6	-0.70	0.91	1.80	33.7	IV/TF	X		37.7
9					59.0								
	I	2.55	4.63	-2.08	56.0	-3.00	0.92	1.64	7.5	IV/PO	X		37.5
	II	2.63	2.65	-0.20	56.2	0.20	-0.40	1.64	7.0	IV/PO	X		36.9
10					94.8								
	I	2.59	2.32	0.27	94.8	0.00	0.27	2.20	20.4	IV/TF	X		37.8
	II	2.09	1.91	0.18	91.9	-2.90	3.08	2.20	20.1	IV/TF	X		37.9

Subject	Day	Daily Intake (l)	Output (l)	I-O (l)	Weight (kg)	Weight (l)	UML (l)	BSA(m^2)	kcal/kg/day	Route of fluid Administered	Ventilator	Mist	Temperature °C.
11					78.3								
	I	1.96	1.96	0.00	77.7	-0.60	0.60	1.77	3.0	IV/PO	X		36.4
	II	1.74	2.03	-0.29	75.5	-2.20	1.91	1.77	3.2	IV/PO	X		36.9
12					79.5								
	I	2.01	1.84	0.17	78.4	-1.10	1.27	2.02	4.3	IV			37.1
	II	2.02	1.45	0.57	79.6	1.20	-0.63	2.02	6.5	IV/PO			37.1
13					74.7								
	I	1.64	3.00	-1.35	73.7	-1.00	-0.41	1.80	3.7	IV			38.2
	II	2.41	2.11	0.30	73.0	-0.70	1.00	1.80	5.6	IV			38.4
14					56.1								
	I	1.89	1.84	0.04	55.7	-0.40	0.44	1.62	10.9	TF	X		38.1
	II	2.05	2.10	-0.05	54.5	-1.20	1.25	1.62	33.0	TF	X		38.1
15					64.5								
	I	2.67	3.51	-0.84	63.2	-1.30	0.46	1.79	16.0	IV/HA			38.0
	II	2.84	3.76	-0.92	61.9	-1.26	0.34	1.79	26.3	IV/HA			38.2
16					92.8								
	I	1.81	0.80	1.01	91.6	-1.20	2.21	2.05	3.4	IV	X		38.3
	II	1.98	2.31	-0.33	89.5	-2.10	1.77	2.05	3.8	IV	X		37.8
17					52.5								
	I	1.56	1.77	-0.20	51.6	-0.90	0.70	1.54	35	IV/TF	X		37.5
	II	2.43	2.01	0.42	52.2	0.60	0.52	1.54	24	IV/TF	X		37.0
18					101.8								
	I	2.18	3.51	-1.33	100.8	-1.50	0.17	2.11	2.8	IV			37.2
	II	1.44	3.33	-1.89	98.5	-1.80	-0.09	2.11	2.3	IV/PO			37.0
19					53.3								
	I	2.67	1.07	1.60	53.1	-0.20	1.80	1.53	20.9	IV/HA	X		38.1
	II	2.65	1.49	1.16	55.3	2.20	-1.04	1.53	21.6	IV/HA	X		38.3
20					82.6								
	I	2.00	4.06	-2.06	79.6	-3.04	0.98	2.00	14	IV	X		37.4
	II	2.10	1.65	0.45	81.4	1.80	-1.35	2.00	16	IV	X		37.1

Subject	Day	Daily Intake (l)	Output (l)	I-O (l)	Weight (kg)	Weight (l)	UML (l)	BSA(m^2)	kcal/kg/day	Route of fluid Administered	Ventilator	Mist	Temperature o C.
21					75.3								
	I	2.63	1.11	1.52	77.0	1.70	-0.18	1.85	5.8	IV		X	39.1
	II	3.48	2.60	0.88	77.0	0.00	0.88	1.85	4.4	IV		X	39.6
22					66.0								
	I	6.60	2.99	3.61	67.7	1.70	1.91	1.80	44.9	IV/PO HA		X	38.0
	II	4.56	2.95	1.62	67.9	0.20	1.42	1.80	51.8	IV/PO HA		X	37.7
23					70.1								
	I	2.26	2.40	-0.23	70.1	0.00	-0.23	1.67	5.5	IV		X	38.0
	II	2.07	3.02	-0.94	68.9	-1.20	0.25	1.67	3.8	IV/PO		X	38.3
24					102.8								
	I	1.90	2.02	-0.12	102.4	-0.40	0.275	2.20	3.1	IV	X		38.6
	II	2.11	2.60	-0.49	99.9	-2.50	-2.01	2.20	3.6	IV	X		38.7
25					72.2								
	I	3.91	2.01	1.90	74.9	2.70	-0.80	1.86	8.9	IV			38.1
	II	2.44	3.24	-0.81		-1.50	0.69	1.86	5.6	IV			37.8
26					41.2								
	I	1.611	1.48	0.13	41.3	0.10	0.03	1.45	30.6	IV/TF	X		37.3
	II	2.02	1.40	0.62	41.7	0.40	0.22	1.45	44.8	TF	X		37.5

I-O = daily intake minus daily output.

Δ weight = $weight_2$ minus $weight_1$.

UML = (I-O) - Δ weight.

BSA = Body surface area.

Temp = mean daily body temperature.

AN ABSTRACT OF THE THESIS OF

LYNN E. OVESON

For the MASTER OF NURSING

Date of Receiving this Degree: June 12, 1981

Title: ASSESSMENT OF THE RELATIONSHIP BETWEEN CHANGE IN WEIGHT AND THE DIFFERENCE BETWEEN INTAKE AND OUTPUT

Approved: ______________________________
Jack L. Keyes, Ph.D., Thesis Advisor

Both changes in body weight and difference between intake and output are used clinically to assess patient's fluid balance. The purpose of this study was to determine what correlation exists between daily changes in body weight and the difference between recorded intake and output. In addition, the relationship between unmeasured water loss and (1) body surface area, (2) mean daily body temperature, and (3) daily caloric intake was examined. The study was undertaken because of the discrepancies in the literature regarding the usefulness of body weight changes and differences between intake and output in the assessment of fluid balance.

Twenty-six hospitalized patients receiving no solid food by mouth were used as subjects in this study. The subjects' ages ranged between 28 and 84 years. All subjects were selected on the basis of availability.

The following results were obtained:

(1) Correlation coefficients (Pearson's r) between changes

in daily weight and difference between intake and output for all subjects for Day I was 0.76 and 0.74 for Day II.

(2) Mean unmeasured water loss for all subjects for Day I was 0.68 l $\pm$ 1.02 l and 0.75 l $\pm$ 1.08 for Day II.

(3) The value of the correlation coefficient (Pearson's r) was low for the following relationships: (a) body surface area _vs_ unmeasured loss, (b) mean daily body temperature _vs_ unmeasured loss and (c) daily caloric intake _vs_ unmeasured loss.

Even though mean unmeasured loss for all subjects was within accepted ranges, individual subjects showed a wide day-to-day variation. This finding plus all others listed above may be greatly influenced by errors in measuring and recording necessary parameters. Therefore, neither difference between intake and output or changes in daily weight may be sufficiently accurate to use in assessment of fluid balance. Nonetheless, both practices should be continued as a part of nursing assessment. By practicing a high degree of accuracy when measuring and recording these parameters, the clinician may be able to detect an early change in a patient's condition.