OXYGEN CONSUMPTION AND CARDIOVASCULAR RESPONSE IN NORMAL SUBJECTS AND IN ACUTE MYOCARDIAL INFARCTION PATIENTS DURING BASIN BATH, TUB BATH, AND SHOWER

A DISSERTATION

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We hereby recommend that the dissertation prepared under our supervision by Elizabeth Hahn Winslow, R.N., B.S., M.S.N entitled Oxygen Consumption and Cardiovascular Response in Normal Subjects and in Acute Myocardial Infarction Patients During Basin Bath, Tub Bath, and Shower

be accepted as fulfilling this part of the requirements for the Degree of Doctor of Philosophy.

Committee:

Dissertation/Theses signature page is here.

To protect individuals we have covered their signatures.

DEDICATED

to

My husband, Rich, for encouraging me and "taking up the slack";

My children, Frank and Heather, for understanding and being proud;

My mother, Cynthia C. Hahn, for asking, "Why not?"

My father, Dr. George A. Hahn, for teaching me to write.

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CHAPTER 1

INTRODUCTION

The nurse is often responsible for recommending activities in which hospitalized patients participate such as range of motion exercises, bathing, and ambulating. The nurse's decision to encourage or discourage a particular activity is frequently based on her assessment of the energy resources of the patient and the energy expenditure required by the activity as well as on her desire to favorably influence patient function. Because little research has been done which measures the energy cost and physiological and psychological responses of patients during activities commonly performed in the hospital, patient activity recommendations are more often based on intuition and tradition than on scientific evidence.

The use of tradition to determine patient activity is especially apparent in the care of the acute myocardial infarction patient. Gradually, however, due to the accumulation of scientific knowledge, practices such as prolonged, complete bed rest and bed pan toileting are changing. However, many acute myocardial infarction patients are still prohibited from taking a tub bath or shower until late in their convalescence or until after they go home. This prohibition has little empirical foundation and is in need of scientific study.

Problem of Study

Therefore, the following research questions were asked:

1. What is the difference in oxygen consumption and cardiovascular response among rest, basin bath, tub bath, and shower, between the two groups of subjects (normal subjects and hospitalized acute myocardial infarction patients), and between the sexes?

2. What is the difference in bath duration among the three methods of bathing in each group of subjects?

3. What is the difference in ranking of perceived effort, ease of bath, enjoyment of bath, and feeling clean after the bath among the three methods of bathing in each group of subjects?

4. What is the difference in ranking of appropriateness of bath among the three methods of bathing in the myocardial infarction patients?

Justification of Problem

Although the patient bath is considered an important activity, little research has been done about bathing. Consequently, the nurse has little empirical evidence to assist her in selecting the bathing method most appropriate for the patient. In some instances, criticalness and instability of the patient's condition, weakness of the patient, or presence of tubes, dressings, casts, traction, or radioactive implants require that the patient receive a bed bath or basin bath. In other instances, the choice of bathing method is not limited--the ambulatory patient, for example, often chooses whichever method of bathing he prefers. However, for the convalescing, acute myocardial infarction patient, patient preference is often disregarded and tradition and intuition direct that these patients take a basin bath during most of their hospitalization.

The basin bath may not be in the patient's best interest because maintenance of basin bathing may increase deconditioning, retard adaptation to higher level activities, and exaggerate the patient's feelings of dependency and invalidism; and, the energy cost and cardiovascular response required by taking a tub bath or shower may be well within the patient's capabilities. Measuring the energy cost, cardiovascular response, and rating of perceived exertion of normal subjects and hospitalized acute myocardial infarction patients during rest and during three methods of bathing (basin bath, tub bath, and shower), timing the length of each bath, and asking the subjects to rank the three methods of bathing for ease, enjoyment, feeling clean afterwards, and appropriateness will provide objective information to assist the nurse select the bathing method most appropriate for the patient.

If the results of this study suggest that the tub bath and shower are appropriate bathing methods for the convalescing myocardial infarction patient, early bathing independence would enhance the return of the patient to a normal activity level and perhaps also retard some of the unwarranted invalidism associated with cardiac disease. In addition, early tub bathing and showering by cardiac patients would result in obvious staffing and economic benefits. On the other hand, if the results of this study suggest that the basin bath is appropriate for the convalescing myocardial infarction patient, then the choice of the basin bath would have empirical validation.

The results of this study will also provide an important step in the collection of basic information about the energy cost and cardiovascular response required by activities commonly performed by hospitalized patients. Once enough information about the physiological costs of activities commonly performed by hospitalized patients is collected, activities can be graded and progressive activity can be based on applied clinical research rather than on intuition.

Progression of activities in current patient activity programs is based on findings from oxygen consumption studies most of which used a small number of normal or convalescing subjects in a wide variety of circumstances and did not monitor cardiovascular response (Benton, Brown, & Rusk, 1950; Gordon, 1952; Gordon & Haas, 1955; Passmore & Durnin, 1955). Therefore, the findings of these studies need to be used cautiously as a basis for prescribing activities for hospitalized patients. In addition, since little research has been done about the types of activities commonly performed by hospitalized patients (e.g., bathing activities, transferring to a stretcher or wheelchair, etc.), little information is available, for normal subjects or for hospitalized patients, about the physiological costs of these activities.

The hospitalized patient is likely to have a reduced maximal energy potential. Consequently, a given activity will represent a greater percentage of the patient's maximal energy potential than of a normal subject's maximal energy potential. The patient, as a result, will have a more marked cardiovascular response than a normal subject. Therefore, it is important not only to investigate the physiological costs of activities commonly undertaken by hospitalized patients, but also to use hospitalized patients as well as normal volunteers as subjects in the investigation.

It is also important to know the individual's subjective response to various activity methods since there may be a relationship between the individual's subjective and physiological responses. Furthermore, subjective response can be used to select the most appropriate activity method if the physiological cost of each method is similar.

In addition to guiding progression of activities for hospitalized or debilitated patients, findings from this study and from similar studies could be useful in developing nursing diagnoses. Once a comprehensive list of activities and their physiological costs is compiled, a patient could be classified by the activity level he could tolerate. The nurse would know that the patient could probably perform activities of an equal or lower level, but that he might have difficulty tolerating higher level activities. Nursing interventions designed to move the patient to higher activity levels would include judicious and systematic introduction of higher activity levels and assessment of patient tolerance to these activity levels.

Conceptual Framework

Levine's (1973) nursing model, specifically her conservation of energy principle, and the overload and progression principles of exercise physiology, form the conceptual framework for this study. Levine's model will be discussed first and then the exercise physiology principles will be discussed.

Levine (1971) believed that the goal of nursing care should be to conserve, or keep together, the wholeness of the individual patient. Levine (1971) perceived four major areas of care in which nursing could fulfill a conservation of wholeness function and stated these as the four conservation principles of nursing intervention. The four conservation principles represent four separate goals of nursing intervention and yet have as a postulate the integrity and unity of the individual (Levine, 1973). Thus, Levine compartmentalized nursing activities, but she did not compartmentalize man (Stevens, 1979).

The four conservation principles state that nursing intervention is based on the conservation of the patient's (a) energy, (b) structural integrity, (c) personal integrity, and (d) social integrity (Levine, 1973). If any of these four elements is disrupted, the person is in a state of altered health (illness) (Esposito & Leonard, 1980). Although all four conservation principles are relevant to this study, the first principle of conservation of energy is most relevant and will be emphasized.

The principle of conservation of energy refers to keeping an appropriate balance between the supply of energy-producing nutrients and the rate of energy-using activities (Levine, 1973). "Countless nursing activities are designed to conserve energy, including all of the procedures that are necessary when the individual is restricted to bedrest" (Levine, 1971, p. 259). But Levine (1971) stressed that energy conservation does not mean merely limitation of activity. Energy conservation also means "the proper disbursement of energy expense, the encouragement to ambulate and exercise, allowing for activity within the range of the individual's capability, safety, and comfort" (Levine, 1971, p. 259). Thus, encouraging one patient to take his own bath, and giving another patient a complete bed bath are both conservation of energy measures.

The principle of conservation of structure refers to maintaining and restoring the anatomical and physiological wholeness of the body (Levine, 1973). Aseptic techniques and nursing interventions to prevent decubitus, footdrop, and orthostatic intolerance are designed to defend structural integrity (Levine, 1971). Getting the patient up out-of-bed to use a bedside commode, to sit in a chair, or to take a bath are conservation of structure measures which can eliminate some of the orthostatic intolerance common to patients early in recovery (Convertino, Hung, Goldwater, & DeBusk, 1982).

The principle of conservation of personal integrity refers to maintaining or restoring the patient's sense of identity and self-worth (Levine, 1973). Nursing interventions which encourage the patient to make decisions for himself, for example, assisting the patient to take the kind of bath he prefers, maintain personal integrity (Levine, 1973). The principle of conservation of social integrity refers to acknowledging that the patient is a social being and facilitating social interaction (Levine, 1973). Positioning the patient in bed so that he is able to socialize with his neighbors is a nursing intervention which conserves social integrity (Levine, 1967). The patient bath also promotes social integrity because the patient who feels and smells clean is more likely to engage in social interaction than the unbathed or inadequately bathed patient who feels dirty and unkept.

Levine's conservation principles of nursing intervention are complementary to the principle of adaptation in the patient. For the nurse to apply the four conservation principles it is essential that she identify the specific patterns of adaptation in every patient and tailor the intervention to enhance the effectiveness of adaptation (Levine, 1971). Levine (1973) defined adaptation as "the process of change whereby the individual retains his integrity within the realities of his environment" (p. 11). Adaptation is not "all or none"; it is susceptible to an infinite range within the limits of life compatibility (Levine, 1973).

In Levine's model, illness is the stressor and the patient is continually trying to adapt to this changed state (Esposito & Leonard, 1980). The degree of adaptation is manifested by the patient's holistic response which includes changes in behavior and/or levels of functioning of the body (Esposito & Leonard, 1980). The nurse assesses the level of adaptation and implements and evaluates nursing interventions to conserve wholeness and enhance successful adaptation.

Levine's model for nursing parallels many elements of the nursing process: the nurse must observe the patient, decide on an appropriate intervention, perform it, and then evaluate its usefulness (Esposito & Leonard, 1980). Levine's four conservation principles can be used to guide patient assessment. For example, the nurse collects data about the patient's energy sources (e.g., nutrition and rest) and about his energy expenditure (e.g., activity level and tolerance, emotional stresses, and body temperature). The nurse than analyzes the data to evaluate the patient's level of adaptation and to determine appropriate interventions. Next, the nurse implements nursing interventions which are designed to conserve the patient's energy and promote adaptation. The nurse, for example, might encourage or restrict independent bathing. The nurse then evaluates the patient's response to the nursing action and the nursing process is repeated.

The overload principle and the progression principle are basic principles in exercise physiology which can be used by the nurse to determine nursing interventions, such as activity prescription, which conserve energy. The overload and progression principles are as important in the rehabilitation of the sick as in the training of athletes (Hellebrandt & Houtz, 1956). The overload principle states that

> Beneficial human performance adaptations occur in response to stress applied at levels beyond a certain threshold value but within the limits of tolerance and safety. Low levels of stress, to which the body has already adapted, are not sufficient to induce a further training adaptation. (Rasch & Burke, 1978, p. 351)

Whether one is concerned with cardiopulmonary factors, strength, or muscular endurance, improvement in function occurs only when the system is challenged (deVries, 1974).

The progression principle, which states that the amount of overload should be increased gradually and systematically, should be integrated with the application of the overload principle (deVries, 1974). If the overload is too small, no improvement will occur; if the overload is too large, injury may result.

Levine's conservation of energy principle and the overload and progression principles of exercise physiology can guide activity prescription for the acute myocardial infarction patient. The acute myocardial infarction patient has an energy imbalance; his illness has diminished his energy reserves and magnified his energy needs. Any available energy is required for essential body functions and healing. The activity of the myocardial infarction patient is severely curtailed immediately after the infarction to free energy for basic body functions and to decrease the work of the injured heart. Once the patient's condition has stabilized, the patient has energy available to perform low energy cost activities. The nurse assesses the patient's adaptation to these activities; if the patient tolerates low level activities, he can then participate in activities which demand higher energy costs. Use of gradually progressive activity helps the patient to keep together energy and to safely and efficiently move to a higher level of adaptation.

The improvement in physiologic function associated with progressive activity results from challenging the system with a work load that is greater than that which the patient has been doing (deVries, 1974). This overload should not imply a load producing an increased hazard or inducing a pathological response; instead it is a load in excess of what the patient has been doing which promotes physiologic responses and establishment of a new equilibrium at a higher level of adaptation. In order to achieve still further improvement once adaptation to a given load has taken place, a higher load must again be introduced. Since the energy balance of the cardiac patient may be tenuous, graded activities are introduced gradually and adaptation is carefully assessed before introducing higher activity levels.

If the patient is confined to bed and not permitted to engage in progressive levels of activities, the consequences of underload result. If "the teleological significance of any response to overloading lies in its contribution to increasing the capacity . . . to perform"

(Jeffress & Peter, 1970, p. 139), then the response to underloading is to decrease performance capacity. Overload is associated with increasing levels of adaptation; underload, by contrast, is associated with decreasing levels of adaptation. Some of the well-known hazards of bedrest, including orthostatic intolerance, result from underload and reduced adaptation capacity (Convertino et al., 1982; Saltin, Blomqvist, Mitchell, Johnson, Wildenthal, & Chapman, 1968).

The nurse is hampered in her attempt to use Levine's conservation of energy principle and the overload and progression principles to conserve energy and promote adaptation because little information is available about the energy expenditure required by activities commonly performed by hospitalized patients. Investigation of the energy expenditure and cardiovascular response required by different bathing methods and by other activities commonly performed by hospitalized patients will provide information about the physiological costs of these activities. This information will enable the nurse to more accurately assess the patient's energy expenditure, to grade activities from low to high energy cost, and to introduce activities in a gradual and progressive manner in order to keep together patient energy and foster adaptation.

Assumptions

The following assumptions were made:

1. The human body adapts to a given level of physical activity.

2. Physical activity requires energy production and expenditure.

3. Physical activity and energy expenditure can be assessed and regulated.

4. Alterations in health are associated with alterations in energy balance and in physical activity capacity.

5. Capacity to perform low energy cost activities precedes capacity to perform high energy cost activities.

6. Physical activity capacity and tolerance are reflected by oxygen consumption, cardiovascular response, perception of effort, and preference.

7. The physical activity undertaken by an individual should be within his physical activity capacity and should foster salutory adaptive changes.

8. Regulation of physical activity is a nursing intervention.

Hypotheses

The following hypotheses were formulated:

1. Oxygen consumption will not differ significantly among rest, basin bath, tub bath, and shower, between the two groups of subjects (normal subjects and hospitalized acute myocardial infarction patients), and between the sexes.

2. Cardiovascular response, as measured by resting and peak bath heart rate, will not differ significantly among rest, basin bath, tub bath, and shower, between the two groups of subjects, and between the sexes.

3. Cardiovascular response, as measured by resting and after-bath rate pressure product, will not differ significantly among rest, basin bath, tub bath, and shower, between the two groups of subjects, and between the sexes.

4. Cardiovascular response, as measured by presence of dysrhythmia, will not differ significantly (a) among rest, basin bath, tub bath, and shower and (b) between the two groups of subjects.

5. Cardiovascular response, as measured by presence of ST segment change of 1 mm or more, will not

differ significantly (a) among the three methods of bathing and (b) between the two groups of subjects.

6. Rating of perceived exertion will not differ significantly among the three methods of bathing (a) in the normal subjects and (b) in the hospitalized acute myocardial infarction patients.

7. Duration of bath will not differ significantly among the three methods of bathing (a) in the normal subjects and (b) in the hospitalized acute myocardial infarction patients.

8. Ranking of "ease of bathing" will not differ significantly among the three methods of bathing (a) in the normal subjects and (b) in the hospitalized acute myocardial infarction patients.

9. Ranking of "enjoyment of bath" will not differ significantly among the three methods of bathing (a) in the normal subjects and (b) in the hospitalized acute myocardial infarction patients.

10. Ranking of "feeling clean after bath" will not differ significantly among the three methods of bathing (a) in the normal subjects and (b) in the hospitalized acute myocardial infarction patients.

11. Ranking by the hospitalized acute myocardial infarction patients of "appropriateness of bath for you

at this stage in your recovery" will not differ significantly among the three methods of bathing.

Definition of Terms

1. Oxygen consumption--the difference between the volume of oxygen inspired and that expired which represents the amount of oxygen used by the body. Oxygen consumption is measured during rest and bathing by the Douglas bag method and is expressed as milliliters per kilogram of body weight per minute (ml/kg/min). There is a direct relationship between oxygen consumption and energy cost because energy is available to the body due to the breakdown of adenosine triphosphate (ATP), the energy store of the body, which is resynthesized in chemical reactions requiring oxygen (Guyton, 1976). Therefore, the terms oxygen consumption, oxygen uptake, energy cost, and energy expenditure may be used interchangeably.

2. Cardiovascular response--resting heart rate, peak heart rate, resting rate pressure product, after-bath rate pressure product, presence of dysrhythmia, and presence of an ST change of 1 mm or more.

3. Resting heart rate--the heart rate, in beats per minute, after at least 12 minutes of supine rest.

4. Peak heart rate--the highest heart rate observed during the bath. Peak heart rate is determined by examining the continuous electrocardiographic tracing taken during the bath and finding the highest heart rate during a 15-second period. This heart rate is multiplied by 4 and expressed as beats per minute (bpm). Heart rate has been shown to correlate well with myocardial oxygen consumption (Kitamura, Jorgensen, Gobel, Taylor, & Wang, 1972).

5. Resting rate pressure product--the product of the systolic blood pressure times the heart rate, divided by 100, after at least 12 minutes of supine rest.

6. After-bath rate pressure product--the rate pressure product obtained immediately after the subject finishes bathing, drying, and dressing. Rate pressure product has been shown to correlate well with myocardial oxygen consumption (Kitamura et al., 1972).

7. Presence of dysrhythmia--any abnormal cardiac rhythm, excluding sinus tachycardia. Presence of dysrhythmia is determined by examining the electrocardiographic tracing during and after the bath. Presence of dysrhythmia is indicated by a "1" and a description of

the dysrhythmia; absence of dysrhythmia is indicated by a "2." A dysrhythmia may be caused by ischemia or other pathology (Kattus, 1975).

8. Presence of an ST change of 1 mm or more--an ST change of 1 mm or more, at 80 milliseconds after the J-point, during or after the bath as compared to before the bath. Presence of an ST change of 1 mm or more is determined by examining the electrocardiographic tracing before, during, and after the bath. Presence of an ST change of 1 mm or more is indicated by a "1" and a description of the direction and degree of the change; absence of a significant change is indicated by a "2." Both ST segment elevation and depression have been shown to be associated with coronary ischemia (Sheffield, 1974).

9. Rating of perceived exertion--the number chosen by the subject from the rating of perceived exertion scale (Borg, 1973). The perceived exertion scale ranges from 6 to 20 with the low numbers representing low perceived exertion and the high numbers representing high perceived exertion; every other number is accompanied by a written description such as "very light" or "very, very hard." The rating of perceived exertion, a

subjective rating of the intensity of work being performed, has been shown to correlate with objective physiological indicators of work intensity such as heart rate and blood lactate concentration (Borg & Linderholm, 1967).

10. Normal subject--a nonhospitalized subject who does not have cardiac disease or important dysfunction of other organ systems and who considers himself healthy.

11. Hospitalized acute myocardial infarction patient--a hospitalized patient who is diagnosed as having an acute myocardial infarction on the basis of the patient's history, electrocardiogram, serum cardiac enzymes, and/or cardiac scan.

12. Uncomplicated--the description of a patient based upon the absence of the following signs and symptoms at the time of selection for the study: (a) chest pain; (b) evidence of heart failure; (c) systolic blood pressure less than 90 mm Hg; (d) significant dysrhythmia, e.g., sinus tachycardia at rest, frequent (more than 5 per minute) premature ventricular or atrial contractions, atrial fibrillation with rapid ventricular response, atrial flutter, second or third degree block, etc.;

(e) fever (oral temperature of 99°F or more); (f) important dysfunction of organ systems including serious disease of the lung, kidney, and gastrointestinal tract; and (g) severe psychological problems.

13. Basin bath--the subject, dressed in bed clothes, sits on the side of the bed, undresses, bathes himself from a basin of water on the overbed table, dries himself, and redresses.

14. Tub bath--the subject, dressed in bed clothes, undresses, gets into the tub, bathes himself, gets out of the tub, dries himself, and redresses.

15. Shower--the subject, dressed in bed clothes, undresses, gets into shower, bathes himself, gets out of the shower, dries himself, and redresses.

Limitations

The following limitations were recognized which could have influenced the findings or generalizability of this study:

1. The subject tended to be affected by the investigation causing the research situation to be atypical (Astrand & Rodahl, 1977).

2. The research equipment affected the subject's responses. For example, the oxygen consumption equipment

and cardiac monitor interfered with the subject's mobility and prevented face washing.

3. The bathing protocol was different for normal subjects and hospitalized acute myocardial infarction patients. The normal subjects took the three baths on 1 day with equilibration periods between each bath; the myocardial infarction patients took the baths on 3 consecutive days.

4. Fatigue and lack of need for the second and third baths could have influenced the results of the normal subjects who took all three baths on 1 day.

5. Day-to-day physical and emotional changes could have influenced the results of the myocardial infarction patients who took the three baths on 3 consecutive days.

6. The Specific Dynamic Action (SDA) of food, the increase in heat production and metabolism following food ingestion, was not well controlled in the myocardial infarction patients. The SDA of food, which varies with food composition and amount, may elevate metabolism 10% with the peak occurring within 1 hour after the meal (Buskirk, Iampietro, & Welch, 1957).

The normal subjects were studied at least 2 hours after food ingestion and performed the three baths within a 2 hour period. Therefore, the SDA of food should have had a fairly stable influence on the results of the normal subjects. The acute myocardial infarction patients, however, were studied on 3 consecutive days at least 1 hour after food ingestion. Although each myocardial infarction patient was studied at approximately the same time each day, the composition and quantity of the subject's food intake varied from day to day and could have influenced the results of the study.

7. A standardized bath motion protocol was not used. Consequently, some of the variability in the findings could have resulted from idiosyncratic bathing techniques. The investigator hoped, however, that the advantages gained from permitting each subject to bathe in his own way in a repeated measures design would outweigh the advantages of a more controlled but more artificial standardized bath motion protocol.

8. The subject's bathing movements were not observed or recorded in order to protect the subject's modesty and enhance the naturalness of the bathing activities. But, this nonobservational technique also prevented collecting information about the relationship

between bathing movements, oxygen consumption, and cardiovascular response.

9. Events occurring in the laboratory or on the patient unit during the study, such as the telephone ringing and other extraneous noises and people passing by or entering the room, could not be well controlled and could have influenced the results of this study.

10. The investigator took the subject's radial pulse and blood pressure during the study. The investigator's awareness of which bath the subject was performing could have influenced the pulse and blood pressure results.

11. The fact that the normal subjects were not matched with the acute myocardial infarction patients in age, weight, race, and other descriptive characteristics could have influenced the results of this study.

12. The normal subjects may have had unrecognized cardiac disease which could have influenced the results of this study.

Summary

The nurse is often responsible for recommending activities in which patients participate. The nurse's encouragement or discouragement of a particular activity is based upon her attempt to conserve patient energy, i.e., to obtain an optimal balance between energy resources and energy expenditure, and on her desire to favorably influence adaptation. The nurse usually must base her activity recommendations on intuition or tradition since little data are available about the energy cost and cardiovascular response demanded by activities commonly performed by hospitalized patients. Therefore, investigation of the physiological costs of various common hospital activities is important in the development of nursing science.

Acute myocardial infarction patients are often prohibited from taking a tub bath or shower until late in their convalescence. This prohibition is in need of scientific study since it is not based on empirical evidence and it may increase the deconditioning and invalidism associated with cardiac disease. Investigation of the energy cost, cardiovascular response, rating of perceived exertion, bath duration, and bath method preference of normal subjects and acute myocardial infarction patients during the basin bath, tub bath and shower will provide objective information to assist the nurse select the bathing method most appropriate for the patient.

CHAPTER 2

REVIEW OF LITERATURE

In order to better understand and investigate responses of normal subjects and hospitalized acute myocardial infarction patients during bathing, the following areas were reviewed in the literature: (a) aerobic and anaerobic energy metabolism, (b) direct and indirect measurement of energy expenditure, (c) total body and myocardial oxygen consumption, (d) normal and abnormal cardiovascular response to exercise, (e) effect of temperature on the body, (f) rating of perceived exertion, and (g) oxygen consumption and hemodynamic responses during bathing.

Energy Metabolism

Aerobic Energy Production

Electric power may be stored in batteries; living cells also store energy. The most abundant "battery pack" used in the cell is the compound called adenosine triphosphate (ATP). The energy stored in ATP is in a rapidly usable form, though in a limited supply. Once the energy has been "discharged," this cellular battery, like a flashlight battery, must again be recharged (Astrand & Rodahl, 1977).

Adenosine triphosphate, which is present everywhere in the cytoplasm and nucleoplasm of all cells, is a nucleotide composed of the nitrogenous base adenine, the pentose sugar ribose, and three phosphate radicals. The last two phosphate radicals are connected with the remainder of the molecule by high energy phosphate bonds. Each of these bonds contains about 8,000 calories of energy per mole of ATP under the physical conditions of the body which is much greater than the energy stored in the chemical bonds of other organic compounds. The high energy phosphate bond is very labile, so that it can be split instantly whenever energy is required. When ATP releases its energy, a phosphoric acid radical is split away and adenosine diphosphate (ADP) is formed (Guyton, 1976).

Energy is then needed to recombine ADP and phosphoric acid to form new ATP. The energy for reforming ATP is derived mostly from various chemical reactions with oxygen and one or more of the foodstuffs--carbohydrates, fats, and proteins. In fact, 95% of all ATP formed in the cell is formed in aerobic chemical reactions;

consequently, oxygen consumption reflects energy expenditure (Guyton, 1976).

In the body carbohydrates are converted to glucose, proteins to amino acids, and fats to fatty acids before reaching the cell. These foodstuffs and oxygen then enter the cell. On entry into the cells, enzymes in the cytoplasm or nucleoplasm act upon glucose to convert it to pyruvic acid (a process called glycolysis) and enzymes act upon the amino acids and fatty acids to convert them to acetoacetic acid. Energy released during the conversion of glucose to pyruvic acid converts a small amount of ADP to ATP.

The major portion of ATP formed in the cell, however, is formed in the mitochondria. The pyruvic acid and acetoacetic acid are both converted into the compound acetyl co-A in the cytoplasm; acetyl co-A is transported with oxygen into the mitochondrion. A number of chemical reactions take place during the Krebs cycle and acetyl co-A is split into its component parts, hydrogen and carbon dioxide. The carbon dioxide diffuses out of the cell. The hydrogen, under the influence of oxidative enzymes, combines with oxygen. The energy released from the combination of hydrogen and oxygen is used to resynthesize tremendous quantities of ATP from ADP. The ATP is then transported out of the mitochondrion into all parts of the cytoplasm and nucleoplasm where its energy is used to energize the function of the cell (Guyton, 1976).

Anaerobic Energy Production

Anaerobic processes, that is, processes which do not use oxygen, can also generate ATP and energy although they are about one-tenth as effective as aerobic processes (Blomqvist, 1978). Anaerobic metabolism is the main source of energy early in exercise when the ATP stores have been depleted, but muscle blood flow has not reached the level necessary to sustain aerobic metabolism, i.e., during the initial 1-2 minutes of exercise (Blomqvist, 1978). Anaerobic metabolism also helps support exercise at supramaximal levels and bridges the gap between the energy demand and the energy actually available from maximal utilization of aerobic processes.

The term anaerobic metabolism has often carried the connotation of a dangerous overload. Although it is true that the contribution from anaerobic processes increases at high work loads, anaerobic processes are clearly part of the physiologic response to exercise at light as well as heavy loads. It is impossible to define a specific level of exercise below which exercise is aerobic and above which it is anaerobic (Blomqvist, 1978).

Carbohydrates are the only significant foods that can provide energy by anaerobic means (Guyton, 1976). As mentioned previously, some energy is released during anaerobic glycolysis when glucose is broken down to pyruvic acid and hydrogen, which react with each other to form lactic acid which diffuses readily out of the cell. Glycolysis can proceed for several minutes supplying the body with ATP anaerobically.

Once oxygen again becomes available, the chemical reaction for formation of lactic acid immediately reverses itself and the lactic acid once again becomes pyruvic acid. Large portions of this are immediately utilized by the citrus acid cycle to provide additional oxidative energy, and large quantities of ATP are formed. This excess ATP then causes as much as three-fourths of the remaining excess pyruvic acid to be converted back into glucose (Guyton, 1976). Thus, the great amount of lactic acid that forms during anaerboic glycolysis does not become lost from the body, for when oxygen is again available, the lactic acid can either be reconverted to glucose or can be used directly for energy. Heart muscle is especially capable of converting lactic acid to pyruvic acid and then using this for energy (Guyton, 1976).

The use of creatine phosphate (CP) for ATP resynthesis also does not require the presence of oxygen (Guyton, 1976; Lamb, 1978). Creatine phosphate, not ATP, is the most abundant store of high energy bonds in muscle cells; its phosphate bond contains 9,500 calories per mol. Creatine phosphate can transfer energy interchangeably with ATP. When extra amounts of ATP are available in the cell, much of its energy is used to build up the CP store of energy. Then, when the ATP begins to be used up, the energy in CP is quickly transferred back to ATP.

The higher energy level of the phosphate bond in CP causes the reaction between CP and ATP to be in favor of ATP. Consequently, the slightest utilization of ATP calls forth the energy from CP to generate new ATP. The greater energy in the CP bond facilitates such a rapid transfer of energy to ATP that almost all the CP must be used up before the concentration of ATP will fall significantly. Therefore, CP is called an ATP "sparer" or "buffer" (Guyton, 1976).

The rebuilding of ATP from CP is especially important during short bursts of extremely heavy exercise. Creatine phosphate is rapidly depleted, within a matter of seconds or minutes, in strenuous muscular work. The next source of energy used to rebuild both CP and ATP is the energy released in the course of oxidation from carbohydrates, fats, and proteins. Thus, the ultimate source of energy for muscle contraction is foodstuffs and oxygen (Astrand & Rodahl, 1977).

Oxygen Debt

In the first few seconds of light exercise during which the circulatory and respiratory adjustments lag behind exercise demands, and during all of short-duration heavy exercise, aerobic processes cannot provide all the energy that is required. This period during which oxygen uptake is below oxygen requirement is called the period of oxygen deficit. Function during this oxygen deficit condition is made possible by several anaerobic sources including (a) the splitting of ATP and CP, (b) the anaerobic breakdown of glucose and glycogen (glycolysis) to lactic acid, and (c) the use of oxygen stores such as that bound to muscle myoglobin and blood oxygen stores (deVries, 1974).

The extra oxygen which is then used after the conclusion of exercise to replenish the high energy stores and to remove substances, chiefly lactic acid, which were formed in the anaerobic pathways of energy metabolism, is called the oxygen debt. In other words, the inadequacy of aerobic energy production to meet the energy needs of the body during exercise is known as the oxygen deficit; and, the body's repayment of this deficit by consuming more than usual amounts of oxygen after exercise is known as the oxygen debt.

Operationally, oxygen deficit is defined as the difference between the total energy cost of work and the oxygen consumption during work, and oxygen debt is the oxygen consumed during recovery that is in excess of the amount that normally would have been consumed at rest during an equivalent time period (Lamb, 1978). Astrand and Rodahl (1977) pointed out, however, that since the basal metabolic rate may vary, it is very difficult to separate accurately the oxygen debt from resting oxygen uptake. It should also be noted that during the oxygen deficit and oxygen debt conditions, oxygen demand and supply are not equal. In contrast, during the steady state condition oxygen uptake equals the oxygen requirement of the body (Astrand & Rodahl, 1977).

In light exercise the oxygen debt may be entirely due to the oxygen deficit at the beginning of exercise (deVries, 1974). In more vigorous exercise, oxygen debt is ordinarily larger than oxygen deficit since oxygen debt reflects payment for the initial anaerobic ATP production as well as increased oxygen uptake due to an increased body temperature, heart rate, and respiratory rate (deVries, 1974).

Oxygen debt includes two components: lactacid, which is represented by proportional increases in blood lactate, and alactacid, for which no lactate is found (Margaria, Edwards, & Dill, 1933). Margaria et al. demonstrated a great difference in the repayment of the two components of the oxygen debt. The alactacid debt was repaid at a rate approximately 30 times faster than the lactacid debt. Thus, the fast component (alactacid) was ascribed to replacement of oxygen and energy and the slow or lactacid component was thought to be used to remove lactate from the blood.

The alactacid mechanism of contracting an oxygen debt occurred far more frequently in the ordinary conditions of the life than the lactacid mechanism, and there was a linear relationship between the rate of oxygen consumption and alactacid oxygen debt (Margaria et al., 1933). The lactacid mechanism appeared to be more like a mechanism of emergency, although its capacity was greater than that of the alactacid.

The lactacid-alactacid mechanism for oxygen debt, described by Margaria et al. almost 50 years ago, has been well verified (deVries, 1974). However, the lact-adic-alactacid explanation may be over simplified since it is clear that many processes besides the elimination of lactate may be involved in the delayed return of oxygen uptake to the resting value after the cessation of exercise such as the increased temperature, heart rate, and respiratory rate.

Measurement of Energy Expenditure

Direct Calorimetry

Adenosine triphosphate is known as the energy store or the energy currency of the body because it has a large quantity of energy (about 8,000 calories per mole) in each of its two high energy phosphate bonds. However, since some chemical reactions that require ATP energy use only a few hundred of the available 8,000 calories, the remainder of this energy is lost in the form of heat.

About 55% of the energy in foods becomes heat during ATP systhesis. Then even more energy becomes heat as it is transferred from ATP to the functional systems of the cells so that not more than 25% of all the energy from the food is finally used by the cell (Guyton, 1976).

Even though 25% of the energy finally reaches the functional systems of the cells, the major proportion of this also becomes heat as is illustrated by the following examples: (a) Proteins are formed and degraded in our bodies. When proteins are formed, ATP is used to form the peptide linkages; when proteins are degraded, the energy stored in the peptide linkages is released in the form of heat. (b) During muscular activity, energy is used to overcome the viscosity of the muscles so that the limbs can move. The viscous movement generates friction and, consequently, heat. (c) As blood flows through the blood vessels, the friction of the blood against the vessel walls generates heat (Guyton, 1976).

Therefore, essentially all the energy released by the metabolic processes in the body eventually becomes heat except when the muscles are used to perform work outside the body. The metabolism of the body means all the chemical reactions in all the cells and the metabolic rate is expressed in terms of the rate of heat liberation during the chemical reaction (Guyton, 1976).

The small calorie (spelled with a small c) is the quantity of heat required to raise the temperature of 1 gram of water 1 degree centigrade. The small calorie is too small a unit to be used when discussing the energy metabolism of the body. Therefore, the big Calorie (spelled with a capital C), or Kilocalorie (Kcal), which is equivalent to 1,000 calories, is used to discuss the amount of energy released from foods or expended by the body. The Calorie is the quantity of heat required to raise the temperature of a Kilogram of water 1 degree centigrade (Lamb, 1978).

As discussed previously, it is only when the body does external work that energy expended within the body does not become heat. Therefore, when a person is not performing external work, his metabolic rate can be determined by simply measuring the amount of heat liberated from the body. This method of assessing energy expenditure is called direct calorimetry. Direct calorimetry is performed in specially constructed chambers in which all the metabolic heat is accumulated by the air and walls of the chamber and changes in their temperature are used to calculate the energy output. Since the equipment used in direct calorimetry is expensive and difficult to use, this method of measuring energy cost is seldom used (deVries, 1974).

Indirect Calorimetry: Closed and Open-Circuit Methods

Since more than 95% of the energy expended in the body is derived from aerobic processes, the metabolic rate can be calculated indirectly from oxygen use. For the average diet, the quantity of energy liberated per liter of oxygen used in the body is approximately 5.0 Kcal. Using this energy equivalent of oxygen, one can calculate the rate of heat liberation in the body from the amount of oxygen used (Guyton, 1976).

There are two methods for doing indirect calorimetry--the closed-circuit method and the open-circuit method. In the closed-circuit method the subject inspires from a face mask which is connected to an oxygen chamber. The subject's expired air is conducted back to the oxygen chamber by way of a soda lime chamber where the carbon dioxide (CO_2) produced is absorbed. Therefore, only the oxygen that remains is returned to the oxygen chamber and the changes in the volume of the oxygen that remains in the chamber are recorded from breath to breath. The closed-circuit method is easy to use, but it is not very accurate--its results are plus or minus 10% of the true value (deVries, 1974). Another disadvantage is that no value for the CO_2 produced is obtained and consequently the respiratory exchange ratio (the ratio between the carbon dioxide produced and the oxygen consumed which may reflect foodstuff metabolism and/or hyperventilation) is not known.

The classical, open-circuit Douglas bag method for determination of oxygen consumption (which will be used in the present study) is theoretically sound, well tested in a variety of circumstances, and in all its relative simplicity is unsurpassable in accuracy (Astrand & Rodahl, 1977). In the Douglas bag method the subject inspires directly from the atmospheric air and expires into a large Douglas bag during a carefully timed period.

The subject has a nose clip on his nose and a mouth piece with a one-way valve in his mouth to prevent gas leakage. The following information is obtained which is then placed in a specially programmed computer or in various mathematical equations to derive oxygen consumption: the inspired and expired concentrations of oxygen, carbon dioxide, and nitrogen which are determined by an electronic gas analyzer with a precision better than plus or minus 0.02% in the range of respiratory gases (deVries, 1974); the expired gas volume which is measured by a Tissot gasometer; the barometric pressure; the air temperature; and the time.

The open-circuit method is more accurate than the closed-circuit method and information is obtained from the carbon dioxide data to enable computation of the respiratory exchange ratio. The error in the open circuit method may be less than plus or minus 1.0% compared to plus or minus 10% in the closed-circuit method (deVries, 1974).

When discussing oxygen consumption, it is important to keep in mind that oxygen consumption (VO_2) is simply the volume of air inspired times the concentration of oxygen inspired minus the volume of air expired times the concentration of oxygen expired. The oxygen concentrations are analyzed with a gas analyzer, the expired air volume is measured, and the inspired air volume is unknown. However, the volume of inspired air can be calculated from the volume of expired air because nitrogen (N_2) does not enter into the physiological reaction in the body (Lamb, 1978). Therefore, the volume of N_2 inspired is unchanged in the body and is equal to the volume of N_2 expired.

Units of Energy Measurement

Several different units of energy measurement are used in the literature. Most of these terms have already been introduced. In the following discussion, these terms will be more fully defined and compared.

1. Oxygen consumption in liters or milliliters per minute (l/min or ml/min)--the total oxygen consumption per minute needed to accomplish a given workload. This is a gross rather than a net value since it includes the basal, or resting, metabolism. This value, which varies in persons of different weights, reflects the total load on the oxygen transportion system (Astrand, 1976).

2. Oxygen consumption in milliliters per minute per kilogram of body weight (ml/kg/min)--the oxygen consumption per kilogram of body weight per minute needed to accomplish a given task. This value, theoretically, should be the same for different individuals performing the same standardized activity. Correction of oxygen consumption for body weight facilitates comparisons and is especially important in activities in which the body must be moved (e.g., walking). However, when oxygen consumption has been corrected for body size it does not reflect the total load on the oxygen transporting systems (Astrand, 1974).

3. Met (metabolic equivalent)--a fairly new and popular way to express oxygen uptake during activity. One met is the individual's resting oxygen consumption, a fairly stable and reproducible value which is equivalent to an oxygen uptake of approximately 3.5 ml/kg/min (Hellerstein & Franklin, 1978). One met, therefore, represents an individual's resting energy expenditure, and other activities can be expressed as multiples of this resting energy requirement. Thus, if dressing requires twice the individual's resting energy requirement, dressing can be said to require 2 mets.

4. Calorie or Kilocalorie--the unit of heat production used in energy metabolism studies. One Kilocalorie, which is equivalent to 1,000 calories, is the quantity of heat required to raise the temperature of 1 Kilogram of water 1 degree centigrade. One Kilocalorie represents an oxygen consumption of approximately 200 milliliters and 5 Kilocalories represents an oxygen consumption of approximately 1 liter.

5. Percent rise of energy cost--a net value, the percent increase above basal rate:

$$\%\text{ rise of energy cost} = \frac{\text{Working } O_2 \text{ consumption/min} - \text{Resting } O_2 \text{ consumption/min}}{\text{resting } O_2 \text{ consumption/min}} \times 100$$

Using the terms discussed above, the oxygen consumption of a 70 kg man during rest could be expressed as: (a) 240 ml/min, (b) 3.43 ml/kg/min, (c) 1 met, or (d) 1.2 Kcal/min, the the oxygen consumption of the same man while dressing could be expressed as: (a) 480 ml/min, (b) 6.86 ml/kg/min, (c) 2 mets, (d) 2.4 Kcal/min, or (e) 100%.

Total Body Oxygen Consumption

Oxygen Consumption for Standardized Work

The mechanical efficiency and metabolic expenditure of simple standardized muscular work do not appear subject to important individual variation although more study is needed in this area, and improvements in efficiency do result from training in complex tasks (Lamb, 1978; Passmore & Durnin, 1955). Energy expenditure during a standardized activity can be closely predicted from knowledge of body weight and no significant increase in precision is gained by also considering height, age, sex, race, or resting metabolism (Mahadeva, Passmore, & Woolf, 1955). Weight is the most important factor in determining individual energy expenditure because oxygen is used by all the body tissues, and the heavier individual has more body tissues requiring more oxygen. Theoretically, then, individuals of the same weight, performing the same simple, standardized activity, should have the same oxygen uptake (VO_2). And, oxygen uptake of persons of different weight can be meaningfully compared by expressing oxygen consumption in terms of ml/kg/min.

Even though numerous studies have been conducted to measure the energy expenditure of a variety of activities, most of these studies have used a small number of normal or convalescing subjects. Consequently, it is not clear whether the findings can be generalized to unhealthy subjects. In addition, the results of a recent study demonstrated that the oxygen consumption obtained from post myocardial infarction patients (PMIP) during exercise

> compared with available cumulative data on normal subjects is significantly variable, suggesting the need for caution when prescribing exercise for the PMIP based on energy costs of standard exercise measurements in normals. (Fletcher, Cantwell, & Watt, 1979, p. 140)

It is apparent, therefore, that more investigation is needed of the energy expenditure of sick and normal individuals involved in simple as well as complex activities before the extent to which one can generalize from one individual to another and from one task to another can be determined.

Maximal Oxygen Consumption

Maximal oxygen consumption (VO_2 max), which is also called maximal oxygen uptake and maximal aerobic power, is the maximal rate at which oxygen can be delivered to the tissues. Maximal oxygen consumption represents the greatest difference between the rate at which oxygen enters and leaves the lungs; therefore, maximal oxygen consumption is the greatest amount of oxygen that can be made available to the body to produce energy and reflects the individual's maximal work capacity and physical fitness (Astrand & Rodahl, 1977). Maximal oxygen consumption is a highly reproducible value which is proportional to body weight (particularly lean body mass), increases with physical training, decreases with bed rest, and diminishes with advancing age (Dehn & Mullins, 1977).

The method of determining maximal oxygen consumption involves working the subject at ever-increasing work loads during which the steady state oxygen consumption is measured. Probably the most important criteria for determining that the subject has achieved maximal oxygen consumption is whether oxygen consumption reaches a plateau with increasing workloads because it is known that oxygen uptake increases linearly with increasing workloads up to the maximal rate of oxygen uptake (Lamb, 1978). According to Shephard (1974), this oxygen consumption plateau should show an oxygen consumption increment of less than 2 ml/kg/min in response to a 1-2% increase of treadmill slope.

Other evidence that a peak oxygen uptake has been reached includes: (a) a maximum heart rate close to the age-related normal value (dropping from 195 beats per minute (bpm) in a young man to about 160 bpm in an elderly person), (b) a respiratory exchange ratio greater than 1.05, and (c) a terminal lactate concentration of more than 100 mg/100 ml in the arterialized capillary blood of young subjects, dropping to 60-80 mg/ml in the elderly (Shephard, 1974). In some instances, symptoms, signs, or electrocardiographic abnormalities may preclude reaching the maximum oxygen uptake as defined above; the oxygen uptake is then called a "symptom-limited" maximum test (Shephard, 1974).

Numerous attempts have been made to predict maximal oxygen consumption from heart rate and ventilation rate determinations during submaximal exercise tests based on the linear relationship between heart rate, ventilation, and oxygen consumption (Lamb, 1978; Nagle, 1973). Through submaximal testing an estimate of maximal oxygen uptake can be made without the need for sophisticated equipment, highly trained clinicians, or undue stress on the subject. Although submaximal tests can usually provide a close approximation of maximal oxygen uptake, they are subject to a prediction error of about 10% or greater (Astrand, 1976; Nagle, 1973).

It is not unusual for oxygen uptake to increase 10 or even 20 times when one passes from a resting condition (about .25 l/min) to strenuous exercise (about 2.5 to 5 l/min). There is a fairly broad range of values for maximal uptake depending upon such factors as fitness, age, and sex. For example, the maximal oxygen uptake of a 50 kg young woman might be 2.3 l/min (or 46 ml/kg/min) and that of a 70 kg young man might be 3.4 l/min (or 48 ml/kg/min). The highest oxygen consumption found in athletes was reported by Astrand and Rodahl (1977): 4.5 l/min (or 77 ml/kg/min) for a female cross country skier and 4.7 l/min (or 94 ml/kg/min) for a male cross country skier.

The percentage of an individual's maximal power demanded by an activity, which is also called the relative oxygen cost of an activity,

$$\% \ VO_2 \ max = \frac{VO_2 \text{ of activity}}{VO_2 \text{ max}} \times 100$$

is important to keep in mind when caring for persons with decreased maximal aerobic power because the relative oxygen cost of the activity will be low for a healthy person but high for an individual with diminished maximal oxygen uptake. For example, both an 80 kg athlete and an 80 kg sedentary man require an oxygen consumption of 1.6 l/min and a cardiac output of 15 l/min to walk 4 mph. However, this 1.6 l/min workload represents only 30% of the athlete's maximal oxygen uptake (5.2 l/min); whereas, it represents 50% of the sedentary man's maximal capacity

(3.2 l/min). Therefore, the athlete can continue walking at 4 mph for a longer period with a lower heart rate and less fatigue than the sedentary man. As Astrand and Rodahl (1977) pointed out, practical experience has shown that one cannot tax more than 30-40% of one's maximal aerobic power during an 8-hour working day without developing subjective and objective symptoms of fatigue.

Myocardial Oxygen Consumption

Determinants of Myocardial Oxygen Consumption

The heart operates with a narrow margin of oxygen supply. Venous oxygen saturations of 30% or less are normally found only in the coronary veins and in the blood leaving exercising skeletal muscle (Blomqvist, 1974). However, skeletal muscle activity can be supported by anaerobic metabolic processes to a much greater extent than cardiac muscle activity. Any increase in myocardial oxygen demand must, therefore, be satisfied primarily by an increase in coronary blood flow which is determined principally by coronary driving pressure and coronary vascular resistance (Blomqvist, 1974).

The six determinants of myocardial oxygen consumption (MVO_2) can be classified into three major determinants and three minor determinants. The major determinants, which require almost 80% of the myocardial oxygen consumption, include ventricular wall tension (which is proportional to the product of ventricular pressure and volume), heart rate, and contractile state (Blomqvist, 1974; Schlant, 1974). The product of tension and heart rate is often referred to as internal work. The minor determinants of MVO_2 include activation energy which accounts for less than 1% of the MVO_2, the basal metabolic rate of the heart which accounts for less than 20% of the MVO_2, and external work, the product of load and fiber shortening (blood pressure x stroke volume), which also has relatively little effect on myocardial oxygen demand (Blomqvist, 1974; Schlant, 1974).

Exercise affects all the major determinants of myocardial oxygen demand. The increase in cardiac output that is required to sustain muscular activity is accomplished primarily by an increase in heart rate which is due to vagal withdrawal and Beta-adrenergic stimulation (Blomqvist, 1974). Systolic arterial blood pressure also increases with exercise.

Rate Pressure Product

Myocardial oxygen consumption can be directly determined as the product of myocardial arteriovenous oxygen difference and coronary blood flow, but since both of these measurements require cardiac catheterization, this technique is not feasible for practical application. However, indirect approaches to assessment of MVO_2, such as the heart rate-blood pressure product, have been rewarding as practical means of estimating MVO_2.

A series of investigations demonstrated a close correlation between directly and indirectly measured MVO_2 in normal young men and in patients with coronary artery disease (Amsterdam, Price, Berman, Hughes, Riggs, DeMaria, Miller, & Mason, 1977; Kitamura et al., 1972). In normal individuals studied during upright exercise, there was a high degree of correlation between MVO_2 and the product of (a) heart rate x peak systolic aortic pressure (r = .90), (b) heart rate x mean systolic aortic pressure (r = .90), and (c) heart rate x mean aortic pressure (r = .80) (Kitamura et al., 1972). Heart rate alone also correlated closely with MVO_2 (r = .88) (Kitamura et al., 1972). Rate pressure product has also been shown to correlate well with MVO_2 in patients with coronary heart disease and in normal subjects receiving propranolol (Amsterdam et al., 1977; Jorgensen, Wang, Wang, Gobel, Nelson, & Taylor, 1973).

Total body oxygen consumption did not predict MVO_2 as well as rate pressure product demonstrating that there may be a significant disparity between external work and that performed by the heart (Kitamura et al., 1972). The correlation coefficients for MVO_2 and total body oxygen consumption expressed as ml/kg/min, l/min, and percentage of maximal were .80, .77, and .72, respectively (Kitamura et al., 1972).

The validity of the rate pressure product as an index of MVO_2 was also established by empirical studies of patients with angina. It was demonstrated that for an individual patient precipitation of angina occurs at a constant rate pressure product (Robinson, 1967). This relationship was consistent and independent of variations in the type, intensity, and duration of exercise (Robinson, 1967). Since heart rate-blood pressure indices of MVO_2 were constant at the point of angina for a given patient despite their failure to account for ventricular volume and contractility, two principal determinants of MVO_2, it was reasonable to conclude that the omitted factors either were constant or were in a manner that caused their effect on MVO_2 to be canceled (Amsterdam et al., 1977).

An increase in the rate pressure product indicated that the subject was able to increase myocardial oxygen consumption to meet the metabolic demands imposed by a given level of activity. The maximal rate pressure product, which can be considered to be a measure of cardiovascular adequacy, decreased with age and with heart disease (Amsterdam et al., 1977). The relative changes in oxygen consumption of the heart and of the body at rest and during exercise can be expressed as the ratio of the product of the heart rate x systolic blood pressure to oxygen uptake of the body. This ratio provides insight into the relative cardiac efficiency--the higher the ratio, the lower the efficiency.

Cardiovascular Response to Exercise

Normal Cardiovascular Response to Exercise

In the transition from rest to maximal exercise in the healthy young man, oxygen intake increases from about .3 to 3 liters per minute (10 fold increase) due to increased transport and extraction of oxygen (Blomqvist, 1974). Oxygen transport and utilization may be described in terms of the following equation: Oxygen uptake = cardiac output x total arteriovenous oxygen difference, where cardiac output = heart rate x stroke volume. Typical values of oxygen uptake, cardiac output, and total arteriovenous oxygen difference (A-V O_2 difference) for a normal young sedentary man during sitting rest and maximal exercise are illustrated in Table 1 (Blomqvist, 1974).

Since oxygen uptake is the product of cardiac output and total arteriovenous oxygen difference, a linear relationship exists between oxygen consumption and cardiac output, and cardiac output rises during exercise roughly in proportion to the increase in oxygen consumption. Because heart rate is a major determinant of cardiac output, a linear relationship also exists between heart rate and oxygen consumption. Accordingly, heart rate, under certain standardized conditions may be used to estimate workload if the the workload-heart rate relationship has been established for the individual, if roughly the same large muscle groups are used, if environmental and emotional stress are similar, etc. (Astrand & Rodahl, 1972). For example, an individual might have heart rates of 85 bpm, 130 bpm, and 170 bpm at 25%, 50%, and 75% of his maximal oxygen uptake.

In the transition from rest to maximal exercise, cardiac output increases about four-fold, from

Table 1

Circulatory Data during Sitting Rest and Maximal Exercise in a Normal Young Sedentary Man

	Oxygen Uptake (l/min)	=	Cardiac Output (Heart Rate x Stroke Volume) (l/min)	x	A-V O_2 Difference ml/100 ml blood
Sitting rest	.3		5.6		5.2
Maximal exercise	3.0		10.0		15.8

Note. The data in Table 1 are derived from Blomqvist, 1974.

approximately 5 to 19 liters per minute, primarily due to a three-fold increase in heart rate (Blomqvist, 1974). The magnitude of the heart rate response is related to the individual's physical fitness level, health, age, and to environmental factors such as temperature and humidity. Heart rate may increase in normal young adults to 100 bpm during light exercise, to 130 bpm in moderate exercise, and to 190-200 bpm during heavy exercise. Since maximal heart rate decreases with age, the peak heart rate may only reach 160 bpm in an older person.

During light exercise the initial heart rate increase may be exaggerated, but it is subsequently reduced to a lower steady-state level (Judy, 1976). In heavy exercise there is a tendency for the heart rate to increase progressively until an adequate cardiac output is achieved. After cessation of exercise, the heart rate gradually returns to its pre-exercise levels, the rate of return being proportional to the severity of the exercise, i.e., the more severe the exercise and the less fit the subject, the slower the return to resting heart rate levels.

Stroke volume depends on cardiac filling; therefore, it is strongly influenced by body position. The magnitude of change in stroke volume is largely a function of which body position is selected as representative of the resting control state (Blomqvist, 1974). Stroke volume at supine rest is equal to that during mild upright exercise and usually within 20% of the maximal stroke volume (Blomqvist, 1974). The stroke volume at standing rest in normal subjects averages less than 65% of the maximum stroke volume (Blomqvist, 1974). Stroke volume at sitting rest falls between the values for the supine and standing position.

Extraction of oxygen is about three times as effective during maximal exercise as at rest. The increasing arteriovenous oxygen difference with increasing workloads reflects a redistribution of blood flow--blood is shunted away from nonworking muscles, the skin, and the splanchnic area and delivered to working muscles.

Systolic blood pressure increases as exercise increases, increasing about 7 to 10 mm Hg per met (Kattus, 1975). At peak effort systolic blood pressure may range from 160-200 mm Hg. Diastolic blood pressure changes only about 10 mm Hg or less, and may either increase or decrease. The blood pressure response to exercise is affected by the individual's age, physical fitness, and health, Older persons may demonstrate large increments of blood pressure during exercise. Sedentary persons and cardiac patients may be unable to generate an adequate blood pressure rise during effort.

Normal individuals are symptom-free at submaximal levels of exercise; at maximal efforts fatigue, exhaustion, and sometimes nausea or dizziness occur (Kattus, 1975). Chest pain, claudication, or intolerable dyspnea do not occur even at maximal exercise in normal individuals (Kattus, 1975). Normal electrocardiographic responses to the increased heart rates associated with exercise include shortened PR and QT intervals often accompanied by upward displacement of the TP baseline with downward displacement of the J-junction (Kattus, 1975).

Abnormal Cardiovascular Response to Exercise

Comparison of oxygen consumption, heart rate, stroke volume, and arteriovenous oxygen difference during maximal exercise in a normal sedentary subject and a patient with cardiac disease (Table 2) shows that differences with respect to maximal heart rate and A-V O_2 difference are relatively small (Blomqvist, 1974). Heart

Table 2

Circulatory Data during Maximal Exercise in a Normal Sedentary Subject and a Cardiac Patient

	Oxygen Uptake (l/min)	Heart Rate (bpm)	Stroke Volume (ml)	Cardiac Output (l/min)	A-V O_2 Difference (ml/100 ml)
Normal Sedentary Subject	3.0	190	100	19.0	15.8
Cardiac Patient	1.5	175	57	10.0	15.0

Note. The data in Table 2 are derived from Blomqvist, 1974.

rate and A-V O_2 difference would also be similar in the normal subject and the cardiac patient at submaximal exercise levels if the workload was measured as a relative load, i.e., percentage of maximal oxygen uptake.

However, the stroke volume response, which is a major determinant of maximal cardiac output and maximal oxygen uptake, differs significantly between the normal subject and the cardiac patient. The cardiac patient's stroke volume response to exercise is often subnormal, and there is frequently a decrease in stroke volume rather than a further increase progressing from light to heavy exercise (Blomqvist, 1974).

The cardiac output, since it is determined by the stroke volume and heart rate, also differs considerably between the normal subject and the cardiac patient during maximal work. Patients with cardiac disease, as a group, have been shown to have a low cardiac output at rest and a subnormal increase in output for any given increase in oxygen uptake (Blomqvist, 1974). The degree of cardiac output abnormality increases as the severity of the disease increases. In mild cardiac disease cardiac output restrictions are not apparent at rest or at low work load levels, only at maximal or near maximal levels; however, as cardiac disease progresses cardiac output restrictions during lower levels of activity become evident.

Abnormal responses to exercise are, therefore, anticipated in patients with heart disease and may also occur in physically unfit subjects. Abnormal responses to exercise include abnormal blood pressure, heart rate, and electrocardiographic changes as well as signs and symptoms indicative of insufficient cardiac output.

A decrease in systolic blood pressure during submaximal physical stress or a failure of blood pressure to increase as external work is increased are abnormal responses which suggest inadequate pumping of the heart (Kattus, 1975). An inordinate increase of systolic blood pressure during exercise indicates an abnormal hypertensive response.

Individuals with greater degrees of cardiac impairment respond to exercise stress with greater increases in heart rate at lower work loads. Thus, development of a heart rate of 150 bpm during dressing or undressing is an abnormal response to a low level activity. Occasionally, bradycardia due to heart blockage or other abnormalities may also occur during exercise.

Any electrocardiographic abnormality not recorded at rest which occurs during exercise must be considered an abnormal response to exercise. The ST segment, in particular, may show an abnormal response to exercise. An ST segment with a 0.1 millivolt (1mm) deviation from baseline at 80 milliseconds after the J-point is diagnosed as an abnormal ST segmental response (Sheffield, 1974). Both ST segment elevation and depression have been shown to be associated with coronary ischemia (Sheffield, 1974).

The development of chest discomfort, severe dyspnea, faintness, claudication, pallor, cyanosis, or cold sweat are other abnormal responses to exercise indicative of inadequate cardiac output (Kattus, 1975). Exercise should be stopped if any of the above abnormal responses to exercise occur.

Effects of Temperature on the Body

Thermoregulation

The temperature of the body is regulated almost entirely by nervous feedback mechanisms which operate through a temperature regulating center in the hypothalamus to keep the core body temperature almost exactly constant at 98.6° F (37° C) except when a person develops a febrile illness (Guyton, 1976). The skin temperature, however, rises and falls with the temperature of the surroundings. In the normal, comfortable individual in a 84.2° F (29° C) environment, skin temperature ranges from 89.6° F to 93.2° F (32° C to 34° C) (Mountcastle, 1980).

When the body becomes too hot the hypothalamic thermostat activates heat loss mechanisms such as sweating, to cause evaporative heat loss from the body, and vasodilation of the skin blood vessels, to conduct the heat from the internal portions of the body to the skin (Guyton, 1976). When the body becomes too cool, the body's thermostat activates heat conserving mechanisms such as shivering, to increase muscle metabolism and heat production, and intense vasoconstriction of all the skin blood vessels, to prevent conduction of heat from the body core to the skin (Guyton, 1976).

A thermoregulatory change in total peripheral resistance (e.g., vasodilatation or vasoconstriction) has effects on heart rate and blood pressure because of the following relationship: mean arterial blood pressure = cardiac output (heart rate x stroke volume) x total peripheral resistance (Guyton, 1976). Since the body's homeostatic mechanisms strive to keep blood pressure stable, a decrease in total peripheral resistance is associated with a compensatory increase in cardiac output, and an increase in total peripheral resistance is associated with a compensatory decrease in cardiac output. If the compensatory change is not effective, a blood pressure increase or decrease will occur.

Effects of Warm and Hot Baths on Cardiovascular Function

Hill and Flack (1909) showed that immersion up to the neck in a hot bath (105° F to 110°F or 40.6°C to 43.3°C) in nine subjects was accompanied in 15 to 30 minutes by increases in rectal temperature to 102°F to 104.6°F (38.9°C to 40.3°C), pulse rate to 160 bpm, breathing frequency and volume to 50 liters, and by a decrease in arterial pressure to as low as 60 mm Hg which was associated with faintness. A cold shower constricted the skin, lowered axillary and mouth temperatures to normal or subnormal (but not rectal temperature), decreased the pulse rate, raised the arterial pressure, and stopped the faintness (Hill & Flack, 1909).

Bazett (1924), who studied the effects of bath temperature during 36 experiments on 14 subjects, found that little or no change in pulse rate occurred if the bath was neutral in temperature (95°F to 97.7°F or 35.5°C to 36.5°C). If the bath was hot, the pulse rate rose roughly proportional to the rise of body temperature. In general, there was a pulse rate change of about 10 bpm for every temperature change of 1°F (Bazett, 1924). In a later study, Keatinge and Evans (1961) also found little heart rate effect in 95°F (35°C) water--the heart rates of 12 subjects increased slightly during the first minute (e.g., to 80 to 85 bpm) and quickly returned to the initial rate. In water at 100°F (37.8°C), however, the heart rate increased significantly within a minute of immersion and continued to rise throughout the experiment (Keatinge & Evans, 1961).

Bazett (1924) found that baths of 93.2°F to 95°F (34°C to 35°C) produced no effect on blood pressure, but the baths felt cold and lowered body temperature. Baths of 96.8°F (36°C) did not affect body temperature, felt warm to the subject, and were associated with a small decrease in systolic and diastolic pressure varying from 0 to 10 mm Hg during the first hour (Bazett, 1924). Bazett found a marked hypernea in hot baths. Ventilation was increased mostly by an increase in depth and only slightly by an increase in rate.

As far as temperature sensations, a bath at 95°F (35°C) was above the normal skin temperature and felt warm when entered. After a short while the bath felt quite comfortable and then it usually felt somewhat cooler than the subject would choose (Bazett, 1924). Usually there was little change in body temperature (Bazett , 1924). There seemed to be no doubt, according to Bazett, that if guided by his own sensations, a subject would choose a bath at a temperature slightly higher than 95°F which was sufficiently high to give him a small rise in body temperature.

In a more recent study, Luria and Picken (1974) studied 12 subjects during a 10-minute immersion in a hot bath (110.5°F ± 1.8°F) 5 times per week for 8 weeks. The average heart rate was 128 ± 11 bpm and the average oral temperature was 101.3°F ± 0.8°F. Three subjects experienced frequent ectopic beats during the hot baths.

Luria and Picken (1974) measured oxygen consumption and blood pressure in five additional subjects during one 10-minute hot bath immersion (112°F ± 1°F). During the last 2 minutes of immersion, mean oxygen consumption was 6.2 ± 1.5 ml/kg/min, oral temperature was 103.1 ± 1.5°F, and heart rate was 141 ± 14 bpm. Diastolic pressure fell by at least 20 mm Hg in four of the five individuals after 10 minutes of immersion whereas systolic pressure was not significantly altered.

It is apparent from the studies described above that immersion in a hot bath has marked cardiovascular effects resulting in vasodilatation, reduced blood pressure, and increased heart rate. Therefore, when hospitalized patients bathe and during investigation of cardiovascular response during bathing, it is important to maintain tub and shower temperature at 95.9°F to 97.7°F (35.5°C to 36.5°C) so that minimal cardiovascular effects occur.

Thermal Pain or Injury

One does not have to worry about the vasodilatation, tachycardia, and hypotension associated with hot bath immersion during a basin bath. However, thermal pain or injury could result from a basin bath if the water temperature was too high. The temperature of basin bath water should feel warm or hot, but it should not be hot enough to elicit painful sensations or thermal injury. The threshold for thermally evoked pain is the rate of heat transfer to the skin that exceeds the rate of heat loss by an amount just sufficient to drive the skin temperature to approximately 111.2°F to 114.8°F (44°C to

45°C) (Guyton, 1976; Mountcastle, 1980). Therefore, to prevent the possibility of thermal pain, the temperature of basin bath water should be less than 111.2°F.

Moritz and Henriques (1947) studied time-surface temperature thresholds for thermal injury in eight subjects using direct exposure of the skin to rapidly flowing hot water. Moritz and Henriques showed that the lowest surface temperature responsible for cutaneous burning in the study was 111.2°F (44°C), and that the time required to cause irreversible damage to epidermal cells at this temperature was 6 hours. The authors noted that burning would probably have occurred at even lower temperatures if the experiments had been prolonged.

The rate at which irreversible cellular injury was sustained increased rapidly as the surface temperature was raised--for each degree rise in surface temperature, between 111.2°F and 123.8°F (44°C and 51°C), the time required to produce thermal injury was reduced by approximately one-half (Moritz & Henriques, 1947). Therefore, only a few minutes exposure to a surface temperature of 123.8°F resulted in complete epidermal necrosis. The authors noted, however, that a large variation in threshold for thermal injury may be present among individuals and that one individual's threshold may change over time.

From the information discussed above, one can conclude that basin bath water at a temperature of 102°F to 110°F (38.9°C to 43.3°C) will feel comfortably hot to most individuals without eliciting painful sensations or thermal injury. Since the temperature of basin bath water tends to cool quickly, a starting temperature of 102°F to 110°F should also prevent the water from becoming uncomfortably cool as the bath progresses.

Bath Water Temperature Recommendations in Nursing Textbooks

Despite the importance of avoiding the untoward cardiovascular and thermal injury effects of hot baths for hospitalized patients, few nursing text books include bath water temperature recommendations, and those that do may suggest very high temperatures. For example, although DuGas (1977) stated that, "a very hot bath will cause the blood to be diverted away from the vital centers of the brain to the surface areas of the body; as a result he may feel faint and lose consciousness" (p. 363), she recommended that unless otherwise ordered, bath tub water should be drawn at 104°F to 105.8°F (40°C to 41°C), "a comfortable and safe temperature for most people" (p. 363). When discussing the bed bath, DuGas (1977) stated:

> Most patients require bath water between 43.3°C to 46.1°C (110°F and 115°F). Water at this temperature is comfortable to most patients and it does not injure skin or mucous membranes. Water at 50°C (120°F) in the basin will cool to the safe temperature range by the time it comes in contact with the patient's skin. (p. 362)

DuGas (1977) provided no references to support her bath water temperature recommendations.

In Sorensen's and Luckmann's popular nursing text book, Niland (1971), in a chapter on providing basic patient hygiene, noted that:

> A patient may experience faintness or weakness because of vasodilatation from hot water (blood normally flowing to the brain shifts from the central nervous system as environmental temperature increase). (p. 579)

Despite this knowledge, the author recommended that shower or tub water temperature be adjusted at 105.8°F to 114.8°F (41°C to 46°C). Niland (1979) recommended that basin water temperature be 109.4°F to 114.8°F (43°C to 46°C). Niland did not include references to support her bath water temperature suggestions.

Rating of Perceived Exertion

Quantification of Perceived Exertion

An individual's decision to continue or to stop hard physical work, as well as the intensity at which he chooses to work, are governed in large part by his subjective feelings (Morgan, 1973a). The important consideration in human performance setting is frequently not "what the individual is doing" but rather "what he thinks he is doing" (Morgan, 1973b). Therefore, in order to understand a person at work, not only his physical performance should be studied, but also the subjective costs behind the performance (Borg, 1973).

The concept of perceived exertion offers a unique approach to the study of human performance. Perceived exertion, which can be defined as one's subjective rating of the intensity of work being performed, is a personal and complex sensation. Perceived exertion can be quantified through the use of a scale developed by Borg in 1962 (Borg, 1973).

The first scale had 21 points and all the odd values from 3 to 19 were anchored with the aid of such verbal expressions as "rather light," "very laborious," etc. In order to increase the linearity of the relationship between rating of perceived exertion (RPE) values and heart rates and at the same time to adjust the ratio of RPE values to heart rates some modifications of the 21 point scale were made. The scale now consists of 15 grades from 6 to 20 in which every second number is accompanied by a written description (Appendix A). This rating of perceived exertion scale is presented to the subject who is asked to indicate the number which reflects the degree of exertion he is experiencing.

Relationship between Perceived Exertion and Physiological Measurements

The ratings of perceived exertion were designed to correspond with heart rates. For healthy middle-aged men doing moderate-to-hard work on a bicycle ergometer or treadmill, the heart rate should be about 10 times the RPE value (Borg, 1973). Correlation coefficients of .83 to .94 between RPE and heart rate (HR) were demonstrated in healthy Swedish populations and in American university students (Bar-Or, Skinner, Buskirk, & Borg, 1972). However, correlations measured in age heterogeneous groups and in various groups of patients were markedly lower, varying from .40 to .70 (Bar-Or et al., 1972).

When different ratings of perceived exertion were used (the RPE scale, a line scale, the old 21 point RPE scale, and a 9-point scale) correlations of .83 to .92 among the different ratings were found, and good correlations between heart rate and perceived exertion (.52 to .72 with the RPE having the highest correlation) were obtained independently of which scale was used (Borg, 1973). There was obviously a fundamental relationship between a physiological indicator of physical stress such as heart rate and a psychological indicator such as rating of perceived exertion.

Interest in the complex psychobiological mechanisms that govern performance has grown over the past 20 years. Studies using the Borg RPE scale showed a linear relationship between RPE and heart rate, proportion of maximal capacity, and blood lactate concentrations during various types of work (Borg & Linderholm, 1967; Ekblom & Goldbarg, 1971; Gamberale, 1972; Skinner, Hutsler, Bergsteinova, & Buskirk, 1973). Studies also showed that age, presence of cardiovascular disease, size of muscle mass used, and physical training may modify the rating of perceived exertion (Borg & Linderholm, 1967, 1970; Ekblom & Goldbarg, 1971). No studies could be found in which RPE was measured in hospitalized patients engaged in low energy cost activities.

Ekblom and Goldbarg (1971) investigated the relationship between the rating of perceived exertion and (a) physical training, (b) autonomic nervous system blockade, and (c) type of physical work. Heart rate was about 15 bpm lower after physical training compared to before training for a given submaximal workload. However, RPE was the same before and after physical training when it was related to a given "relative" oxygen uptake, oxygen deficit, or blood lactate concentration.

The results of the investigation of the influence of parasympathetic and beta adrenergic blockade also showed that RPE was related to a given relative oxygen cost, oxygen deficit, and blood lactate level, but the RPE was not related to the heart rate response which had been altered by drugs (Ekblom & Goldbarg, 1971). Therefore, it was apparent that a tachycardia was not the primary factor for the setting of the RPE during exercise.

Investigation of RPE during different types of physical work showed that rating of perceived exertion during arm work was significantly higher than during comparable leg work (Ekblom & Goldbarg, 1971). Even for a given submaximal "relative" oxygen uptake or heart rate, RPE was higher during arm work than during leg work. However, RPE for a given blood lactate concentration was the same during arm and leg work. When comparing bicycle work with running, the higher RPE for a given submaximal work load on the bicycle might have been caused by the higher local muscular strain, indicated by the higher blood lactate concentration. In an additional study, three subjects performed the same maximal work with legs only and with arms and legs (Ekblom & Goldbarg, 1971). The RPE was much higher for isolated leg work than for combined arm and leg work, suggesting that RPE during heavy exercise seemed to be related to the size of the muscle mass involved.

Bar-Or et al. (1972) studied perceived exertion during exercise in 15 physically active and in 19 sedentary men, 41-60 years old, during a graded bicycle ride and a graded treadmill test until a HR of 150 bpm was reached or the subject rated the exertion as very hard. During the last 20 seconds of each work load, heart rate and RPE were obtained. The relationship between the correlation coefficient for heart rate and RPE in relation to relative work intensity indicated by heart rate was poor at low work loads, increased with moderate work loads, and then decreased. Thus, a zone of "best" perception appeared to occur around a heart rate of 125-135 bpm. The authors could not offer a good explanation for these findings.

In a study by Rosentswieg, Williams, Sandburg, Kolten, Engler, and Norman (1979), 18 highly fit professional hockey players gave a mean perceived exertion rating of 13 following a Balke treadmill test to a heart rate of 180 which theoretically should produce a RPE of 18. The same subjects assigned a mean RPE of 9 to a maximum isokinetic strength test with the Cybex II instrument which elicited a RPE of 13 from untrained men. Rosentswieg et al. recommended that the rating of perceived exertion should be interpreted carefully since it appeared to be both task and population specific, and was based upon more than just physical fitness elements. Rosentswieg et al. suggested that professional hockey players do not view exertion in the same manner as others less accustomed to pain and maximal efforts.

It is evident, from the studies discussed above, that perception of effort is a complex, multifaceted phenomenon which, despite growing interest and research, is not well understood. Measurement of rating of perceived exertion in different groups of subjects during different methods of bathing will provide information about the individual's subjective responses to bathing. This information, related to physiological findings and questionnaire answers, may enhance understanding of responses to low energy cost activities.

Oxygen Consumption and Cardiovascular Response during Bathing

Oxygen Consumption during Personal Hygiene: Five Studies

In one of the earliest reports found about energy expenditure during bathing, the oxygen consumption of a 28-year-old, 57.7 kg, infantry recruit, was measured (the authors do not report the measurement method) during three trials of washing hands, face, and neck and brushing hair (Cathcart & Trafford, 1920). The average oxygen consumption during washing was 8.76 ml/kg/min (standard deviation = 1.27) which represented almost 3 times the subject's basal oxygen uptake.

About 30 years later, Passmore, Thomson, and Warnock (1952) used the Kofranyi-Michaelis calorimeter, a portable, open-circuit device, to determine the energy cost of about

30 separate activities for five healthy male students who weighed an average of 73 kg and were between 19 and 25 years old. The mean oxygen consumption during dressing, washing, and shaving was 10.22 ml/kg/min (standard deviation = 0.92) which represented 3.21 mets. These results are higher than those of Cathcart and Trafford (1920) as would be expected since the subjects in this study dressed and shaved in addition to washing. These results are less variable than those of Cathcart and Trafford (1920) which is not expected since five subjects participated in this study by Passmore et al. (1952) and only one subject participated in Cathcart and Trafford's (1920) study. Passmore et al. (1952) did not describe what "washing" entailed.

A comprehensive summary of human expenditure (Passmore & Durnin, 1955) provided brief information from three studies (which are not available in the original form) measuring the energy costs of adults carrying out personal care. The mean oxygen uptake during washing, shaving, dressing, and/or undressing in a total of five males, 20-28 years of age, and three females, 43-55 years of age, was 8.69 ml/kg/min which is similar to Cathcart and Trafford's (1920) results.

In summary, the results of five studies in which the metabolic expenditure of 14 healthy subjects (11 men, 19-28 years old; 3 women, 43-55 years old) was determined during washing, shaving, brushing hair, dressing, and/or undressing showed that the oxygen consumption required by these personal care activities ranged from 7.65 to 11.87 ml/kg/min and averaged 9.53 ml/kg/min which represented about 3 times the basal energy expenditure.

Oxygen Consumption during Showering: Two Studies

Gordon (1952) noted that:

> In the course of management of pulmonary tuberculosis, the question often arises as to how much physical activity a given patient may assume and yet safely avoid stress with possible reactivation of his disease. Precise definition of the limit between tolerance and stress is not possible, for neither are the relevant factors fully understood nor are the measurements feasible. However, the intensity of physiological work, i.e., the energy expended in the performance of a task, can be readily obtained. (p. 291)

Therefore, Gordon (1952) used the Douglas bag method to measure the metabolic cost of common activities such as leather tooling, copper tooling, chisel carving, using a wheelchair, and showering in order to assist the clinician decide whether to allow a patient to engage in a particular activity.

Gordon (1952) measured oxygen consumption in one ambulatory pulmonary tuberculosis patient and three healthy individuals during rest and during showering in water adjusted to each subject's liking and judged to be tepid. The collection of expired air was started after the subject had showered for 2 minutes and was continued for 5 to 12 minutes. The percentage rise in energy cost above basal rate during showering ranged from 242% in the patient to 377% in one of the healthy subjects. The oxygen uptake during showering ranged from 12.54 in the patient to 17,49 ml/kg/min in one of the healthy subjects (standard deviation = 2.18) and averaged 15.31 ml/kg/min which represented over 4 times the basal energy cost.

Gordon's (1952) energy cost results are higher and more variable than those reported in the five personal care studies discussed previously as would be expected since showering requires more muscle activity and is probably performed in a greater variety of ways than "morning wash-up." It is surprising that the one patient subject in Gordon's (1952) study had an energy expenditure during showering much lower than that of the three normal subjects. The patient was described as being "more deliberate in his actions" than the other subjects (Gordon, 1952, p. 205).

Gordon (1952) emphasized that the investigation was concerned only with the intensity of the rates of energy cost of various activities and not with the total sum of daily energy expenditure since

> Intensity is fully as important as the total sum, since a short burst of relatively high energy cost may be injurious to the tuberculous patient by exceeding a certain critical level above which physiological stress may cause pathologic changes. (Gordon, 1952, p. 206)

Gordon (1952) pointed out that the percentage rise of energy cost over basal for showering (242 to 377%) was higher than that for any of the occupational therapy tasks studied (22% to 173%) or for self-propulsion in a wheelchair (134% to 138%). Gordon also stated that the metabolic cost of showering was comparable to that of walking 3.75 mph or walking downstairs. Therefore, Gordon (1952) believed that

> A physician rightly hesitates to allow showering for some patients still in a dubious clinical status; the four or five minutes required to perform the activity contributes an insignificant amount to the total daily expenditure, yet the relatively high intensity of physiological stress engendered even for a short time casts doubt on the wisdom of allowing it. (pp. 206-207)

However, Gordon (1952) advised physicians to prescribe occupational therapy activities for patients since

> The small physiological cost that they [the occupational tasks] would entail may be more than balanced by the release of mental tension and, consequently, achievement of more nearly complete rest during the remainder of the day. (p. 208)

Gordon presented a table of energy costs of self-care and work activities (derived from this and other studies). However, Gordon (1952) stressed that

> the presentation of tables of energy cost should not be interpreted to mean the advocacy for activity in precise dosages. This procedure is neither attainable nor desirable. Rather, it is hoped that on the basis of a rough approximation of the physiological stress, sustained in doing a given activity, the patient and physician will be on surer ground. From a practical point of view, choice of activities may be contained within physiologically meaningful limits. (p. 208)

In a follow-up study, Gordon and Haas (1955) used the Douglas bag method to determine the energy cost of showering for 10 pulmonary tuberculosis patients who were on the rehabilitation ward and were engaging in physical activity for 2 to 3 hours daily. To insure the collection of an adequate amount of expired air (90-120 liters), the subject completed several showers during one session. Therefore, several cycles contributed to the overall value obtained. Each shower lasted approximately 8 minutes; the water temperature ranged from 32°C to 38°C (89.6°F to 100.4°F).

Oxygen debt due to showering was also measured. After a suitable volume of expired air had been collected during seated rest and then during showering (subsequent to a 3-minute preliminary workout), the subject was immediately seated again and expired air was obtained successively at minute intervals for 3 to 4 minutes to determine oxygen uptake during the recovery period.

Oxygen consumption during showering ranged from 8.10 to 15.28 ml/kg/min and averaged 11.43 ml/kg/min (standard deviation = 2.46) which represented approximately 3 mets. These results showed a relatively wide scatter about the mean similar to the results in Gordon's (1952) study. The mean oxygen consumption during showering in this study, 11.43 ml/kg/min, was lower than the mean of 15.31 ml/kg/min found in Gordon's previous study. Gordon and Haas (1955) pointed out that the results found in this study probably did not represent the full oxygen requirements because a measurable oxygen debt of .4 to 1.5 liters over 2.75 to 4 minutes (100 ml/min to 500 ml/min, mean 281 ml/min) was found following showering.

These authors noted that the prolongation of the shower to approximately 8 minutes might have favored the accumulation of an oxygen debt considerably above that found under ordinary circumstances. Nevertheless, it is difficult to explain why considerable oxygen debts were incurred during an activity which represented only 3 times the basal energy cost. Perhaps the subjects were very deconditioned (despite their ambulatory status) and the prolonged showers taxed a high percentage of their maximal oxygen consumption. Or, perhaps the concept, oxygen debt, is not well understood.

Gordon and Haas (1955) explained the fairly wide variability of the energy cost findings for showering:

> A factor influencing variation in oxygen uptake appears to be the nature of the task itself. The progressive increase in metabolic work as the subject goes from rug hooking to showering, in general, is associated with increasing magnitude of variation from the mean. . . . Operations without precise regulation and involving larger muscle masses may favor wider variation in motion patterns and, consequently, in metabolic work. This is actually another way of saying that training is important and results in economy of work. Nonetheless, the large variations in a given task, do not vitiate the study, because it was of interest to assess the metabolic expenditure of patients in realistic conditions and not under ideal conditions. (p. 727)

Gordon and Haas (1955) pointed out that their energy cost findings for showering and for the other activities provided some idea of the degree of stress imposed by various tasks and aided the clinician in prescribing activities. The authors observed that it would seem contradictory to allow a patient to shower and yet deny him a lower energy cost activity such as rug hooking. In addition, the authors emphasized that the data presented were related to intensity of physiologic effort rather than to the total amount of work done:

> Showering itself may take two to three minutes and will contribute an insignificant amount to the total daily expenditure; yet the relatively high intensity of physiologic stress engendered for even a short time may exceed a certain critical level above which injury may ensue. (Gordon & Haas, 1955, p. 728)

In summary, the average oxygen uptake during showering in the two studies discussed above using a total of 11 pulmonary tuberculosis patients and 3 normal subjects was 12.54 ml/kg/min, or approximately 3.6 mets. It is of interest that the average oxygen consumption during showering was much higher for the normal subjects (16.23 ml/kg/min) than for the patients (11.53 ml/kg/min). Observations of showering motions, which could have helped explain the energy cost differences between the normal subjects and the tuberculosis patients, were not made.

Oxygen Consumption and Cardiovascular Response during Various Methods of Bathing: Two Studies

In a recent study, Johnston, Watt, and Fletcher (1981) measured oxygen consumption, hemodynamic, and electrocardiographic responses to bathing in 12 uncomplicated, recent postmyocardial infarction patients because "reports of sudden death and electrocardiographic changes after showering have prompted new emphasis on such practices during the early phase of hospital inpatient rehabilitation" (p. 666). Ten of the 12 patients completed the entire study protocol. Patient 1 had a congenital lip which interfered with oxygen consumption so only his cardiovascular data were accepted. Patient 8 underwent myocardial revascularization on day 5 of his hospitalization, so he was able to complete only one bath (tub bath) during the study. The data from his tub bath were included in the study.

The 10 male and 2 female patients, who averaged 54.8 years of age and 4 days post infarction, took a basin bath, tub bath, and shower, in random order, on

3 consecutive days. The bath water temperature was maintained at 96°F $\pm$ 2°F. The patient performed the baths with no assistance from the nurse. The average time required for the basin bath (4 min., 38 sec.) was longer than the average time required for a tub bath (3 min., 34 sec.) or a shower (3 min., 7 sec.) (Johnston et al., 1981).

A Max Planck respirator was used to measure oxygen consumption from the time the patient began bathing until he completed toweling off after the bath. Heart rate was determined by radial pulse palpation when the subject signaled he had completed 50% of the bath and immediately after he had finished the bath; blood pressure and a 12-lead electrocardiogram were taken before and after each bath; and cardiac auscultation for murmurs and gallop rhythm was done before and after each bath. None of the patients had any significant symptoms during bathing (Johnston et al., 1981).

The mean oxygen uptakes required by the basin bath, tub bath, and shower were 8.94 (SD = 3.25), 9.01 (SD = 3.22), and 13.02 ml/kg/min (SD = 1.46), respectively. The mean oxygen uptakes of the three baths, divided by the approximate energy cost of rest, 3.5 ml/kg/min, represented 2.55, 2.57, and 3.72 mets. Since Johnston et al. did not determine the subjects' resting oxygen consumptions, the met values may not be accurate. The bathing oxygen consumption results showed that taking a shower required an oxygen consumption 44% greater than that required by taking a tub bath or a basin bath ($p < .01$) (Johnston et al., 1981). However, the oxygen uptake results demonstrated considerable variability among individuals taking the same bath, emphasizing the individual differences.

Rate pressure product results averaged 131.89 for basin bath, 139.54 for tub bath, and 150.70 for shower. Rate pressure product was significantly higher ($p < .05$) for shower than for basin bath but not for tub bath (Johnston et al., 1981). Reduction of the data revealed that the heart rate component was mainly responsible for the change seen in the rate pressure product (Johnston et al., 1981).

No patient complained of angina during or after the baths. No serious dysrhythmias were observed during or after the baths. Two cardiologists who did not know the identity of the patients read the pre bath and post bath electrocardiograms and found significant ST displacement (≥ 1 mm) in 6 of 11 patients after the shower, in 4 of

12 patients after the tub bath, and in 2 of 11 patients after the basin bath (Johnston et al., 1981).

When comparing cardiac auscultatory findings before and after bathing, the heart sounds became softer in one patient after shower and in another patient after both tub bath and basin bath; third heart sounds developed in one patient after shower, in another patient after shower and after basin bath, and in a third patient after basin bath; and occasional premature ventricular contractions were noted in one patient after basin bath and after shower, and in another patient after tub bath (Johnston et al., 1981).

As a result of their findings, Johnston, Watt, and Fletcher (Note 1) concluded that: (a) nurses should caution postinfarction patients regarding taking a shower and encourage taking a tub bath or basin bath; (b) nurses should monitor their patients during initial self-bathing procedures; and (c) if the patient's preferred method of bathing is the shower, he/she should shower before hospital discharge while being evaluated hemodynamically. The investigators did not specify criteria for determining when an activity was within a patient's capacity.

Comparison of the energy cost of showering for post myocardial infarction patients with the energy cost for healthy subjects and tuberculosis patients (Table 3) shows that the cardiac patient's energy cost is below that of the healthy subject and very similar to, though slightly above, that of the tuberculosis patient. These findings suggest that use of energy cost data from normal subjects may not be appropriate for approximating the energy cost of a sick individual. The standard deviations associated with the results in Table 3 demonstrate considerable individual variation which also emphasizes the need for caution when predicting one individual's response from another individual.

During showering, cardiac patients as well as tuberculosis patients required lower oxygen consumptions than normal subjects during showering. Perhaps these patients, like the one in Gordon's (1952) study, were more deliberate in their actions and perhaps they consciously strived to conserve energy.

In another study, Erickson (1975) studied the cardiovascular response of 10 hospitalized male patients, 1 to 2.5 weeks postmyocardial infarction, during sitting and standing showers. Erickson noted that the patients disliked sitting during showering. The showering activity was divided into six phases: initial rest, move to shower,

Table 3

Comparison of the Energy Cost of Showering of Normal Subjects, Tuberculosis Patients, and Myocardial Infarction Patients

Study Date	Study Author	Subjects Number	Subjects Type		VO_2 ml/kg/min	VO_2 mets
1952	Gordon	3	normal	$\bar{X}$	16.23	4.63
1952	Gordon	1	TBC patient		12.54	3.58
1955	Gordon & Haas	10	TBC patients	$\bar{X}$	11.43	3.27
1981	Johnston et al.	10	MI patients	$\bar{X}$	13.02	3.72

disrobe and shower, dry and dress, return to bed, and recovery rest. Blood pressure was measured during each of these phases and a continuous electrocardiogram was taken. Cardiovascular response was evaluated by analyzing heart rate, heart rhythm, blood pressure, and rate pressure product. The ST segment displacement was computer analyzed.

Modal heart rate changes were statistically significant for phases only, not for position (Erickson, 1975). Eight pairs of phases had a significant heart rate difference during the standing shower and two pairs during the sitting shower, suggesting greater exertion during the standing shower. All patients' modal and maximal heart rate data followed essentially the same trend, increasing during the disrobe and shower and dry and dress phases and then decreasing during the return to bed and recovery rest phases.

The highest maximal heart rates occurred during the dry and dress phase for five patients and during disrobe and shower phase for five patients (Erickson, 1975). Five patients had the highest maximal heart rate during standing shower and five during the sitting shower. Eight patients had maximal heart rates above 100 bpm;

four of these patients had maximal heart rates of 130 bpm or more.

Systolic blood pressure, rate pressure product, and ST changes were significant for individuals' differences only, not for phase or position. The highest systolic blood pressure was 162.

Mean rate pressure products for all 10 subjects displayed a trend of increase from initial rest to disrobe, shower, dry, and dress phases, and then a decrease to recovery rest as did the maximal and modal heart rates and systolic blood pressures (Erickson, 1975). The highest mean rate pressure product, 109, which occurred during the sitting shower, disrobe and shower phase, was considerably lower than the mean rate pressure product of 150 found by Johnston et al. (1981) in post-myocardial infarction patients during standing showers. The mean rate pressure product during the five phases of Erickson's (1975) study ranged from 87 to 106; however, for the 10 individuals the range was 61 to 188. The rate pressure products were found to be statistically significant for individual differences but not for phase or position differences.

No patient had an ST segment depression of 0.1 millivolt or more (evidence of myocardial ischemia) during showering (Erickson, 1975). However, the magnitude of ST elevation (approximately 0.1 mv) exceeded that which occurred during maximal exercise testing by the Seattle Heart Watch Group (.08 mv) and suggested myocardial dilatation. No relationship could be found when ST deviation during the sitting shower was compared with ST deviation during the standing shower.

All patients remained in normal sinus rhythm or sinus tachycardia during the study. Four patients had infrequent premature ventricular contractions (Erickson, 1975). No patient experienced symptoms suggestive of cardiovascular stress such as chest pain, shortness of breath, or fatigue.

Air temperature ranged from 69°F to 86°F, and water temperature ranged from 85°F to 105°F during the study (Erickson, 1975). The changes in air and water temperature did not seem to affect the patient's cardiovascular response to showering.

Erickson (1975) concluded that "showering is not physiologically dangerous for the myocardial infarction patient if his acute phase has been stable and if it is done under controlled conditions with nursing supervision" (p. 93). Erickson (1975) emphasized that

> evaluation of the myocardial infarction patient during showering should be carried out for the patient's safety and his increased psychological confidence before he is discharged from the hospital and allowed to engage in this increased activity at home without supervision. (p. 93)

Erickson (1975) recommended that additional studies of cardiac patients during bathing be carried out in order to provide information about the care of the post-myocardial infarction patient. Erickson suggested that the responses of normal subjects and postmyocardial infarction subjects be compared during showering, and that the responses of postmyocardial infarction subjects be compared during tub bathing and showering.

Summary

The following areas were reviewed in the literature: energy metabolism, measurement of energy expenditure, total body and myocardial oxygen consumption, normal and abnormal response to exercise, effect of temperature on the body, perception of effort, and oxygen uptake and cardiovascular response during bathing. Highlights from these areas will be discussed below to summarize this chapter.

Adenosine triphosphate (ATP) is the energy currency of the body. The body's energy expenditure is reflected by its oxygen consumption because 95% of all ATP is formed in the cell in chemical reactions which require oxygen (Guyton, 1976). Oxygen consumption, the difference between the amount of oxygen inspired and that expired, is the product of heart rate, stroke volume, and total A-V O_2 difference. Therefore, oxygen uptake has a linear relationship with cardiac output and heart rate.

Maximal oxygen consumption, the greatest amount of oxygen that can be made available to the body to produce energy, indicates a person's maximal work capacity and level of physical fitness. The percentage of an individual's maximal oxygen consumption demanded by an activity is known as the relative oxygen cost of the activity. The relative oxygen cost of an activity has, under some conditions, a constant relationship to the heart rate so that the higher the relative oxygen cost of the activity, the higher the heart rate response. Because there may be a significant disparity between external work and that performed by the heart, total body oxygen consumption does not predict myocardial oxygen consumption as well as rate pressure product (Kitamura et al., 1972).

In the transition from rest to maximal exercise oxygen consumption increases 10 fold, from 300 to 3,000 ml., due to the increased transport and extraction of oxygen (Blomqvist, 1974). Individuals with cardiac disease, however, may not be able to increase their cardiac output sufficiently in response to heavy or, in some individuals, light activity. During exercise, these individuals may develop abnormal blood pressure, heart rate, and electrocardiographic changes, as well as signs and symptoms indicative of inadequate cardiac output.

Immersion of the body in a hot tub bath or shower may induce thermoregulatory changes in total peripheral resistance which can result in untoward heart rate and blood pressure alterations. Exposure of the skin to hot water can also produce pain and thermal injury. Maintenance of the tub bath and shower water temperature at 96°F to 98°F was shown to provide a comfortable bath temperature with minimal cardiovascular effects (Bazett, 1924); maintenance of basin bath water temperature at 102°F to 110°F should provide water that feels comfortably hot to most individuals without eliciting painful sensations or thermal injury and without cooling too quickly (Moritz & Henriques, 1924; Mountcastle, 1980).

Investigation of an individual's subjective responses, as well as his objective responses, during physical activity, is important to understand a person at work. Perception of effort can be quantified through the use of a scale developed by Borg in 1962 (Borg, 1973). Perceived exertion has been shown to be related to physiological variables such as heart rate, relative oxygen cost, and blood lactate concentrations (Borg & Linderholm, 1967; Ekblom & Goldbarg, 1971).

Results from the few studies that have been conducted investigating oxygen consumption during bathing are summarized in Table 4. Oxygen consumption was measured during showering in three studies which used a total of 3 normal subjects, 11 pulmonary tuberculosis patients, and 12 acute myocardial infarction patients (Grodon, 1952; Gordon & Haas, 1955; Johnston et al., 1981). Oxygen consumption during showering ranged from 8.10 to 17.49 ml/kg/min and showed a fairly wide scatter about the mean. Showering required a significantly greater oxygen uptake than taking a tub bath or a basin bath (Johnston et al., 1981).

Two studies were discussed which assessed cardiovascular response during bathing in a total of 20 acute

Table 4

Summary of Findings: Oxygen Consumption During Bathing

Authors	Date	Subject(s)	Activity	Method	VO_2 ml/kg/min	VO_2 mets
Cathcart & Trafford	1920	1 male, 28 yrs.	washing hands, face, neck; brushing hair (3 trials)	?	$\bar{X}$ 8.76 SD 1.27	2.93
Passmore et al.	1952	5 males 19-25 yrs.	washing, shaving, dressing (1-2 trials each)	Kofranyi-Michaelis	$\bar{X}$ 10.22 SD 0.92	3.21
Passmore & Durnin	1955	1 male 28 yrs.	washing, dressing	?	7.65	2.21
		3 females 43-55 yrs.	washing, dressing, undressing	?	$\bar{X}$ 9.43	2.69
		4 males 20-25 yrs.	washing, shaving	?	$\bar{X}$ 8.39	2.40
Gordon	1952	1 TBC male, 3 healthy males, ? ages	shower 7-14 min. tepid water	Douglas Bag	$\bar{X}$ 15.31 SD 2.18	4.37

Table 4 (continued)

Author(s)	Date	Subject(s)	Activity	Method	VO_2 ml/kg/min	VO_2 mets
Gordon & Haas	1955	10 TBC males ? ages	Shower 8 min. 89.6°F to 100.4°F	Douglas Bag	$\bar{X}$ 11.43 SD 3.20	3.27
Johnston et al.	1981	8 MI males 2 MI females $\bar{X}$ 54.8 yrs.	Shower $\bar{X}$ 3 min, 7 sec., 96°F ± 2°F	Max Planck	$\bar{X}$ 13.02 SD 1.46	3.72
			Tub Bath $\bar{X}$ 3 min, 34 sec. 96°F ± 2°F	Max Planck	$\bar{X}$ 9.01 SD 3.22	2.57
			Basin bath $\bar{X}$ 4 min, 38 sec. 96°F ± 2°F	Max Planck	$\bar{X}$ 8.94 SD 3.25	2.55

myocardial infarction patients (Erickson, 1975; Johnston et al., 1981). The rate pressure product was significantly higher for shower than for basin bath, but not for tub bath (Johnston et al., 1981). No subject experienced symptoms suggestive of cardiovascular distress during bathing. The authors of both studies recommended that acute myocardial infarction patients should be evaluated during showering in the hospital before showering at home.

In conclusion, little clinical investigation of subjects engaged in common hospital activities, such as bathing, has been conducted despite the importance of such research in the development of nursing science and despite the availability of the methods and instruments necessary to conduct the research. Measurement of the oxygen consumption, cardiovascular response, rating of perceived exertion, bath duration, and bath preference of normal subjects and hospitalized postmyocardial infarction patients during a basin bath, tub bath, and shower will provide empirical data to guide bath activity prescription.

CHAPTER 3

PROCEDURE FOR COLLECTION AND TREATMENT OF DATA

A repeated measures design with two grouping factors (Dayton, 1970) was used to test the null hypotheses that no differences in the dependent variables existed among rest, basin bath, tub bath, and shower, between the two groups of subjects (normal subjects and acute myocardial infarction patients), and between the sexes. The independent variables included type of activity (rest, basin bath, tub bath, and shower), group (normal subjects and hospitalized acute myocardial infarction patients), and sex. The dependent variables included oxygen consumption, heart rate, rate pressure product, presence of dysrhythmia, presence of ST change of 1 mm or more, rating of perceived exertion, bath duration, and ranking of bath method for ease, enjoyment, feeling clean, and appropriateness.

Each subject was studied during rest and during bathing. Each normal subject took a basin bath, tub bath, and shower in random order on 1 day with an equilibration period between each bath. Each acute myocardial infarction patient took the basin bath, tub bath, and shower in random order on 3 consecutive days.

Setting

Normal subjects were studied in a room in the human exercise laboratory of a large health science center in Texas and in a patient bathroom at the adjoining 800-bed county hospital. The subject was studied during rest and during the basin bath in the room in the laboratory. The room, which served as an office for the laboratory research nurse as well as a study area for research subjects, was equipped with a hospital bed, overbed table, and chair. The subject was studied during the tub bath and shower in a patient bathroom at the hospital. The patient bathroom was a large room with a combination tub-shower. The tub-shower was enclosed by a curtain and equipped with a handrail above the tub.

Acute myocardial infarction patients were studied on their units at the county hospital. The hospital had a 12-bed coronary care unit and a 28-bed telemetry unit. The acute myocardial infarction patient was generally transferred from the coronary care unit to the telemetry unit after his condition had stabilized. The myocardial infarction patient was studied during rest and during the basin bath in his hospital room. Most of the patients were in semi-private rooms. The patient was studied during the tub bath in the tub room and during the shower in the shower room. The tub room, which was located near the nurses' station, was a large room with a tub. The tub had a hand rail on the wall above it. No curtain enclosed the tub. The shower room, which was beside the tub room, had a curtained stall shower and a small dressing room beside the shower. During the study a chair was placed beside the tub and beside the shower.

Population and Sample

A non-random selection process was used to obtain subjects for study. Normal subjects and hospitalized acute myocardial infarction patients who fulfilled the sample criteria were invited to participate in the study.

To be eligible to participate in the study, each subject had to be: (a) willing to participate in the study, (b) 18 years of age or older, (c) able to see and hear, (d) able to speak and understand the English language, (e) able to stand unsupported, (f) able to get his entire body wet while bathing, and (g) able to hold the mouthpiece in his mouth and breathe through it. In addition, the normal subject had to: (a) have no known cardiovascular disease and (b) consider himself healthy. And, the acute myocardial infarction patient had to (a) be in uncomplicated, stable condition; (b) be more than 4 days but less than 21 days postinfarction; (c) be 24 hours or more posttransfer from the coronary or intensive care unit; (d) not require nasal oxygen; and (e) have his physician's permission to participate in the study.

Twenty-three normal subjects and 19 AMI patients participated in the study. Normal subjects were friends or acquaintances of the investigator, or health science center personnel who responded to signs requesting research subjects. The AMI patients were patients who were hospitalized during the study period. Eleven (3 female and 8 male) AMI patients who were eligible for the study refused to participate. One patient refused because he was already in another research project and he did not want to get involved in too many studies; another patient refused because she wanted to bathe when and if she chose, not according to a predetermined protocol; another patient was scheduled for some diagnostic tests and felt too busy; another patient refused because he did not want to do anything different; and, the remaining seven patients refused primarily because they did not want to bother with the study.

Protection of Human Subjects

Written approval to conduct the study was obtained from the Institutional Review Boards at the Texas Woman's University (Appendix B), the Health Science Center (Appendix C), and the participating hospital (Appendix D). Written permission was also received from the Texas Woman's University graduate school (Appendix E). Written permission for the hospitalized acute myocardial infarction patient to participate in the study was also obtained from the patient's physician (Appendix F).

Individuals eligible for the study were informed orally and in writing about the overall nature of the study, the purpose of the study, the potential discomforts associated with participating in the study, and the possible benefits from participating in the study (Appendix G). The individual was informed that one bath might represent more exertion for him than another, and elicit a higher heart rate - blood pressure response. All individuals were informed of their right not to participate in the study and of their right to withdraw from the study at any time without penalty. The hospitalized acute myocardial infarction patient was informed that the physician had given him permission to participate in the study if the patient desired. The investigator stressed, however, that the physician's permission did not obligate the patient to participate in the study, that the decision to participate or not was entirely the patient's, and that the patient's health care would not be affected by his decision. If the individual refused to be in the study, the investigator thanked him for listening to the description of the study and for considering participating in the study. If the individual agreed to be in the study, the individual signed the Lay Summary and Consent to Act as Subject for Research form and the investigator signed the form as a witness (Appendix G).

Instruments

The following information forms, data collection sheets, and instruments were used in the study:

1. Information about the Normal Subject Form (Appendix H).

2. Information about the Patient form (Appendix I).

3. Oxygen Consumption, Air and Water Temperature, and Rating of Perceived Exertion Data Collection Sheet (Appendix J).

4. Manual Cardiovascular Data Collection Sheet (Appendix K).

5. Holter Monitor Cardiovascular Data Collection Sheet (Appendix L).

6. Bath Method Preference Questionnaire (Appendix M).

7. Borg Rating of Perceived Exertion Scale (Appendix A).

8. Conventional scale to obtain subject's weight and height.

9. Rocar stop watch to time gas collection.

10. Tycos hand aneroid sphygmomanometer (Model HRI 8104-5098-02) with visible accuracy check and Littmann cardiology stethoscope (Model 2125) to measure blood pressure.

11. Holter cardiac monitor (Del Mar Avionics Electrocardiocorder Model 445A) with battery, electrode cable, five electrode wires, Red Dot foam pad monitoring electrodes, and recording tape and reels to record electrocardiogram.

12. Holter electrocardiogram scanner (Del Mar Avionics Dynamic Electrocardioscanner Model 655) to scan Holter electrocardiogram.

13. Bard-Parker featherweight non-sterile vinyl medical gloves (H 8294-00223) with finger tips cut off and masking tape to water-proof cardiac electrode wire-cable connection.

14. Thirty, 60, and 150 liter plastic Douglas bags with standard valve, nose clip, mouthpiece, Daniels respiratory valve, and 64-inch tubing on a rolling intravenous pole to collect expired gas.

15. Standard adjustable helmet to hold mouthpiece and respiratory valve in a comfortable, secure position.

16. Perkin-Elmer 1100 Medical Gas Analysis machine (mass spectrometer) to analyze inspired and expired gas.

17. Collins Chair Compensated Gasometer (Tissot) to measure expired gas volume.

18. Fisher Scientific Barometer to measure barometric pressure.

19. Texas Instruments Programmable 59 calculator with write-out and Douglas bag program to calculate oxygen consumption.

20. Pool-master mercury thermometer (Model 288) to measure water temperature.

21. Taylor mercury air thermometer (Model 5152A-5) to measure air temperature.

Data Collection

Pilot Study

The pilot study proposal was approved by the Human Subjects Review Committee of Texas Woman's University. Oxygen consumption, cardiovascular response, bath duration, rating of perceived exertion, and bath method preference were determined in six healthy female volunteers, who averaged 35 years of age, during rest and during four randomly ordered methods of bathing: basin bath (BB), tub bath (TB), sitting shower (SISH), and standing shower (STSH). (For the pilot study, sitting shower was studied as well as standing shower to determine which shower to use in the main study). The Douglas bag method was used to determine oxygen consumption; a Hewlett-Packard Oscilloscope and Tapewriter were used to determine heart rate and rhythm; and a conventional cuff sphymomanometer and stethoscope were used to measure blood pressure.

The subject rested, sitting, for 10 minutes. Oxygen consumption during 4 minutes of sitting rest was then determined. Blood pressure and a 15-second electrocardiogram were taken at the end of the resting period while the subject's equipment was still in place. The subject then took the four baths, randomly ordered, with equilibration periods of 10 minutes or more between each bath. The investigator washed the subject's back and feet during the basin bath; the subject performed the other three baths unassisted.

The subject's blood pressure and 15-second electrocardiogram were taken before the subject started the bath, but after the oxygen consumption equipment was in place. The oxygen consumption collection was begun before the subject, dressed in a bathing suit, took off her robe and started bathing. A continuous electrocardiogram could not be taken during the bath because the subject's bathing movements severely distorted the electrocardiographic tracing. The subject signaled when she was halfway through each bath. At that time, the subject paused while her blood pressure and electrocardiogram were taken. At the end of the bath, the subject dried herself and put on her robe. Gas collection was stopped and an after-bath blood pressure and electrocardiogram were taken before the oxygen collection equipment was removed. The subject was asked to select a rating of perceived exertion after each bath. After completing all four baths, the subject completed the Bath Method Preference Questionnaire.

The following results were obtained:

Oxygen Consumption (ml/kg/min)*

	Rest	BB	TB	SISH	STSH
Mean	3.76	6.09	7.45	7.49	7.72
Standard Deviation	0.32	1.00	1.39	1.29	1.50

*BB differed significantly from other three bathing methods, $p < .05$ (ANOVA with repeated measures).

Oxygen Consumption (mets)*

	Rest	BB	TB	SISH	STSH
Mean	1	1.58	1.94	1.95	2.01
Standard Deviation	0	0.15	0.23	0.17	0.26

*not tested for significance.

Heart Rate during Bathing (bpm)*

	Rest	BB	TB	SISH	STSH
Mean	77.33	71.17	72.33	70.67	75.17
Standard Deviation	12.52	11.50	12.31	11.62	5.56

*no significant difference among the four bathing methods (ANOVA with repeated measures).

Rate Pressure Product/100 during Bathing*

	Rest	BB	TB	SISH	STSH
Mean	82.50	76.26	77.44	77.51	84.11
Standard Deviation	22.83	24.05	20.54	20.48	18.97

*no significant difference among the four bathing methods (ANOVA with repeated measures).

Dysrhythmias and ST Deviation

(none observed)

Rating of Perceived Exertion*

	Rest	BB	TB	SISH	STSH
Mean	6.83	9.17	9.50	9.50	9.50
Standard Deviation	0.75	0.98	1.38	1.76	1.05

*no significant difference among the four bathing methods (Friedman two-way ANOVA).

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	BB	TB	SISH	STSH
Feeling Clean*				
Mean	1.17	1.83	3.17	3.83
Standard Deviation	0.41	0.41	0.41	0.41

*significant difference $p < .001$ (Friedman two-way ANOVA by ranks). Post Hoc pairwise comparison: BB significantly different from STSH.

The results of the pilot study indicated that the four methods of bathing required low energy cost (less than twice resting energy cost) and minimal cardiovascular stress for normal female subjects. Oxygen consumption was significantly lower during the basin bath than during the other three methods of bathing ($p < .05$). Heart rate and rate pressure product did not differ significantly among the four baths. The relatively high mean heart rate and rate pressure product at rest probably reflected subject anxiety. The relatively low mean heart rates and rate pressure products during the baths probably did not accurately reflect activity-induced cardiovascular changes because the subject had to stop all bathing activity and stand still for approximately 2 minutes for blood pressure and electrocardiographic determinations.

The subjects' ratings of perceived exertion were similar for all four baths. The basin bath required approximately twice as much time as the other bathing methods. The subjects liked the standing shower best, followed in order by the sitting shower, the tub bath, and the basin bath.

The pilot study showed that the proposed study was feasible with the following modifications: (a) a Holter monitor would be used instead of the Hewlett-Packard monitor in order to provide a continuous electrocardiogram during bathing and permit identification of peak heart rate, rhythm disturbance, and ST deviation during bathing; (b) a standing shower would be studied rather than a sitting shower, or both, because no significant differences were found between the standing and sitting shower, and because most individuals prefer a standing shower; (c) expired gas would be collected for 3 minutes following the shower, while the subject was sitting at rest, to determine oxygen debt; and, (d) the resting collection would be done with the subject supine in order to better reflect resting energy cost and cardiovascular response.

A second pilot study was then conducted incorporating these modifications. Two women and two men, who averaged 38 years of age, participated in the second pilot study. The following results, which were not analyzed statistically, were found:

Oxygen Consumption (ml/kg/min)

	Rest	BB	TB	SH	Oxygen debt after shower ml/min
Mean	3.89	5.61	7.03	8.14	75.5
Standard Deviation	.60	.59	1.39	1.14	34.86

Oxygen Consumption (mets)

	Rest	BB	TB	SH
Mean	1	1.45	1.84	2.10
Standard Deviation	0	.16	.45	.18

Peak Heart Rate (bpm) (n = 2)

	Rest	BB	TB	SH
Mean	65	95	100	110
Standard Deviation	14.14	21.21	21.21	14.14

After-Bath Rate Pressure Product/100

	Rest	BB	TB	SH
Mean	66.68	74.14	76.16	81.14
Standard Deviation	11.37	16.89	13.50	10.96

Dysrhythmia and ST Deviation

None observed.

Rating of Perceived Exertion

	Rest	BB	TB	SH
Mean	6.50	8.50	8.25	9.00
Standard Deviation	.58	1.29	.96	.82

Duration of Baths (seconds)

	BB	TB	SH
Mean	598.62	470.50	399.12
Standard Deviation	168.08	155.74	110.03

Ranked Preference of Bathing Method
(1 = Worst; 4 = Best)

	BB	TB	SH
Ease of Bathing			
Mean	1.50	2.25	2.25
Standard Deviation	1	.96	.50
Enjoyment of Bath			
Mean	1	2	3
Standard Deviation	0	0	0
Feeling Clean			
Mean	1	2	3
Standard Deviation	0	0	0

The oxygen consumption, rate pressure product, dysrhythmia, ST deviation, rating of perceived exertion, duration, and preference results of the second pilot study were similar to those in the first pilot study. The heart rate results were much higher using the Holter monitor as compared to the heart rate results obtained using the Hewlett-Packard monitor. The higher heart rate results were expected since the Holter monitor provided a continuous electrocardiogram throughout bathing and permitted identification of peak heart rate.

As a result of the second pilot study the following modifications were made in the proposed study: (a) blood pressure would be taken immediately before and after the bath but would not be taken during the bath because the pause in bathing activity for blood pressure measurement could lower oxygen consumption results; (b) the investigator would take a 15-second radial pulse during the bath when the subject signaled he was halfway through the bath. The pause for a 15-second pulse, which should not significantly alter oxygen consumption or cardiovascular response, would permit the nurse a "hands on" assessment of the subject during the bath; (c) the investigator would not wash the subject's back and feet during the basin bath because in many hospitals the non-intensive care unit patient does not receive assistance during the bath and because the study was concerned with the energy cost and cardiovascular response of the subject while he is bathing himself, not while he is being bathed; (d) female subjects would not be permitted to wear a one-piece bathing suit during the bath because the bathing suit covers too much skin and could alter bathing movements. Female subjects would be encouraged to bathe nude. Male normal subjects would be permitted to wear a bathing suit for the following reasons: (a) the bathing suit should not markedly alter bathing movements in the male; (b) normal male subjects were reluctant to participate in the study without wearing a bathing suit; (c) wearing a bathing suit would probably influence the results less than anxiety about exposure; and, (d) funds were not available to hire a male research assistant.

Main Study

The main study was then initiated, incorporating the modifications suggested in the first and second pilot studies. The procedure for finding and studying normal subjects is described in detail below. Then, the procedure for finding and studying acute myocardial infarction patients is described. The procedure for studying acute myocardial infarction subjects is identical to that used for studying normal subjects except for the few minor differences which are noted.

To obtain normal subjects, the investigator invited friends and acquaintances to participate in the study. The investigator also placed signs in the medical school elevators requesting subjects for a non-invasive oxygen consumption and cardiovascular response study and offering $15 payment. Twenty-three normal individuals volunteered to participate in the study. The investigator and subject arranged a mutually convenient date and time for the study. The investigator asked each subject not to eat, smoke, or drink caffeine containing beverages for 2 hours before the study, and to refrain from vigorous exercise for 8 hours before the study.

The subject met the investigator at the Human Exercise Laboratory at the medical school at the appointed time. The investigator reviewed the research purpose and procedure with the subject and oriented the subject to the area and the equipment. The subject read and signed the Lay Summary and Consent to Act as Subject for Research form and the investigator signed the form as a witness. The subject completed the Information about the Normal Subject form. The female subject dressed in a hospital gown, and the male subject dressed in a bathing suit and hospital gown. The investigator weighed the subject and determined his height on the laboratory scale. The investigator recorded the subject's weight and height on the Oxygen Consumption Data Collection Sheet.

The subject lay down in a hospital bed in a quiet room in the laboratory. The head of the bed was positioned at 30° from horizontal. The investigator cleaned the subject's skin with alcohol, shaved hair off the chest if necessary, and placed five Red Dot electrodes on the subject's chest with the two positive chest electrodes in V_1 (in the fourth intercostal space one finger breadth to the right of the sternum), and V_5 (in the fifth intercostal space at the anterior axillary line) positions. The investigator then snapped the five electrode wires to the electrodes. The investigator had previously taped a non-sterile vinyl glove around the electrode wire connection to the electrode cable to waterproof the connection.

The investigator then placed the cuff sphygmomanometer on the subject's arm and took a prestudy blood pressure and radial pulse. Subsequent blood pressures during the study were taken in the same arm. Next, the investigator explained the Borg Rating of Perceived Exertion Scale to the subject. The subject then rested supine before the resting collection.

The purposes of the resting collection were to provide baseline oxygen consumption and cardiovascular response data for descriptive purposes and to acquaint the subject with the equipment and the measurement techniques. The following protocol was followed for the resting collection:

1. Subject rests supine in bed for 10 minutes.

2. Investigator places oxygen consumption equipment (mouthpiece, helmet, and noseclip) on the subject and adjusts them for comfort. Subject rests for 1 to 2 more minutes to become accustomed to the equipment and to "wash-out" the tubing (replace room air in tubing with expired air).

3. Investigator instructs subject to relax as completely as possible during the 3 minute resting collection.

4. Investigator starts Holter monitor and pushes event marker 5 times to indicate resting collection on the tracing.

5. Investigator simultaneously starts stop watch and gas collection into 30 liter Douglas bag which is labeled "Rest."

6. After 2 minutes, investigator takes and records subject's 15-second radial pulse and blood pressure.

7. After 3 minutes, investigator simultaneously stops watch and gas collection.

8. Investigator stops Holter monitor and winds the Holter tape 3 times to provide a blank tape between activities.

9. Investigator removes oxygen consumption equipment from subject.

10. Investigator requests and records subject's rating of perceived exertion for rest.

Following the resting collection, the subject took the three baths in random order. Random bath order was determined in the following manner: The investigator wrote basin bath, tub bath, or shower on three identical cards. The three cards were placed, face down, in a shoe box and shuffled. The investigator blindly drew the cards, one at a time, and listed the order on a sheet of paper. This process was repeated until random order was listed for 45 subjects. Subject number 1 took the baths in the order noted first on the list; subject 2 took the baths in the order noted second on the list; and this process was repeated for each subject.

The normal subject took the basin bath in a room in the Exercise Laboratory, and the tub bath and shower in a patient bathroom at the adjoining hospital. Equilibration periods of at least 10 minutes were provided between each of the three baths.

The normal subject was encouraged to pretend that each bath was his only bath that day, and to make each bath as typical for him as possible. Male subjects were asked to wash their bathing suit area. All subjects were told not to wash their face or hair because of the equipment. The subjects were warned not to get shower water in the exhalation port of the respiratory valve.

The following protocol was followed for the bath collections:

1. Subject rests, sitting, for 10 minutes. (For the basin bath the subject sits on the edge of the bed; for the tub and shower the subject sits on a chair beside the bath).

2. Investigator uses the water thermometer to adjust the bath water at the appropriate temperature and records the temperature on the data collection sheet. Bath water temperature is 102°F to 110°F for basin bath and 96°F to 98°F for tub and shower. The investigator immerses the water thermometer in the tub water and basin water to

obtain the temperature reading. The investigator places the thermometer in a basin and collects the shower water in the basin to obtain the shower water temperature. The investigator checks the water temperature at least 2 times to make sure the temperature is correct. The investigator fills the tub to a depth of 7.5 to 8.5 inches.

3. Investigator places soap, washcloth, towels, and air thermometer near the subject.

4. Investigator places oxygen consumption equipment on the subject.

5. Investigator instructs the subject to bathe in as typical a manner as possible. She instructs the subject to clap twice when he is halfway through the bath so she can take his pulse. She instructs him to clap twice and sit down after he has finished bathing, drying, and dressing in hospital gown so she can do the "after bath" measurements. The investigator also suggests that for the basin bath the subject may stand up briefly to bathe his pelvic area and upper legs.

6. Investigator starts Holter monitor and pushes Holter monitor event marker 1 time to indicate "before bath" on the tracing.

7. Investigator takes and records subject's radial pulse and blood pressure.

8. Investigator pushes Holter monitor event marker 2 times to indicate "subject bathing" on the tracing.

9. Investigator simultaneously starts stop watch and gas collection into 150 liter Douglas bag which is labeled "basin bath," "tub bath," or "shower."

10. Investigator leaves room and stands outside door. Subject takes off gown, bathes halfway, and claps twice.

11. Investigator enters room, takes and records subject's 15-second radial pulse, and leaves room.

12. Subject finishes bathing and drying, dresses in hospital gown, claps twice, and then sits down, if he was standing.

13. Investigator enters room and simultaneously stops watch and gas collection.

14. Investigator pushes Holter monitor event marker 3 times to indicate "after bath" on tracing.

15. Investigator takes and records subject's 15-second pulse and blood pressure.

16. Investigator stops Holter monitor and winds the Holter tape 3 times.

17. Investigator removes oxygen consumption equipment from subject.

18. Investigator requests and records subject's rating of perceived exertion for bath.

19. Investigator notes and records room temperature and time.

This protocol was followed for the three baths. In addition, immediately following the shower, a 3-minute Douglas bag was collected to obtain an indicator of oxygen debt. The oxygen debt bag was collected in the following manner:

1. After taking the subject's pulse (part 1 of number 15 in the bath protocol), the investigator quickly switches the expiratory tube from the 150 liter shower Douglas bag to a 60 liter Douglas bag labeled "oxygen debt." The investigator simultaneously starts stop watch (using a second stop watch) and gas collection into the oxygen debt bag.

2. The investigator takes the subject's blood pressure, records the pulse and blood pressure, and stops and winds Holter monitor tape (number 16 in the bath protocol).

3. After 3 minutes the investigator simultaneously stops second watch and oxygen debt bag collection.

4. The investigator then performs numbers 17, 18, and 19 in the bath protocol.

After the subject completed the resting protocol and all three baths, he dressed and then completed the Bath

Method Preference Questionnaire. The investigator reviewed the questionnaire to make sure that all the questions were answered before the subject left. The time required from the time the subject entered the laboratory until he left was approximately 2 hours.

The investigator then analyzed each Douglas bag. The investigator used the mass spectometer to determine the inspired and expired concentrations of nitrogen, oxygen, and carbon dioxide, the Tissot to determine the volume of expired gas, the Tissot thermometer to determine the temperature of the expired gas, and the barometer to determine barometric pressure. The investigator recorded the gas concentrations, expired gas volume, expired gas temperature, and barometric pressure on the Oxygen Consumption Data Collection Sheet. The investigator then placed these values, as well as the gas collection time, into a programmed calculator to obtain oxygen consumption for rest and for each bath.

The programmed calculator provided oxygen consumption results in ml/min which the investigator divided by the subject's weight to obtain oxygen consumption in ml/kg/min. The investigator also divided the subject's bathing oxygen consumption in ml/kg/min by the subject's resting oxygen consumption in ml/kg/min to obtain the number of mets required for each bath. The investigator then recorded resting and bathing oxygen consumption in ml/min, ml/kg/min, and mets on the Oxygen Consumption Data Collection Sheet.

The Holter monitor electrocardiograms were interpreted by the supervisor of the cardiac noninvasive laboratory at the hospital. The supervisor, who had over 9 years experience reading electrocardiograms, interpreted all of the inpatient and outpatient Holter electrocardiograms at the hospital, reading approximately 160 electrocardiograms per month. The investigator observed the supervisor interpret the electrocardiograms for the first 10 subjects to make sure that the supervisor understood the marking system and the information needed from the electrocardiograms, and also to become acquainted with the Holter monitor scanning system. The supervisor recorded her findings on the Holter Monitor Cardiovascular Data Collection Sheet.

The procedure for obtaining acute myocardial infarction patients as subjects for this study differed from the procedure used to obtain normal research subjects. The investigator reviewed the Patient Care Kardex and the patients' charts and talked with the nursing and medical staffs on the telemetry unit to locate patients eligible for the study. After finding a potential patient subject, the investigator reviewed the patient's chart in detail and completed the Information about the Patient form. If the patient fulfilled the criteria for the study, the investigator asked the patient's physician for permission to invite the patient to participate in the study and requested that the physician sign the Physician Consent for Patient to Act as Subject for Research form. After obtaining the physician's permission, the investigator invited the patient to participate in the study.

After the patient agreed to be in the study and signed the consent form, the investigator completed the Information about the Patient form by asking the patient what kind of bath he took at home and by asking the patient to describe his prehospitalization exercise habits. The patient and investigator then determined mutually convenient times to conduct the three baths. The patient and investigator selected the same time for each of the three consecutive days, choosing a time that was at least 1 hour after meal time. The investigator asked the patient not to smoke or drink caffeine containing beverages for

2 hours before the study. The investigator told the nursing staff the times and dates of the study baths and placed a card with the study bath times and dates on the patient's Kardex.

The investigator met with the patient at the appointed time for 3 consecutive days. The investigator recorded the date and time of each bath on the Oxygen Consumption Data Collection Sheet. The investigator weighed the patient and determined his height on the first day of the study. The resting collection and the first bath were done on the first day of the study; the next two baths were done on the following two days. The patient rested in his bed for the resting collection, took the basin bath in his room, and took the tub bath and shower in the tub room and shower room which were located near the nurses' station.

The patient walked to the tub and shower room if his activity level order permitted walking that distance; otherwise, the investigator transported the patient to the tub and shower room by wheelchair. The male patients were dressed in pajama bottoms for the study; female patients were dressed in a night gown, and some wore underpants. Each patient wore similar attire for each bath. All of the patients bathed nude. To protect the male patient's modesty, the patient still had his pajama bottoms on when his radial pulse was taken during the basin bath; he placed a towel over his lap when his radial pulse was taken during the tub bath; and, he was covered by the shower curtain when his pulse was taken during the shower. Before each bath the investigator emphasized that the patient should inform the investigator immediately if any chest pain, shortness of breath, dizziness, or other discomfort occurred during the study.

The patients, most of whom had not taken a tub bath or shower in over a week, took much longer baths than the normal subjects. The Douglas bag had a 150 liter capacity; therefore, for most subjects the bath could not last longer than 10-12 minutes since the investigator did not want the expired air to be under pressure in the bag, or to use two Douglas bags, or to purchase a larger Douglas bag. Therefore, the investigator asked the patients not to spend more than 10 minutes bathing and gave them a warning at 7 minutes or when the bag was getting full.

The resting data collection protocol collection protocol was identical for normal subjects and for acute myocardial infarction patients. The bath data collection protocol was also identical for both groups except for the minor differences pointed out such as measures to protect the patient's privacy and to keep the tub bath and shower at less than 10-12 minutes duration.

Following each patient bath the investigator described the patient's response to the bathing activity to the patient's nurse and in the nurses' notes in the patient's chart. After completion of the patient's study, the investigator reviewed the oxygen consumption and cardiovascular response results with the patient and summarized the findings in the progress notes of the patient's chart.

Treatment of Data

Frequency counts, percentages, and descriptive statistics were used to describe the subjects and the findings. Frequency counts and percentages, by sex and by group, were calculated for the categorical variables such as sex, race, occupation, type of myocardial infarction, and type of bath usually taken at home. Means, ranges, and standard deviations were calculated for the continuous variables such as age, weight, height, oxygen consumption, heart rate, and rate pressure product.

Specific statistical analysis procedures were used to test the 11 hypotheses. Repeated measures analysis of variance with two grouping factors was used to test for the presence of type (rest, basin bath, tub bath, and shower), group (normal subjects and acute myocardial infarction patients), and sex effects for oxygen consumption (ml/kg/min), heart rate, and rate pressure product (Hypotheses 1, 2, and 3). If a significant F ratio occurred, a Duncan's multiple range test or a Newman-Keuls multiple comparison procedure was performed to identify the significant differences. When no interaction was present, the Duncan's test was used; when interaction was present, the Newman-Keuls test was used.

The Fisher exact probability test (2-tail) was used to test for significant differences in presence of dysrhythmia between the normal subjects and the AMI patients (Hypothesis 4, part b). The Friedman two-way analysis of variance by ranks was used to test for a type effect (rest, basin bath, tub bath, and shower) for presence of dysrhythmia (Hypothesis 4, part a). No statistical test was performed for Hypothesis 5 because no ST segment deviations were observed.

The Friedman two-way analysis of variance by ranks was used to test for a type effect for rating of perceived exertion for each group (Hypothesis 6). A nonparametric multiple comparison procedure was performed when a significant type effect was found.

Repeated measures analysis of variance was performed to compare duration of basin bath, tub bath, and shower in each group (Hypothesis 7). When a significant F ratio occurred, a Newman-Keuls multiple comparison procedure was performed to isolate the significant differences.

The Friedman two-way analysis of variance by ranks was used to test for type effect for ranking of ease of bathing, enjoyment of bath, and feeling clean after bath in each group (Hypotheses 8, 9, and 10). The Friedman test was also used to test for type effect for ranking of appropriateness of bath in the myocardial infarction patients (Hypothesis 11). Nonparametric multiple comparisons were performed when a significant type effect was found.

Additional findings were also analyzed. A repeated measures analysis of variance with two grouping factors was used to test for the presence of type, group, and sex effects for oxygen consumption, measured in mets, and for heart rate change. If a significant F ratio occurred, and no interaction was present, a Duncan's multiple range test was performed to isolate the significant differences. If a significant *F* ratio occurred, and interaction was present, a Newman-Keuls multiple comparison procedure was performed to identify the significant differences.

After-shower oxygen debt findings were presented by group and sex. Means, ranges, and standard deviations were used to describe the oxygen debt findings.

Spearman correlations were done for selected variables including rating of perceived exertion and peak heart rate. The Fisher exact probability test (2-tail) was used to examine the relationship between the bath method used at home and the ease, enjoyment, feeling clean, and appropriateness variables.

The Medical Computing Resources Center at the University of Texas Health Science Center in Dallas was used for statistical analysis of all the data. The Statistical Analysis Systems (SAS) program, and the Interactive Statistical Package (ISP) for multiple comparisons, were used. The SAS program was developed by SAS Institute in Cary, North Carolina. The ISP program was developed by the Medical Computing Resources

Center at the University of Texas Health Science Center in Dallas. For purposes of this study, the level of significance was set at .05.

CHAPTER 4

ANALYSIS OF DATA

The findings of the study, which was conducted during the 6-month period from November 30, 1981 until May 27, 1982, are presented in this chapter. The normal subjects and acute myocardial infarction (AMI) patient subjects are described in the first part of this chapter. The findings of the study, according to the testing of the hypotheses, are presented in the second section of this chapter. In the final section of this chapter, additional findings are presented.

Description of Sample

Forty-two subjects met the requirements for inclusion and consented to participate in the study. The data from one normal male subject and one acute myocardial infarction (AMI) male subject were not included in the analysis of the findings. The hot water heater at the hospital malfunctioned during the normal male's tub bath and shower; consequently, his bath water was not at the correct temperature and his data were excluded from the analysis. The AMI male subject was discharged from the hospital early due to a death in his family. Since this myocardial infarction patient had completed only one bath (shower), his data were also excluded from analysis. Therefore, the description of the subjects and the findings are based on the remaining 40 subjects.

The 22 normal subjects and the 18 AMI subjects will be described in terms of sex, age, weight, height, race, occupation, and type of bath usually taken at home. In addition, information about the normal subject's health status, medications, and participation in regular exercise will be given; and, information about the AMI subject's diagnosis, number of days in the coronary care unit (CCU), complications, pre-existing health problems, medications, number of days after the myocardial infarction and after transfer from CCU before the study was initiated, activity level on the day the study was started, and the subject's prehospitalization activity level will be provided. Finally, the normal subjects and the AMI subjects will be discribed in terms of the following resting, or baseline, values: oxygen consumption, heart rate, rate pressure product, and rating of perceived exertion.

Sex and Age

The 22 normal subjects included 11 females and 11 males who ranged in age from 21 to 46 years with a mean age of 28.68 years (Table 5). The mean age of the normal females, 30.18 years, was 3 years older than the mean age of the normal males, 27.18 years.

The 18 AMI patients included 5 females and 13 males. The AMI patients, who were older than the normal subjects, ranged in age from 27 to 67 years, with a mean age of 49 years for both females and males (Table 5).

Weight and Height

The normal female subjects ranged in weight from 48.75 to 87.84 kg with a mean weight of 60.49 kg (Table 6). The normal females ranged in height from 159 to 177 cm with a mean height of 167 cm. The normal males averaged 75.86 kg in weight, ranging from 65.91 to 95.21 kg; and, the normal males averaged 175 cm in height, ranging from 161 to 190 cm. Eighteen (82%) of the normal subjects would be considered to have a normal weight for their height. Four (18%) of the normal subjects (2 females and 2 males) would be considered overweight.

The AMI females were heavier and taller than the normal females, and their weights and heights showed

Table 5

Age of Normal Subjects and Acute Myocardial Infarction (AMI) Patients by Group and Sex

Group	n	Sex	Age In Years		
			Mean	Range	SD
Normal	22	F & M	28.68	21-46	6.41
AMI	18	F & M	49.05	27-67	10.27
Normal	11	F	30.18	22-40	6.03
Normal	11	M	27.18	21-46	6.70
AMI	5	F	49.20	27-64	14.06
AMI	13	M	49.00	38-67	9.15

Table 6

Weight and Height of Normal Subjects and Acute Myocardial Infarction (AMI) Patients by Group and Sex

			Weight kg			Height cm		
Group	*n*	Sex	Mean	Range	*SD*	Mean	Range	*SD*
Normal	11	F	60.49	48.75-87.84	12.02	167.00	159-177	6.50
AMI	5	F	96.18	51.93-144.86	34.56	170.40	157-183	12.56
Normal	11	M	75.86	65.91-95.23	7.80	175.36	161-190	6.95
AMI	13	M	83.34	54.09-115.91	19.24	171.31	160-185	7.24

more variability than the normal females (Table 6; Table 7). The AMI females averaged 96.18 kg in weight; the lightest female weighed 51.93 kg; and, the heaviest female weighed 144.86 kg. The AMI females averaged 170.40 cm tall ranging from 157 to 183 cm in height. The AMI males were heavier and shorter than the normal males and their weights were more variable than those of the normal males (Table 6; Table 7). The AMI males averaged 83.34 kg, ranging from 54.09 to 115.91 kg in weight and they averaged 171.31 cm in height, ranging from 160 to 185 cm tall. Only 5 (28%) of the AMI subjects (1 female and 4 males) were of normal weight; 13 (72%) were overweight, and 8 (3 females and 5 males) of the 13 would be considered obese.

Race and Occupation

All of the normal subjects were Caucasians except for 2 Black males and 1 Chinese male. Most of the normal subjects were employed in the health care area. Five of the normal females were registered nurses; the occupations of the other 6 females included dietitian, medical student, physician's assistant student, probation officer, research assistant, and social worker. Five of the normal male subjects were medical students; the occupations of

Table 7

Information about Acute Myocardial Infarction Patients: Sex; Age; Weight; Height; Occupation; Diagnoses; Number of Days in CCU, after AMI, and after CCU Transfer; and Ordered Activity Level on First Study Day

							Number of Days			
Patient	Sex	Age (Years)	Weight (kg)	Height (cm)	Occupation	Diagnoses	In CCU	After AMI	After CCU Transfer	Ordered Activity Level
1	M	38	102	175	Carpenter	Inferolateral & RV MI. Obesity.	4	9	5	6
3	M	58	77	168	Disabled	Anterolateral SEMI with CHF & VE. Hx of CHF & HTN.	2	6	4	BR with BRP (about 6)
4	M	39	106	170	Painter	Lateral SEMI. Hx of AP. Obesity.	Not in CCU	9	NA	7
5	F	49	145	180	Domestic Worker	Inferior MI with VE. Hx of HTN & hyperlipidemia. Obesity.	5	7	2	5
6	M	61	61	160	Manual Laborer	Inferior MI with pericarditis.	11	13	2	8
7	M	44	54	168	Construction Worker	Apical SEMI with pulmonary edema & episode of AF. Hx of HTN, COPD, & AP.	3	7	4	Short walks in hall (about 7)
8	F	27	90	157	Waitress	Anterolateral MI with VF. Possible Stein-Leventhal Syndrome. Hx of asthma & seizure disorders. Obesity.	7	11	4	6
9	M	51	71	178	Auto Parts Store Owner	Anteroseptal MI with VT. Hx of HTN.	1	5	4	7
10	F	58	52	157	Housewife	Inferior MI. Hx of HTN & MI.	3	7	4	5

Table 7 (continued)

Patient	Sex	Age (Years)	Weight (kg)	Height (cm)	Occupation	Diagnoses	Number of Days: In CCU	After AMI	After CCU Transfer	Ordered Activity Level
11	M	50	103	179	Retired Carpenter	Inferior & RV MI with VT, VF, third degree block, asystole, & temporary cardiac pacemaker. Hx of HTN & MI. Obesity.	6	8	2	6
12	F	64	111	183	Housewife	SEMI. DM on insulin. Hx of HTN, MI, & CVA Obesity.	6	10	4	7
13	M	45	116	175	Truck driver	Posterolateral SEMI. DM on insulin. Hx of HTN, MI, & hyperlipidemia. Obesity.	6	8	2	6
14	F	48	83	175	Cook	Inferoposterior MI (extensive) with low output syndrome, pulmonary edema, hypoxic episode requiring intubation & VE. DM on insulin. Hx of HTN & chronic bronchitis.	8	11	3	9
15	M	40	63	175	Construction Worker	Inferoapical MI with cerebral emobolism, CVA, & pericarditis. Hx of HTN & polycythemia.	4	7	3	6
16	M	42	75	165	Construction Worker	Anterolateral MI (extensive) with VT, CHF, pericarditis & hypoxemia. Hx of HTN.	7	17	10	8

Table 7 (continued)

Patient	Sex	Age (Years)	Weight (kg)	Height (cm)	Occupation	Diagnoses	Number of Days: In CCU	After AMI	After CCU Transfer	Ordered Activity Level
17	M	56	83	162	Janitor	Inferior & RV MI with VE, bradycardia, & pericarditis. Obesity.	4	9	5	6
18	M	67	79	168	Carpenter	Anterolateral MI. Hx of HTN & peptic ulcer disease.	3	6	3	6
19	M	46	92	185	Construction Worker	Anteroseptal MI with AF episode with rapid ventricular response. Hx of peripheral vascular disease.	5	14	9	12
_n_ = 18.					Primarily Blue Collar Occupations	3(17%) SEMI 6(33%) Anterior MI 9(50%) Inferior or Posterior MI	$\bar{x}$ = 5 SD = 2	$\bar{x}$ = 9 SD = 3	$\bar{x}$ = 4 SD = 2	

Note. AP = angina pectoris; AF = atrial fibrillation; BR with BRP = bedrest with bathroom privileges; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; CVA = cerebral vascular accident; DM = diabetes mellitus; HTN = hypertension; Hx = history; MI = myocardial infarction; NA = not applicable; RV = right ventricular; SEMI = subendocardial myocardial infarction; VE = ventricular ectopy; VT = ventricular tachycardia; VF = ventricular fibrillation.

Data from patient 2 were excluded from analysis because the subject was discharged from the hospital before completing all three baths.

the other 6 normal male subjects included graduate student, maintenance worker, medical representative, physician, physiologist, and security guard.

The AMI patients were primarily Black in contrast to the normal subjects, most of whom were Caucasian. Twelve (67%) of the AMI patients were Black, including 4 females and 8 males; 5 (28%) of the AMI patients were Caucasian, including 1 female and 4 males; and 1 male was Spanish-American.

Two of the female AMI patients were housewives; the occupations of the 3 other female AMI patients included cook, domestic worker, and waitress (Table 7). Four of the male AMI patients were construction workers, 2 were carpenters, 1 was a retired carpenter, 1 was disabled, and the occupations of the remaining 5 AMI patients included janitor, manual laborer, owner of an automobile parts store, painter, and truck driver (Table 7).

Type of Bath Usually Taken at Home

Nine (82%) of the normal female subjects took a shower when at home; 1 normal female generally took both a tub bath and a shower (she tub bathed and then rinsed off in the shower), and 1 female took a tub bath at home although she said she would prefer to take a shower if one were available (Table 8). All 11 normal male subjects bathed by shower when at home. Therefore, 20 of the 22 (91%) normal subjects took a shower at home; 1 normal subject took both a tub bath and a shower; and 1 normal subject took a tub bath.

Most of the AMI subjects took a tub bath at home, in contrast to the normal subjects who usually bathed by shower (Table 8). All 5 AMI female subjects generally took a tub bath while at home although 1 patient said she would prefer a shower if one were available. Six (46%) of the AMI males bathed by tub when at home and 7 (54%) bathed by shower when at home. Therefore, 11 AMI patients (61%) bathed by tub when at home and 7 (39%) bathed by shower when at home.

Health Status of Normal Subjects

The normal subjects considered themselves healthy, appeared healthy, and reported no cardiopulmonary health problems. One normal female subject took thyroid medication; no other normal subjects took medications other than aspirin, vitamins, or birth control pills. Fifteen (68%) of the normal subjects (9 females and 6 males) engaged in some form of exercise on a regular basis.

Table 8

Type of Bath Usually Taken at Home by Normal Subjects and Acute Myocardial Infarction (AMI) Patients

Group	n	Sex	Type of Bath	Number	Percentage
Normal	22	F & M	Tub	1	4.5
			Shower	20	91
			Tub & Shower	1	4.5
AMI	18	F & M	Tub	11	61
			Shower	7	39
Normal	11	F	Tub	1	9
			Shower	9	82
			Tub & Shower	1	9
Normal	11	M	Tub	0	0
			Shower	11	100
AMI	5	F	Tub	5	100
			Shower	0	0
AMI	13	M	Tub	6	46
			Shower	7	54

Health Status of AMI Patients

Diagnosis, Number of Days in Coronary Care Unit, and Complications. Three (17%) AMI patients were diagnosed as having had a subendocardial myocardial infarction; 6 patients (33%) had an anterior infarction; and 9 patients (50%) had an inferior or posterior myocardial infarction (Table 7). Seventeen of the 18 AMI patients were admitted to the coronary care unit (CCU) and remained in the CCU for 1 to 11 days (mean 5 days); 1 patient, Patient 4, was admitted directly to the telemetry unit (Table 7).

Only 7 (39%) of the AMI patients had relatively uncomplicated recoveries following the AMI; 11 patients (61%) had complications during their hospitalizations (Table 7). For example, Patient 11's AMI was complicated by ventricular tachycardia, ventricular fibrillation, third degree heart block, asystole, and need for a temporary cardiac pacemaker; Patient 14's AMI was complicated by low output syndrome, pulmonary edema, an hypoxic episode requiring intubation, and ventricular ectopy; and Patient 15's AMI was complicated by cerebral embolism, with cerebral vascular accident, and pericarditis.

<u>Pre-existing Health Problems</u>. In addition to having complications during recovery from the myocardial infarction, many of the AMI patients had pre-existing health problems (Table 7). For example, 12 patients (67%) had a history of hypertension; 3 patients (17%) had had 1 or more previous myocardial infarctions; 3 patients (17%) had diabetes mellitus requiring insulin; 2 patients (11%) had hyperlipidemia; and other patients had chronic obstructive pulmonary disease, seizure disorder, peripheral vascular disease, peptic ulcer disease, or residual weakness from a previous cerebral vascular accident.

<u>Medications</u>. All of the AMI patients were taking one or more medications at the time of the study. Ten patients were taking diuretics such as Lasix or Diuril; 6 patients were taking vasodilators such as Isordil and nitroglycerine; 4 patients were taking antiarrhythmic agents such as Quinidex and Pronestyl; 3 patients were taking the cardiac glycoside, digoxin; and 3 patients were taking antihypertensive medications such as Aldomet and Clonidine.

Some of the other medications prescribed for one or two of the AMI patients included Dilantin and phenobarbital, heparin, Indocin, Nifedipine, potassium chloride, and Tagamet. None of the AMI patients was receiving Inderal at the time of the study.

Number of Days after Infarction and after Coronary Care Unit Transfer, and Activity Level. The AMI patients were studied from 5 to 17 days (mean 9.11 days) after the myocardial infarction, and 2 to 10 days (mean 4.12 days) after transfer from the CCU to the telemetry unit (Table 7). The activity stage noted on the physician's order sheet for the patient on the first day of the study ranged from Stage 5 to Stage 12 (mean stage 6.83) (Table 7). The physician ordered the level of activity for the AMI patient, usually following the Cardiac Rehabilitation Activity Schedule (Appendix N) and severely restricting the patient's activity during the first few days post-infarction and then progressively mobilizing the patient. The ordered activity stage, however, did not usually correspond with the activity the patient was actually doing. Most of the patients were engaging in more activity than was ordered. However, for all the patients except Patient 13 and Patient 19, the study tub bath and study shower were the first tub bath or shower the patient took following the myocardial infarction.

The activity levels of the AMI patients prior to hospitalization varied widely from no regular physical exercise to vigorous manual labor as is suggested by the patients' occupations. None of the AMI patients engaged in any form of regular exercise other than job-related exercise.

Resting Oxygen Consumption

The oxygen consumption of the 22 normal subjects during 3 minutes of supine rest ranged from 2.72 to 4.90 ml/kg/min and averaged 3.63 ml/kg/min (Table 9). The mean oxygen consumption of the normal females, 3.60 ml/kg/min, was very similar to that of the normal males, 3.66 ml/kg/min.

The resting oxygen consumption of the 18 AMI patients, which was slightly lower than that of the normal subjects, averaged 3.36 ml/kg/min and ranged from 2.19 to 4.75 ml/kg/min (Table 9). The oxygen consumption of the 5 AMI female subjects at rest, 3.04 ml/kg/min, was slightly lower than that of the 13 AMI male subjects during rest, 3.48 ml/kg/min.

The resting oxygen consumption findings were statistically analyzed as part of the analysis of the bathing oxygen consumption findings. A repeated measures

Table 9

Resting Oxygen Consumption in Normal Subjects and Acute Myocardial Infarction (AMI) Patients by Group and Sex

Group*	n	Sex**	Oxygen Consumption ml/kg/min Means	Range	SD
Normal	22	F & M	3.63	2.72-4.90	.49
AMI	18	F & M	3.36	2.19-4.75	.61
Normal	11	F	3.60	2.72-4.90	.56
Normal	11	M	3.66	3.02-4.45	.44
AMI	5	F	3.04	2.19-3.68	.55
AMI	13	M	3.48	2.64-4.75	.61

Note. *No significant differences between groups.

**No significant differences between sexes.

analysis of variance with 2 grouping factors (Dayton, 1970) was performed to test for the presence of type (rest, basin bath, tub bath, and shower), group (normal subjects and AMI patients), and sex effects for oxygen consumption (ml/kg/min). A significant three-way interaction (type x group x sex) was found, F (3, 102) = 3.77, $p < .013$. A Newman-Keuls multiple comparison procedure (Glass & Stanley, 1970) was then performed to identify the significant differences.

Testing for type effect showed that resting oxygen consumption was significantly lower than oxygen consumption during basin bath, tub bath, or shower for normal females, normal males, AMI females, and AMI males ($p < .05$). Testing for group effect showed no significant differences in resting oxygen consumption between normal females and AMI females, or between normal males and AMI males. Testing for sex effect showed no significant differences in resting oxygen consumption between normal females and normal males, or between AMI females and AMI males. It was concluded that resting oxygen consumption (ml/kg/min) was significantly lower during rest as compared to bathing, and that resting oxygen consumption did not differ significantly between normal subjects and AMI patients, or between females and males.

Resting Heart Rate

The resting heart rate of the 22 normal subjects ranged from 48 to 80 beats per minute (bpm) and averaged 65 bpm (Table 10). The mean resting heart rate of the normal females, 63 bpm, was slightly lower than that of the normal males, 67 bpm.

The resting heart rate of the AMI subjects was faster and more variable than that of the normal subjects averaging 77 bpm and ranging from 56 to 100 bpm (Table 10). The mean resting heart rate of the 5 AMI female subjects, 92 bpm, was 20 bpm faster than the mean resting heart rate of the 13 AMI male subjects, 72 bpm.

The resting heart rate findings were statistically analyzed as part of the analysis of the bath peak heart rate findings. A repeated measures analysis of variance with 2 grouping factors (Dayton, 1970) was performed to test for presence of type (rest, basin bath, tub bath, and shower), group (normal subjects and AMI patients), and sex effects for heart rate. A significant two-way interaction (group x sex) was found, F (1, 99) = 10.11, $p < .003$. A significant type effect, without interaction, was also found, F (3, 99) = 106.20, $p < .0001$. A Newman-Keuls multiple comparison procedure (Glass & Stanley,

Table 10

Resting Heart Rate (HR) in Normal Subjects and Acute Myocardial Infarction (AMI) Patients by Group and Sex

Group*	n	Sex**	Heart Rate		
			Mean	bpm Range	SD
Normal	22	F & M	65	48-80	9.73
AMI	18	F & M	77	56-100	13.09
Normal	11	F	63	48-80	10.29
Normal	11	M	67	52-80	9.09
AMI	5	F	92	84-100	6.32
AMI	13	M	72	56-88	10.26

Note. *Resting HR for normal females significantly slower than resting HR for AMI females ($p < .05$).
Resting HR for normal males significantly slower than resting HR for AMI males ($p < .05$).

**Resting HR for normal females significantly slower than resting HR for normal males ($p < .05$).
Resting HR for AMI females significantly faster than resting HR for AMI males ($p < .05$).

1970) was performed to isolate the significant differences in the two-way interaction. A Duncan's multiple range test (Dayton, 1970) was used to test the type effect (since no interaction was found) and to identify the significant differences.

Testing for group effect showed that resting heart rate for normal females (63 bpm) was significantly slower than resting heart rate for AMI females (92 bpm) ($p < .05$). Resting heart rate for normal males (67 bpm) was also significantly slower than resting heart rate for AMI males (72 bpm) ($p < .05$).

Testing for sex effect showed that normal females had a significantly slower heart rate at rest (63 bpm) than normal males (67 bpm) ($p < .05$). In contrast, AMI males had a significantly slower heart rate at rest (72 bpm) than AMI females (92 bpm) ($p < .05$). Testing for type effect showed that males and females, normal subjects and AMI patients, all had a significantly slower heart rate during rest than during the three bathing methods ($p < .05$).

Resting Rate Pressure Product

The mean rate pressure product during rest for the normal subjects was 71.94, ranging from 46.08 to 94.70 (Table 11). The mean rate pressure product of the normal

Table 11

Resting Rate Pressure Product (RPP) in Normal Subjects and Acute Myocardial Infarction (AMI) Patients by Group and Sex

Group*	*n*	Sex**	Rate Pressure Product (systolic blood pressure x heart rate/100) Mean	Range	*SD*
Normal	22	F & M	71.94	46.08-94.40	14.15
AMI	17	F & M	90.38	65.28-139.44	22.24
Normal	11	F	65.32	46.08-94.08	13.70
Normal	11	M	78.57	57.20-94.40	11.68
AMI	4***	F	115.28	80.00-139.44	28.75
AMI	13	M	82.71	65.28-114.40	13.52

Note. *Resting RPP significantly lower for normal females compared to AMI females ($p < .05$).
No significant difference in resting RPP for normal males and AMI males ($p < .05$).

**Resting RPP significantly lower for normal females compared to normal males ($p < .05$).
Resting RPP significantly higher for AMI females compared to AMI males ($p < .05$).

***No RPP data obtained for AMI female patient 5 due to her obesity and the difficulty in obtaining an accurate blood pressure.

female subjects, 65.32, was lower than that of the normal males, 78.57.

The mean resting rate pressure product for the AMI patients, 90.38, was approximately 18 units higher than that of the normal subjects (Table 11). The mean resting rate pressure product of the 5 female AMI patients, 115.28, was approximately 33 units higher than the resting rate pressure product of the 13 AMI male patients, 82.71.

The resting rate pressure product (RPP) findings were statistically analyzed as part of the analysis of the after-bath RPP findings. A repeated measures analysis of variance with 2 grouping factors (Dayton, 1970) was performed to test for presence of type (rest, basin bath, tub bath, and shower), group (normal subjects and AMI patients), and sex effects for RPP. A significant three-way interaction (type x group x sex) was found, $\underline{F}$ (3, 105) = 3.06, $\underline{p} < .031$. A Newman-Keuls multiple comparison procedure (Glass & Stanley, 1970) was then performed to isolate the significant differences.

Testing for type effect showed that in normal females and males, resting RPP did not differ significantly from the RPP obtained immediately after each of of the three baths. In AMI females, resting RPP did not differ significantly from the RPP obtained after the basin bath or shower; however, resting RPP was significantly lower than the RPP obtained immediately after the tub bath ($p < .05$). In AMI males, resting RPP was significantly lower than the RPP obtained immediately after all three baths ($p < .05$).

Testing for group effect showed that resting RPP was significantly lower for normal females as compared to AMI females ($p < .05$). In the males, no significant difference was found between the resting RPP for normal males and the resting RPP for AMI males.

Testing for sex effect showed that the resting RPP for normal females was significantly lower than that for normal males ($p < .05$). The sex effect for the AMI patients was opposite the sex effect for the normal subjects. In the AMI subjects, the resting RPP for the AMI females was significantly higher than for the resting RPP for the AMI males ($p < .05$).

Rating of Perceived Exertion during Rest

Fifteen (68%) of the normal subjects selected a rating of perceived exertion (RPE) of 6 or 7 (very, very light) for rest; 7 (32%) of the normal subjects chose a RPE of 8 or 9 (very light) for rest (Table 12). Sixty-four percent of the normal females and 73% of the normal males selected a RPE of 6 or 7 during rest; and 36% of the normal females and 27% of the normal males selected a RPE of 8 or 9 during rest.

Eleven (69%) of the AMI subjects chose a RPE of 6 or 7 during rest; and 5 AMI subjects (31%) chose a RPE of 8 or 9 during rest (Table 12). Sixty percent of the AMI female subjects and 73% of the AMI male subjects selected a RPE of 6 or 7 for rest; the remaining subjects chose a RPE of 8 or 9 during rest. The resting RPE data were provided for descriptive and baseline purposes. No statistical analysis was performed on the resting RPE data.

Findings

Hypothesis 1

Hypothesis 1 stated: Oxygen consumption will not differ significantly among rest, basin bath, tub bath, and shower, between the two groups of subjects (normal subjects and hospitalized acute myocardial infarction patients), and between the sexes. A repeated measures analysis of variance with two grouping factors (Dayton,

Table 12

Rating of Perceived Exertion (RPE) during Rest in Normal Subjects and Acute Myocardial Infarction (AMI) Patients

Group	*n*	Sex	RPE	Frequency	Percentage
Normal	22	F & M	6 & 7	15	68
			8 & 9	7	32
AMI*	16	F & M	6 & 7	11	69
			8 & 9	5	31
Normal	11	F	6 & 7	7	64
			8 & 9	4	36
Normal	11	M	6 & 7	8	73
			8 & 9	3	27
AMI	5	F	6 & 7	3	60
			8 & 9	2	40
AMI*	11	M	6 & 7	8	73
			8 & 9	3	27

<u>Note</u>. *Two AMI male subjects did not provide ratings because they had difficulty understanding the RPE concepts.

1970) was used to test Hypothesis 1. The description and statistical analysis related to the resting oxygen consumption results were presented in the description of the sample to provide baseline oxygen consumption information. The bathing oxygen consumption findings will now be addressed. The bathing oxygen consumption findings, by group, sex, and type of bath are shown in Table 13.

In the normal subjects, the mean oxygen consumption was lowest during basin bath and highest during shower. The mean oxygen consumption during basin bath, tub bath, and shower was 7.57, 7.79, and 8.08 ml/kg/min, respectively (Table 13). The oxygen consumption results of the normal females and males were similar although the male results during tub bath and shower were more variable than the female results. The response pattern was different for the normal females and males; the females had the highest oxygen consumption during shower and the lowest during tub bath; and, the males had the highest oxygen consumption during tub bath and the lowest during basin bath. Oxygen consumption during bathing ranged, in the normal subject, from a low of 5.47 ml/kg/min in a normal male during basin bath, to a high of 10.50 ml/kg/min in a normal male taking a shower.

Table 13

Oxygen Consumption (VO_2) during Basin Bath, Tub Bath, and Shower in Normal Subjects and Acute Myocardial Infarction (AMI) Patients by Group and Sex

		Oxygen Consumption (ml/kg/min)								
		Basin Bath***			Tub Bath			Shower		
Group*	Sex**	Mean	Range	*SD*	Mean	Range	*SD*	Mean	Range	*SD*
Normal	F & M	7.57	5.47-9.76 (*n* = 21)	.95	7.79	6.36-9.76 (*n* = 20)	.97	8.08	6.82-10.50 (*n* = 22)	.98
AMI	F & M	6.14	3.13-8.59 (*n* = 18)	1.51	6.88	4.65-9.12 (*n* = 16)	1.43	6.66	4.96-8.44 (*n* = 17)	1.19
Normal	F	7.78	6.29-9.76 (*n* = 11)	.95	7.65	6.36-9.30 (*n* = 10)	.95	7.80	6.82-9.32 (*n* = 11)	.75
Normal	M	7.35	5.47-8.45 (*n* = 10)	.94	7.93	6.78-9.76 (*n* = 10)	1.02	8.37	6.93-10.50 (*n* = 11)	1.13
AMI	F	4.78	3.13-6.80 (*n* = 5)	1.41	5.67	4.65-7.68 (*n* = 3)	1.74	5.81	4.96-7.70 (*n* = 5)	1.10
AMI	M	6.67	4.10-8.59 (*n* = 13)	1.23	7.16	4.70-9.12 (*n* = 12)	1.27	7.02	5.12-8.44 (*n* = 13)	1.08

Note. *VO_2 during all 3 baths significantly lower for AMI patients than for normal subjects (p < .05).
**Normal females had a significantly lower VO_2 during shower than normal males (p < .05); AMI females had a significantly lower VO_2 during all 3 baths than AMI males (p < .05).
***VO_2 during basin bath, in normal males and AMI females, significantly lower than VO_2 during tub bath and shower (p < .05).

The AMI patients had lower and more variable oxygen consumption results than the normal subjects during the three baths (Table 13). In contrast to the normal subjects who had the highest mean oxygen consumption during shower, the AMI group had the highest mean oxygen consumption during the tub bath. The mean oxygen consumption in the AMI patients was 6.14 ml/kg/min during basin bath, 6.88 ml/kg/min during tub bath, and 6.66 ml/kg/min during shower. The oxygen consumption of the AMI females during bathing was lower and more variable than the bathing oxygen consumption for AMI males, normal females, or normal males. The response pattern was different for the AMI females and males: the females had the highest oxygen consumption during shower; and, the males had the highest oxygen consumption during tub bath. Both AMI males and AMI females had the lowest oxygen consumption during basin bath. In the AMI patients, oxygen consumption ranged from a low of 3.13 ml/kg/min in an AMI female during basin bath to a high of 9.12 ml/kg/min in an AMI male taking a tub bath.

Repeated measures analysis of variance with two grouping factors (Dayton, 1970) was performed to test for presence of type (rest, basin bath, tub bath, and shower), group (normal subjects and AMI patients), and sex effects for oxygen consumption. A significant three-way interaction (type x group x sex) was found, F (3, 102) = 3.77, $p < .013$. Therefore, Hypothesis 1 was rejected. A Newman-Keuls multiple comparison procedure (Glass & Stanley, 1970) was performed to identify the significant differences.

Testing for type effect showed no significant difference in oxygen consumption among the three baths for normal females and AMI males. In the normal males and AMI females, the oxygen consumption during basin bath was significantly lower than the oxygen consumption for tub bath and shower ($p < .05$); however, the oxygen consumption during tub bath and shower did not differ significantly. Testing for group effect showed that oxygen consumption during all three methods of bathing was significantly lower in the AMI patients as compared to the normal subjects ($p < .05$).

No significant sex effect for oxygen consumption was found in normal subjects during basin bath and tub bath; however, during shower normal females had a significantly lower oxygen consumption than normal males ($p < .05$). In the AMI subjects, AMI females had a significantly lower oxygen consumption during all three baths than AMI males ($p < .05$).

Hypothesis 2

Hypothesis 2 stated: Cardiovascular response, as measured by resting and peak bath heart rate, will not differ significantly among rest, basin bath, tub bath, and shower, between the two groups of subjects, and between the sexes. A repeated measured analysis of variance with two grouping factors (Dayton, 1970) was used to test Hypothesis 2. The description and statistical analysis related to the resting heart rate results were presented in the description of the sample to provide baseline heart rate information. The bathing heart rate results will now be addressed. The peak bath heart rate findings, by group, sex, and type of bath, are presented in Table 14.

In the normal subjects, the mean peak heart rate was lowest during basin bath and highest during shower (Table 14). The mean peak heart rate in the normal subjects was 86 bpm during basin bath, 89 bpm during tub bath, and 93 bpm during shower. In the normal group, the peak heart rate findings were most variable during tub bath and least variable during basin bath.

Table 14

Peak Heart Rate (PHR) during Basin Bath, Tub Bath, and Shower in Normal Subjects and Acute Myocardial Infarction (AMI) Patients by Group and Sex

		Peak Heart Rate (bpm)								
		Basin Bath***			Tub Bath			Shower		
Group*	Sex**	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD
Normal	F & M	86	64-100 (n = 20)	9.30	89	60-128 (n = 19)	14.46	93	72-124 (n = 20)	11.45
AMI	F & M	105	76-120 (n = 17)	12.08	108	80-144 (n = 18)	17.51	112	84-132 (n = 17)	14.24
Normal	F	85	64-96 (n = 10)	10.67	83	60-100 (n = 10)	11.28	90	72-108 (n = 10)	11.80
Normal	M	88	72-100 (n = 10)	8.10	95	80-128 (n = 9)	15.59	96	88-124 (n = 10)	11.07
AMI	F	111	100-120 (n = 5)	7.69	121	100-144 (n = 5)	18.63	122	116-132 (n = 5)	8.76
AMI	M	103	76-120 (n = 12)	13.00	104	80-128 (n = 13)	15.18	107	84-132 (n = 12)	13.94

Note. *PHR of AMI patients significantly higher than PHR of normal subjects ($p < .05$).
**PHR of normal females significantly lower than PHR of normal males ($p < .05$).
PHR of AMI females significantly higher than PHR of AMI males ($p < .05$).
***PHR during basin bath significantly lower than PHR during shower ($p < .05$).

In the normal females, the mean peak heart rate was 85 bpm, 83 bpm, and 90 bpm for basin bath, tub bath, and shower, respectively. In the normal males, the mean peak heart rate was 88 bpm, 95 bpm, and 96 bpm for basin bath, tub bath, and shower. Thus, the normal males and normal females had the highest mean peak heart rate during shower. The normal females had the lowest mean peak heart rate during tub bath; in contrast, the normal males had the lowest mean peak heart rate during basin bath. The normal males had higher mean peak heart rates during all three baths than the normal females. Peak heart rate during bathing ranged from a low of 60 bpm in a normal female during tub bath, to a high of 128 bpm in a normal male during tub bath.

Like the normal subject group, the mean peak heart rate in the AMI patient group was lowest during basin bath and highest during shower (Table 14). However, the peak heart rates were higher and more variable in the AMI group as compared to the normal group. The mean peak heart rate in AMI patients was 105 bpm during basin bath, 108 bpm during tub bath, and 112 bpm during shower. In the AMI patients, as in the normal subjects, the peak heart rate findings were most variable during tub bath and least variable during basin bath.

In the AMI females the mean peak heart rate was 111 bpm, 121 bpm, and 122 bpm for basin bath, tub bath, and shower, respectively. In the AMI males the mean peak heart rate was 103 bpm, 104 bpm, and 107 bpm for basin bath, tub bath, and shower, respectively. Thus, both AMI females and AMI males had the highest mean peak heart rate during shower and the lowest during basin bath. The peak heart rate findings were most variable during tub bath and least variable for basin bath in both the AMI females and males. The AMI females had higher peak heart rates during all three baths than the AMI males which contrasts with the findings in the normal group in which the peak heart rates of the males were higher than those of the females. The peak heart rates of the AMI patients were higher than the peak heart rates of the normal subjects. In the AMI group, peak heart rate ranged from a low of 76 bpm in an AMI male during a basin bath to a high of 144 bpm in an AMI female during a tub bath.

Repeated measures analysis of variance with two grouping factors (Dayton, 1970) was performed to test for presence of type (rest, basin bath, tub bath, and shower), group (normal subjects and AMI patients), and sex effects for heart rate. A significant type effect, without interaction, was found, F (3, 99) = 106.20, $p < .0001$. A significant group x sex interaction was found, F (1, 99) = 10.11, $p < .003$. Therefore, Hypothesis 2 was rejected. A Duncan's multiple range test (Dayton, 1970) was used to test the type effect and to isolate the significant differences. A Newman-Keuls multiple comparison procedure (Glass & Stanley, 1970) was performed to identify the significant differences in the two-way interaction.

Testing for type effect showed that peak heart rate during basin bath was significantly lower than peak heart rate during shower ($p < .05$). Peak heart rate during basin bath did not differ significantly from peak heart rate during tub bath; and, peak heart rate during tub bath did not differ significantly from peak heart rate during shower. Testing for group effect showed that the peak heart rate of the AMI patients was significantly higher than the peak heart rate of the normal subjects ($p < .05$).

Testing for sex effect showed that normal males had a significantly higher peak heart rate than normal females ($p < .05$). Among the AMI patients, however, the females had a significantly higher peak heart rate than the males ($p < .05$).

Hypothesis 3

Hypothesis 3 stated: Cardiovascular response, as measured by resting and after-bath rate pressure product, will not differ significantly among rest, basin bath, tub bath, and shower, between the two groups of subjects, and between the sexes. A repeated measures analysis of variance with two grouping factors (Dayton, 1970) was used to test Hypothesis 3. The description and statistical analysis related to the resting rate pressure product results were presented in the description of the sample to provide baseline rate pressure product information. The bathing rate pressure product results will now be addressed. The after-bath rate pressure product findings, by group, sex, and type of bath, are presented in Table 15.

In the normal subjects, the after-bath rate pressure product was similar after all three baths (Table 15). The mean rate pressure product was lowest after basin bath (78.55) and highest after shower (79.80); after tub bath the mean rate pressure product was 78.99.

The mean rate pressure product was highest in normal females after basin bath and lowest after shower; in

Table 15

Rate Pressure Product (RPP) after Basin Bath, Tub Bath, and Shower in Normal Subjects and Acute Myocardial Infarction (AMI) Patients by Group and Sex

			After-Bath Rate Pressure Product								
			Basin Bath			Tub Bath***			Shower		
Group*	n	Sex**	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD
Normal	22	F & M	78.55	45.12-101.84	15.11	78.99	50.88-107.92	16.59	79.80	49.92-107.20	16.65
AMI	17	F & M	115.02	76.16-167.04	28.37	119.60	75.60-204.80	34.04	110.93	76.80-147.84	21.83
Normal	11	F	72.09	45.12-94.40	14.61	70.65	50.88-91.20	13.05	70.54	49.92-96.00	12.87
Normal	11	M	85.01	61.60-101.84	13.19	87.32	64.80-107.92	15.97	89.06	67.20-107.20	15.10
AMI	4	F	125.88	79.20-167.04	39.92	147.78	76.80-204.80	52.97	119.36	95.68-145.60	20.57
AMI	13	M	111.69	76.16-149.60	24.96	110.93	75.60-163.20	22.31	108.34	76.80-147.84	22.34

Note. *RPP after all three baths significantly higher for AMI patients than for normal subjects ($p < .05$).
**After-bath RPP significantly lower for normal females than for normal males ($p < .05$).
After-bath RPP significantly higher for AMI females than for AMI males ($p < .05$).
***RPP significantly higher for AMI females after tub bath than after basin bath or shower ($p < .05$).

normal males by contrast, the mean rate pressure product was lowest after basin bath and highest after shower. Mean rate pressure product, in the normal group, ranged from a low of 45.12 in a normal female after basin bath to a high of 107.92 in a normal male after tub bath.

In the AMI patients, the after-bath rate pressure product had a different pattern, and was higher and more variable than in the normal subjects (Table 15). The mean after-bath rate pressure product in the AMI group was lowest after shower (110.93), and highest after tub bath (119.60); after basin bath the mean rate pressure product was 115.02.

The rate pressure product findings were higher in the AMI females as compared to the AMI males; and during basin bath and tub bath, the rate pressure product findings were more variable in the females than in the males. In both the AMI females and males, the rate pressure product was lowest after shower. The rate pressure product was highest after tub bath in the AMI females; by contrast, in the AMI males the rate pressure product was highest after basin bath. In the AMI group, rate pressure product ranged from a low of 75.60 in an AMI male after tub bath to a high of 204.80 in an AMI female after tub bath.

A repeated measures analysis of variance with two grouping factors (Dayton, 1970) was performed to test for presence of type (rest, basin bath, tub bath, and shower), group (normal subjects and AMI patients), and sex effects for after-bath rate pressure product. A significant three-way interaction (type x group x sex) was found, F (3, 105) = 3.06, $p < .031$. Therefore, Hypothesis 3 was rejected. A Newman-Keuls multiple comparison procedure (Glass & Stanley, 1970) was done to identify significant differences.

The statistical analysis related to the resting rate pressure product findings was presented in the description of the sample to provide baseline rate pressure product information. The statistical analysis related to after-bath rate pressure product will now be discussed.

Testing for type effect showed no significant difference in rate pressure product after basin bath, tub bath, and shower in the normal females, normal males, and AMI males. In the AMI females, however, rate pressure product was significantly higher after tub bath than after basin bath and after shower ($p < .05$). Testing for group effect showed that after-bath rate pressure product was significantly higher for the AMI group as compared to the normal group after all three baths.

Testing for sex effect showed that normal females had a significantly lower rate pressure product after all three baths than normal males. The AMI females by contrast, had a significantly higher rate pressure product after all three baths as compared to AMI males.

Hypothesis 4

Hypothesis 4 stated: Cardiovascular response, as measured by presence of dysrhythmia, will not differ significantly (a) among rest, basin bath, tub bath, and shower and (b) between the two groups of subjects. The Friedman two-way analysis of variance (Siegel, 1956) was used to test Hypothesis 4, part a. The Fisher exact probability test (2-tail) (Siegel, 1956) was used to test Hypothesis 4, part b. The dysrhythmia findings are presented in Table 16.

The cardiac dysrhythmias included frequent unifocal premature atrial contractions (PACs), rare and occasional unifocal premature ventricular contractions (PVCs), and frequent multifocal premature ventricular contractions (Table 16). If a premature beat occurred 1 time per minute or less, the occurrence was described as "rare";

Table 16

Presence and Type of Dysrhythmias among Acute Myocardial Infarction (AMI) Patients during Rest and during Bathing*

Patient	Sex	Age (Years)	Type AMI	Presence and Type of Dysrhythmia during: Rest	Basin Bath	Tub Bath	Shower
3	M	58	Anterolateral MI	Frequent Unifocal PACs	Frequent Unifocal PACs	Frequent Unifocal PACs	Frequent Unifocal PACs
7	M	44	Apical SEMI	Occasional Unifocal PVCs	Occasional Unifocal PVCs	Frequent Multifocal PVCs	Occasional Unifocal PVCs
10	F	58	Inferior MI	Not Recorded	Frequent Unifocal PVCs	Rare Unifocal PVCs	Rare Unifocal PVCs
12	F	64	SEMI	Occasional Unifocal PVCs	None	None	Occasional Unifocal PVCs
13	M	45	Postero-lateral SEMI	Occasional Unifocal PACs	Occasional Unifocal PACs	Occasional Unifocal PACs	Occasional Unifocal PACs
14	F	48	Infero-posterior MI (extensive)	None	None	Occasional Unifocal PVCs	Occasional Unifocal PVCs
17	M	56	Inferior & RV MI	None	Occasional Unifocal PVCs	Occasional Unifocal PVCs	Occasional Unifocal PVCs

Note. *No significant difference in presence of dysrhythmia among rest, basin bath, tub bath, and shower.

SEMI = subendocardial myocardial infarction;
PVCs = premature ventricular contractions;
PACs = premature ventricular contractions;

Rare = 1 premature beat per minute, or less;
Occasional = 2-5 premature beats per minute;
Frequent = 6 or more premature beats per minute.

if a premature beat occurred 2-5 times per minute, the occurrence was described as occasional; and, if a premature beat occurred 6 or more times per minute, the occurrence was described as "frequent."

Cardiac dysrhythmias occurred in 5 (71%) of the 7 AMI patients with dysrhythmias during basin bath, in 6 (86%) of the patients during tub bath, and in all 7 (100%) of the patients during shower (Table 16). The resting electrocardiogram, which was obtained in 6 of the 7 AMI patients with dysrhythmias, showed presence of dysrhythmia in 3 (50%) of the 6 patients.

The presence, type, and frequency of the dysrhythmia did not change during rest and the three methods of bathing in three of the AMI patients (Patients 3, 13, and 17). In Patient 7, occasional unifocal premature ventircular contractions (PVCs) were present during rest, basin bath, and shower; the PVCs became frequent and multifocal during tub bath. However, in Patient 10 the frequent unifocal PVCs observed during basin bath decreased to rare PVCs during tub bath and shower. Patient 12 had no PVCs during basin bath or tub bath, but she had occasional unifocal PVCs during rest and during shower. In Patient 14, no dysrhythmias were observed on her tracing during rest or basin bath; however, occasional unifocal PVCs were observed during tub bath and shower.

The Friedman two-way analysis of variance by ranks (Siegel, 1956) was used to test for type effect in presence of dysrhythmia. The Friedman test showed no significant difference in presence of dysrhythmia among rest, basin bath, tub bath, and shower, Friedman's Chi Square = .94, $p < .815$). Therefore, Hypothesis 4, part a, was not rejected.

No cardiac dysrhythmias were observed on the electrocardiographic tracings of the normal subjects during rest or during bathing. However, cardiac dysrhythmias were observed on the electrocardiographic tracings of 7 (41%) of the 17 AMI patients (Table 16). (Complete electrocardiographic data were not obtained for one AMI patient due to an equipment problem). Three (43%) of the 7 AMI patients with dysrhythmias were females.

The Fisher exact probability test (2-tail) showed that presence of dysrhythmia differed significantly between the normal subjects and the AMI patients ($p < .002$). Therefore, Hypothesis 4, part b, was rejected.

Hypothesis 5

Hypothesis 5 stated: Cardiovascular response, as measured by presence of ST segment change of 1 mm or more, will not differ significantly (a) among the three methods of bathing and (b) between the two groups of subjects. No change in ST segment of 1 mm or more during or after the bath as compared to before the bath was observed on the electrocardiographic tracings of the normal subjects or of the hospitalized AMI patients. No statistical test was indicated. Hypothesis 5, part a, and Hypothesis 5, part b, were not rejected.

Hypothesis 6

Hypothesis 6 stated: Rating of perceived exertion will not differ significantly among the three methods of bathing (a) in the normal subjects and (b) in the hospitalized AMI patients. The Friedman two-way analysis of variance by ranks (Siegel, 1956) was used to test Hypothesis 6. The rating of perceived exertion scale ranges from 6 to 20 with verbal descriptors accompanying every odd number (Borg, 1973). A rating of 7 is described as very, very light and a rating of 19 is described as very, very hard.

In the normal subjects, the median score for rating of perceived exertion (RPE) for all three baths was 9, or very light. The mean ranks for basin bath, tub bath, and shower were 2.52, 1.70, and 1.77, respectively, with a high rank signifying a high RPE and a low rank signifying a low RPE.

The Friedman test showed that in the normal subjects, the RPE rankings differed significantly among the three bath methods, Friedman's Chi Square = 9.07, $\underline{p} < .011$. Therefore, Hypothesis 6, part a, was rejected.

A non-parametric multiple comparison procedure (Noether, 1971) was performed to locate the significant differences in RPE among the three bath methods. The multiple comparison procedure showed that the RPE ranking was significantly higher (or that perceived exertion was significantly greater) for basin bath as compared to tub bath and shower ($\underline{p} < .05$). The comparison procedure showed that the RPE for tub bath and shower did not differ significantly.

In AMI patients, the median RPE scores for basin bath, tub bath, and shower were 10.5, 9.0, and 9.5, respectively, and the mean ranks were 2.16, 1.75, and 2.09. The Friedman test showed no significant differences among the AMI patients' RPE rankings for the three bathing methods, Friedman's Chi Square = 1.53, $p < .465$. Therefore, Hypothesis 6, part b, was not rejected.

Hypothesis 7

Hypothesis 7 stated: Duration of bath will not differ significantly among the three methods of bathing (a) in the normal subjects and (b) in the hospitalized AMI patients. A repeated measures analysis of variance (Dayton, 1970) was used to test Hypothesis 7. In the normal subjects the mean duration was 502.45 seconds for basin bath, 376.23 seconds for tub bath, and 343.16 seconds for shower (Table 17). Analysis of variance with repeated measures showed that, in the normal subjects, bath duration differed significantly among the three baths, $F\ (2, 44) = 20.70$, $p < .001$; therefore, Hypothesis 7, part a, was rejected.

A Newman-Keuls multiple comparison procedure (Glass & Stanley, 1970) was performed to identify the significant differences. The Newman-Keuls test showed that, in normal subjects, the duration for basin bath was significantly longer than the duration of tub bath or the duration of shower ($p < .05$), and that tub bath and shower duration did not differ significantly.

Table 17

Bath Duration (in seconds) for Basin Bath, Tub Bath, and Shower in Normal Subjects and by Acute Myocardial Infarction (AMI) Patients

Group	n	Sex	Basin Bath Mean	Basin Bath SD	Tub Bath Mean	Tub Bath SD	Shower Mean	Shower SD
Normal	22	F & M	502.45*	179.33	376.23	146.45	343.16	82.57
AMI	18	F & M	492.72**	98.09	571.00	93.16	526.58	92.61
Normal	11	F	510.63	157.99	344.23	84.60	322.23	86.00
Normal	11	M	494.27	205.97	408.23	188.76	364.09	77.18
AMI	5	F	481.80	147.42	583.00	66.76	501.70	45.23
AMI	13	M	496.92	79.48	566.38	103.57	536.15	105.41

Note. *In normal subjects, basin bath duration significantly longer than tub bath and shower duration ($p < .05$).
**In AMI subjects, basin bath duration significantly shorter than tub bath duration ($p < .05$).

Duration tested within each group only.
Duration not tested by sex or between the two groups.

In the hospitalized AMI patients, the mean duration was 492.72 seconds for basin bath, 571 seconds for tub bath, and 526.58 seconds for shower (Table 17). Analysis of variance with repeated measures (Dayton, 1970) showed that, in the AMI patients, bath duration differed significantly among the bath methods, F (2, 36) = 5.24, $p < .01$). Therefore, Hypothesis 7, part b, was rejected.

A Newman-Keuls multiple comparison procedure (Glass & Stanley, 1970) was performed to isolate the significant differences. The Newman-Keuls test showed that, in AMI patients, the duration for basin bath was significantly shorter than the duration of the tub bath ($p < .05$). The Newman-Keuls test showed that no significant differences existed between the duration of basin bath and shower, and between the duration of tub bath and shower.

Hypothesis 8

Hypothesis 8 stated: Ranking of "ease of bathing" will not differ significantly among the three methods of bathing (a) in the normal subjects and (b) in the hospitalized AMI patients. The Friedman two-way analysis of variance by ranks (Siegel, 1956) was used to test Hypothesis 8. A rank of 1 signified the easiest bath and a rank of 3 signified the hardest bath; a rank of 2 signified a degree of ease between easiest and hardest.

In normal subjects, the median score for ease was 3, or hardest, for basin bath; 2 for tub bath; and 1, or easiest, for shower. The mean ranks for basin bath, tub bath, and shower were 2.77, 1.68, and 1.55, respectively. The Friedman test showed that the ease rankings differed significantly among the bath methods, Friedman's Chi Square = 19.91, $p < .001$. Therefore, Hypothesis 8, part a, was rejected.

A non-parametric multiple comparison procedure (Noether, 1970) was performed to locate the significant differences in ease rankings among the bath methods. The multiple comparison procedure showed that, in normal subjects, the ease ranking for basin bath was significantly higher (signifying harder) than the ease ranking for tub bath and shower ($p < .05$). The ease ranking for tub bath did not differ significantly from the ease ranking for shower.

In AMI patients, the median score for ease was 2 for basin bath, 1.5 for tub bath, and 2 for shower; the mean ranks for basin bath, tub bath, and shower were 2.22, 1.72, and 2.06. The Friedman test showed that the ease rankings did not differ significantly among basin bath, tub bath, and shower, Friedman's Chi Square = 2.33, $p < .311$. Therefore, Hypothesis 8, part b, was not rejected.

Hypothesis 9

Hypothesis 9 stated: Ranking of "enjoyment of bath" will not differ significantly among the three methods of bathing (a) in the normal subjects and (b) in the hospitalized AMI patients. The Friedman two-way analysis of variance by ranks (Siegel, 1956) was used to test Hypothesis 9. A rank of 1 signified the most enjoyable bath and a rank of 3 signified the least enjoyable bath; a rank of 2 signified a level of enjoyment in between the most enjoyable and the least enjoyable bath.

In normal subjects, the median score for enjoyment of bath was 3, or least enjoyable, for basin bath, 2 for tub bath, and 1, or most enjoyable, for shower; and, the mean ranks for basin bath, tub bath, and shower were 3, 1.68, and 1.32, respectively. The Friedman test showed that the enjoyment rankings differed significantly among the three bath methods, Friedman's Chi Square = 34.45, $p < .001$. Therefore, Hypothesis 9, part a, was rejected.

A nonparametric multiple comparison procedure (Noether, 1971) was performed to locate the significant differences in bath enjoyment rankings among the bath methods. The multiple comparison procedure showed that, in normal subjects, the enjoyment rank for basin bath was significantly higher (signifying less enjoyment) than the enjoyment rank for tub bath and shower ($p < .05$), and that no significant differences existed between the enjoyment ranks for tub bath and shower.

In the AMI patients, the median scores for enjoyment of basin bath, tub bath, and shower were 3, 1, and 2, respectively, and the mean ranks were 2.78, 1.44, and 1.78. The Friedman test showed that the enjoyment rankings differed significantly among the bath methods, Friedman's Chi Square = 17.33, $p < .001$. Therefore, Hypothesis 9, part b, was rejected.

A nonparametric multiple comparison procedure was performed to locate the significant differences in bath enjoyment rankings among the three bath methods. The multiple comparison procedure showed that, in AMI subjects, the enjoyment rank for basin bath was significantly higher (signifying less enjoyment) than the enjoyment rank for tub bath and shower ($p < .05$), and that no significant differences existed between the enjoyment ranks for tub bath and shower.

Hypothesis 10

Hypothesis 10 stated: Ranking of "feeling clean after bath" will not differ significantly among the three methods of bathing (a) in the normal subjects and (b) in the hospitalized AMI patients. The Friedman two-way analysis of variance by ranks (Siegel, 1956) was used to test Hypothesis 10. A rank of 1 represented "most clean," a rank of 3 represented "least clean," and a rank of 2 signified a rank between most clean and least clean.

In the normal subjects, the median score for feeling clean after the bath was 3 (or least clean) for basin bath, 2 for tub bath, and 1 (or most clean) for shower. The mean ranks for basin bath, tub bath, and shower were 2,86, 2.05, and 1.09, respectively. The Friedman test showed that the feeling clean rankings differed significantly among the bath methods, Friedman's Chi

Square = 34.64, $p < .001$. Therefore, Hypothesis 10, part a, was rejected.

A nonparametric multiple comparison procedure (Noether, 1971) was performed to locate the significant differences in feeling clean rankings among the three bath methods. The multiple comparison procedure showed that the feeling clean ranks differed significantly among all three bath methods with the normal subjects feeling most clean after the shower and least clean after the basin bath ($p < .05$).

In the AMI patients the median score for "feeling clean after bath" was 3 (or least clean) for basin bath, 2 for tub bath, and 1 (or most clean) for shower. The mean ranks for basin bath, tub bath, and shower were 2.89, 1.61, and 1.50, respectively. The Friedman test showed that feeling clean rankings differed significantly among the bath methods, Friedman's Chi Square = 21.44, $p < .001$. Therefore, Hypothesis 10, part b, was rejected.

A nonparametric multiple comparison procedure was performed to locate significant differences in feeling clean rankings among the three bath methods. The multiple comparison procedure showed that, in AMI patients, the feeling clean ranking was significantly higher (signifying less clean) for basin bath as compared to tub bath and shower ($p < .05$). The multiple comparison procedure showed that no significant difference existed between the feeling clean ranks for tub bath and shower.

Hypothesis 11

Hypothesis 11 stated: Ranking by the hospitalized acute myocardial infarction patients of "appropriateness of bath for you at this stage of your recovery" will not differ significantly among the three methods of bathing. The Friedman two-way analysis of variance by ranks (Siegel, 1956) was used to test Hypothesis 11. A rank of 1 represented "most appropriate" and a rank of 3 represented "least appropriate" with 2 signifying a rank between most appropriate and least appropriate.

The median score for appropriateness was 3 (signifying least appropriate) for basin bath, 2 for tub bath, and 1 (signifying most appropriate) for shower. The mean ranks for basin bath, tub bath, and shower were 2.89, 1.72, and 1.39, respectively. The Friedman test showed that the appropriateness rankings differed significantly among the three bath methods, Friedman's Chi Square = 22.33, $p < .001$. Therefore, Hypothesis 11 was rejected.

A nonparametric multiple comparison procedure (Noether, 1971) was performed to locate the significant differences in appropriateness rankings among the methods of bathing. The multiple comparison procedure showed that the appropriateness rank for basin bath was significantly higher (signifying less appropriate) than the ranks for tub bath and shower (p .05), and that the ranks for tub bath and shower did not differ significantly.

Additional Findings

Type, Group, and Sex Effects for Oxygen Consumption Measured in Mets

Type, group, and sex effects for oxygen consumption measured in ml/kg/min were discussed under the findings for Hypothesis 1. Oxygen consumption, however, was also measured in mets. To obtain mets, the individual's bathing oxygen consumption, in ml/kg/min, was divided by his resting oxygen consumption in ml/kg/min. A repeated measures analysis of variance with two grouping factors (Dayton, 1970) was used to analyze the oxygen consumption findings measured in mets. The mets results, by group, sex, and type of bath, are presented in Table 18.

Table 18

Oxygen Consumption (VO_2) Measured in Mets during Basin Bath, Tub Bath, and Shower Normal Subjects and Acute Myocardial Infarction (AMI) Patients by Group and Sex

		Oxygen Consumption (Mets)								
		Basin Bath***			Tub Bath			Shower		
Group*	Sex**	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD
Normal	F & M	2.13	1.24-2.69 (n = 21)	.29	2.19	1.84-2.72 (n = 20)	.28	2.24	1.90-2.82 (n = 22)	.25
AMI	F & M	1.82	1.30-2.28 (n = 18)	.27	2.04	1.49-2.50 (n = 16)	.28	2.04	1.64-2.40 (n = 17)	.23
Normal	F	2.18	1.71-2.69 (n = 11)	.29	2.14	1.87-2.68 (n = 10)	.29	2.19	1.90-2.70 (n = 11)	.27
Normal	M	2.07	1.24-2.28 (n = 10)	.30	2.23	1.84-2.72 (n = 10)	.29	2.29	2.06-2.82 (n = 11)	.22
AMI	F	1.55	1.30-1.85 (n = 5)	.22	1.90	1.49-2.12 (n = 3)	.35	1.92	1.64-2.26 (n = 5)	.26
AMI	M	1.92	1.55-2.28 (n = 13)	.22	2.07	1.67-2.50 (n = 13)	.27	2.08	1.78-2.40 (n = 12)	.20

Note. *VO_2 in mets during all 3 baths significantly lower for AMI patients as compared to normal subjects ($p < .05$).
**No significant difference in VO_2 in mets between females and males.
***VO_2 in mets during basin bath in AMI patients significantly lower than VO_2 during tub bath and shower ($p < .05$).

In normal subjects, the mean energy cost was 2.13 mets during basin bath, 2.19 mets during tub bath, and 2.24 mets during shower (Table 18). In normal subjects, the energy cost of bathing ranged from a low of 1.24 mets in a normal male during basin bath to a high of 2.82 mets in a normal male during a shower.

The energy cost of bathing in AMI subjects was lower than that of normal subjects. For AMI patients, taking a basin bath required 1.82 mets, and taking a tub bath and a shower each required 2.04 mets. The energy cost of bathing ranged, in the AMI group, from a low of 1.30 mets in an AMI female taking a basin bath to a high of 2.50 mets in an AMI male taking a shower.

Repeated measures analysis of variance with two grouping factors (Dayton, 1970) was performed to test for presence of type, group, and sex effects for energy cost measured in mets. No significant sex effect was found, $F\ (1, 99) = .15$, $p < .704$. A significant type x group interaction was found, $F\ (3, 99) = 6.61$, $p < .0005$. A Newman-Keuls multiple comparison procedure (Dayton, 1970) was performed to identify the significant differences.

Testing for type effect showed no significant difference in met energy cost among the three methods of bathing in the normal subjects. In the AMI patients, however, energy cost during basin bath was significantly less than energy cost during tub bath or shower ($p < .05$). Testing for group effect showed that the AMI patients had a significantly lower energy cost during all three methods of bathing than the normal subjects ($p < .05$).

Oxygen Debt after Shower

Immediately after the subject completed the shower and sat down, after-shower oxygen consumption was measured for 131 to 195 seconds to obtain an index of the oxygen debt. Oxygen debt was defined as "the oxygen consumed during recovery that is in excess of the amounts that normally would have been consumed at rest during an equivalent time period" (Lamb, 1978, p. 80).

The duration of the oxygen debt collection was 180 seconds in all of the normal subjects and in 11 (69%) of the AMI patients. The oxygen debt collection was 131 seconds in 2 AMI patients, and 149 seconds, 151 seconds, or 195 seconds in the other 3 AMI patients. The duration of the oxygen debt collection was shorter than specified in the research protocol for the 4 AMI patients because the 60 liter Douglas bag was not available and the 30 liter bag was not large enough for a 3-minute collection in some subjects; the collection was longer than specified in 1 AMI patient due to a procedural problem.

To obtain the oxygen debt value, the subject's resting oxygen consumption in ml/min (which was obtained during 3 minutes of supine rest) was subtracted from his after-bath oxygen consumption in ml/min (which was obtained immediately after the shower while the subject was sitting quietly in a chair). The oxygen debt results are shown in Table 19.

Oxygen debt averaged 112.95 ml/min in the normal subjects, ranging from 51 to 187 ml/min (Table 19). Oxygen debt averaged 130.81 ml/min in the AMI subjects, ranging from 69 to 301 ml/min.

Oxygen debt was measured for descriptive purposes and to add to the understanding of the bath oxygen consumption findings. The oxygen debt findings were not analyzed statistically.

Type, Group, and Sex Effects for Heart Rate Change

The subject's pulse was taken immediately before and immediately after each bath, according to the

Table 19

Oxygen Debt after Shower in Normal Subjects and Acute Myocardial Infarction (AMI) Subjects by Group and Sex

Group	n	Sex	Weight (kg)	Oxygen Debt after Shower (ml/min) Mean	Range	SD
Normal	22	F & M	68	112.95	51-187	33.48
AMI	16	F & M	87	130.81	69-301	54.73
Normal	11	F	60	96.09	51-143	28.83
Normal	11	M	76	129.82	82-187	29.94
AMI	4	F	98	101.25	69-125	23.47
AMI	12	M	83	140.67	85-301	59.26

research protocol. The before-bath pulse was subtracted from the after-bath pulse to obtain a heart rate change score. A repeated measures analysis of variance with two grouping factors (Dayton, 1970) was used to analyze the heart rate change scores. The heart rate change scores, by group, sex, and type of bath are presented in Table 20.

In normal subjects, little heart rate change was observed after the bath as compared to before the bath. The mean heart rate change score was approximately 1 to 3 bpm after the three baths and ranged from -8 to 12 bpm. In AMI subjects a greater heart rate change was observed. The mean heart rate change score was approximately 10 to 12 bpm after all three baths and ranged from -12 to 28 bpm.

A repeated measures analysis of variance with two grouping factors (Dayton, 1970) was performed to test for the presence of type, group, and sex effects for heart rate change. No significant type effect was found, F (2, 72) = .38, $p < .687$; and, no significant sex effect was found, F (1, 72) = .16, $p < .692$. However, a significant group effect was found, F (1, 72) = 12.70, $p < .001$. Heart rate change for the AMI patients

Table 20

Heart Rate Change from Before-Basin Bath, Tub Bath, and Shower to After-Bath in Normal Subjects and in Acute Myocardial Infarction (AMI) by Group and Sex

			Heart Rate Change (bpm) (After-Bath Heart Rate--Before-Bath Heart Rate)								
			Basin Bath***			Tub Bath			Shower		
Group*	n	Sex**	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD
Normal	22	F & M	3.45	-4 to 12	4.50	1.27	-4 to 8	3.57	2.18	-8 to 12	4.57
AMI	18	F & M	9.78	0 to 28	7.91	11.78	-12 to 28	11.76	9.11	0 to 28	7.86
Normal	11	F	4.36	0 to 12	4.18	2.18	-4 to 8	4.14	3.64	-4 to 12	4.54
Normal	11	M	2.54	-4 to 12	4.82	0.36	-4 to 4	2.80	0.73	-8 to 8	4.31
AMI	5	F	8.00	4 to 20	6.93	12.80	-8 to 24	12.46	7.20	0 to 20	8.67
AMI	13	M	10.46	0 to 28	8.41	11.38	-12 to 28	11.98	9.85	0 to 28	7.76

Note. *Heart rate change score for AMI patients significantly higher than that for normal subjects ($p < .05$).
**No significant difference in heart rate change between females and males.
***No significant difference in heart rate change among the 3 bath methods.

was significantly higher than heart rate change for the normal subjects.

Relation of Bath Preference at Home to Bath Preference in the Study

The Fisher exact probability test (2-tail) (Siegel, 1956) was used to examine the relationship between the type of bath the subject usually took while at home and the type of bath chosen as first choice, or best, for ease, enjoyment, feeling clean, and appropriateness.

Only four subjects chose the basin bath as the easiest bath. No significant difference was found between those who tub bathed at home and those who showered at home in the ranking of basin bath as first choice for ease ($p < .078$).

No subject chose the basin bath first, or best, for enjoyment, feeling clean, or appropriateness. Four subjects, however, chose the basin bath as second choice for enjoyment; 5 chose the basin bath as second choice for feeling clean; and, 2 subjects chose basin bath as second choice for appropriateness. The remaining subjects chose the basin bath as third choice, or worst, for enjoyment, feeling clean, and appropriateness.

No significant difference was found between subjects who tub bathed at home and those who showered at home in selection of tub bath ($p < .730$) or shower ($p < .096$) as first choice for ease. Subjects who tub bathed at home, however, chose tub bath as first choice for enjoyment significantly more than those who showered at home ($p < .035$); and, subjects who showered at home chose the shower as first choice for enjoyment significantly more than those who tub bathed at home ($p < .035$).

Subjects who took a tub bath at home selected tub bath as first choice for feeling clean significantly more than those who showered at home ($p < .004$). Subjects who took a shower at home selected shower as first choice for feeling clean significantly more often than those who tub bathed at home ($p < .004$). No significant difference was found, however, between subjects who tub bathed at home and those who showered at home in the selection of tub bath or shower as first choice for appropriateness ($p < .151$).

Spearman Correlations for Selected Variables

Spearman rank-correlation coefficients (Glass & Stanley, 1970) were calculated for selected variables.

The following variables were among those examined: bath rating of perceived exertion and bath peak heart rate; age and bath oxygen consumption in ml/kg/min; weight and peak bath heart rate; weight and bath oxygen consumption in ml/kg/min; weight and after-bath rate pressure product; duration of bath and bath oxygen consumption in ml/kg/min; duration of bath and peak bath heart rate; length of stay in coronary care unit and peak bath heart rate; length of stay in coronary care unit and bath oxygen consumption in ml/kg/min; and, number of days after coronary care unit transfer and bath oxygen consumption in ml/kg/min. No significant correlations were found for any of the variables tested.

Summary of Findings

The findings of the study related to the three bath methods will be summarized in the order in which they were presented, beginning with a summary of the results from testing the 11 hypotheses, and ending with a summary of the analysis of additional findings. Oxygen consumption findings, peak heart rate findings, and rate pressure product findings during bathing were analyzed for type (basin bath, tub bath, and shower), group (normal subjects and acute myocardial infarction subjects) and sex effects (Hypotheses 1, 2, and 3).

Testing the oxygen consumption findings for type effect showed no significant difference in oxygen consumption among the three baths for normal females and AMI males; however, in normal males and AMI females, oxygen consumption was significantly lower for basin bath as compared to tub bath and shower. Testing for group effect showed that oxygen consumption during all three baths was significantly lower for the AMI group as compared to the normal group. And, testing for sex effect showed that normal females had a significantly lower oxygen consumption during shower than normal males; but, no significant differences were found between normal females and normal males during basin bath and tub bath. The AMI females had a significantly lower oxygen consumption during all three baths than AMI males.

Testing the peak bath heart rate findings for type effect showed that peak heart rate was significantly lower during basin bath than during shower in all of the subjects; however, no significant differences were found between basin bath and tub bath, or between tub bath and shower. Testing the peak heart rate results for group effect showed that the peak bath heart rate was significantly higher in the AMI patients than in the normal subjects. Testing for sex effect showed that normal males had a significantly higher peak bath heart rate than normal females while AMI females had a significantly higher peak bath heart rate than AMI males.

Testing the after-bath rate pressure product results for type effect showed no significant difference in rate pressure product after basin bath, tub bath, and shower in normal females, normal males, and AMI males. In the AMI females, however, rate pressure product was significantly higher after tub bath as compared to after basin bath and shower. Testing for group effect showed that after-bath rate pressure product was significantly higher in the AMI group as compared to the normal group. Testing for sex effect showed that normal females had a significantly lower after-bath rate pressure than normal males while AMI females had a significantly higher after-bath rate pressure product than AMI males.

Presence of dysrhythmia during bathing was analyzed for type and group effects (Hypothesis 4). Presence of dysrhythmia did not differ significantly among the three bath methods; however, the AMI patients had significantly more cardiac dysrhythmias than the normal subjects.

A ST segment change of 1 mm or more was not observed on any of the subject's electrocardiographic tracings during or after bathing as compared to before bathing (Hypothesis 5).

Statistical analysis of the rating of perceived exertion findings for type effect was performed within each group of subjects (Hypothesis 6). The normal subjects perceived basin bath as requiring significantly more exertion than the tub bath or shower; but, the normal subjects perceived no significant difference in the exertion for tub bath and shower. In the AMI patients, rating of perceived exertion did not differ significantly among the three bath methods.

Bath duration was analyzed for type effect within each group of subjects (Hypothesis 7). In the normal subjects, the duration of the basin bath was significantly longer than the duration of the tub bath and shower; but, the duration of the tub bath and shower did not differ significantly In the AMI patients, the duration of basin bath was significantly shorter than the duration of tub bath; but, the duration of basin bath and shower, and of tub bath and shower, did not differ significantly.

The preference variables, ease of bath, enjoyment of bath, and feeling clean after bath, were analyzed within each group of subjects for type effect (Hypotheses 8, 9, and 10). The variable, appropriateness of bath, was analyzed for type effect within the AMI patient group only (Hypothesis 11).

The normal subjects ranked basin bath as significantly less easy than tub bath or shower; however, the ease rankings for tub bath and shower did not differ significantly. In the AMI patients no significant difference in ease ranking was found among any of the bath methods. The normal subjects and the AMI patients enjoyed the basin bath significantly less than the tub bath or shower; however, no significant difference was found in the enjoyment rankings for tub bath and shower.

In normal subjects, the feeling clean ranks differed significantly among all three baths with the subjects feeling most clean after the shower and least clean after the basin bath. In AMI patients, the feeling clean ranking for basin bath also showed that the

AMI patients felt significantly less clean after basin bath as compared to after tub bath and shower. However, in the AMI patients, no significant difference was found in the feeling clean ranks for tub bath and shower. The AMI patients ranked the basin bath as significantly less appropriate for them than the tub bath and shower. No significant difference was found, however, in the appropriateness ranks for tub bath and shower.

In the analysis of additional findings, bath oxygen consumption, measured in mets, was examined for type, group, and sex effects. In normal subjects, no significant difference in met energy cost was found among the three bath methods; in the AMI patients, however, energy cost during basin bath was significantly less than energy cost during tub bath or shower. No significant sex effect was found; however, a significant group effect was found. The AMI patients had a significantly lower energy cost during bathing than the normal subjects.

The after-shower oxygen debt findings were described by group and sex in terms of duration, means, ranges, and standard deviations. Oxygen debt, which was measured during approximately 3 minutes of sitting rest, ranged from a low of 51 ml/min to a high of 301 ml/min. Oxygen debt averaged 113 ml/min in the normal group and 131 ml/min in the AMI group.

Heart rate change, before-bath heart rate subtracted from after-bath heart rate, was analyzed. No significant type or sex effect was found; however, a significant group effect was found since the heart rate change score was significantly higher for AMI patients as compared to normal subjects.

The relationship between the type of bath the subject usually took while at home and the type of bath chosen as first choice, or best, for ease, enjoyment, feeling clean, and appropriateness, was examined. No subject chose the basin bath as first for enjoyment, feeling clean, or appropriateness. Four subjects chose the basin bath as best for ease; however, no significant difference was found between those who tub bathed at home and those who showered at home in the ranking of basin bath as first choice, or best, for ease.

No significant difference was found between subjects who tub bathed at home and those who showered at home in selection of tub bath or shower as their first choice for appropriateness. However, subjects who tub bathed at home chose tub bath as first choice for enjoyment and feeling clean significantly more than those who showered at home; and, subjects who showered at home selected the shower as first choice for enjoyment and feeling clean significantly more often than those who tub bathed at home.

Spearman-rank correlation coefficients were performed for a number of selected variables including peak heart rate and rating of perceived exertion, age and bath oxygen consumption, and weight and bath oxygen consumption. No significant correlations were found for any of the variables tested.

CHAPTER 5

SUMMARY OF THE STUDY

Patient activity prescription is more often based on intuition and tradition than on scientific evidence because little research has been conducted to measure the patient's oxygen consumption, cardiovascular response, rating of perceived exertion, and preference during common activities. The use of tradition to guide patient activity selection and progression is especially apparent in the care of the acute myocardial infarction patient. The hospitalized acute myocardial infarction patient, for example, is often required to bathe from a basin, and prohibited from taking a tub bath or shower, until late in his hospitalization or until after he goes home.

Prohibiting the myocardial infarction patient from taking a tub bath and shower has little empirical foundation and is in need of scientific study. Requiring bathing by basin, and prohibiting bathing by tub and shower, may not be in the patient's best interests. Maintenance of basin bathing may increase deconditioning, retard adaptation to higher level activities, and exaggerate the patient's feelings of dependency and invalidism; and, taking a tub bath or shower may be well within the patient's capabilities, in terms of the required oxygen consumption and cardiovascular response, and be preferred by patients.

Therefore, the following research questions were investigated:

1. What is the difference in oxygen consumption, heart rate, and rate pressure product among rest, basin bath, tub bath, and shower, between the two groups of subjects (normal subjects and hospitalized acute myocardial infarction patients), and between the sexes?

2. What is the difference in presence of dysrhythmia (a) among rest, basin bath, tub bath, and shower and (b) between the two groups of subjects?

3. What is the difference in ST segment change of 1 mm or more (a) among the three methods of bathing and (b) between the two groups of subjects?

4. What is the difference in bath duration among the three methods of bathing in each group of subjects?

5. What is the difference in ranking of perceived effort, ease of bath, enjoyment of bath, and feeling clean after the bath among the three methods of bathing in each group of subjects?

6. What is the difference in ranking of appropriateness of bath among the three bath methods by the myocardial infarction patients?

Summary

Levine's conservation of energy principle provided the focus for the research. A repeated measures design with two grouping factors was used to study 22 normal subjects and 18 hospitalized acute myocardial infarction (AMI) patients during rest, basin bath, tub bath, and shower. The resting measurements were performed to provide descriptive, baseline data and to enhance understanding of the findings. The bathing measurements were performed to compare the bath methods.

The normal subjects were studied on 1 day during rest and during the three randomly ordered baths; the AMI patients were studied on 3 consecutive days during rest and during the three randomly ordered baths. The normal subjects were healthy subjects (primarily nurses and medical students) who averaged 29 years of age. The AMI patients, averaged 49 years of age, had remained in the coronary care unit for an average of 5 days, and were an average of 9 days postinfarction and 4 days post-transfer from the coronary care unit. Most of the AMI patients had multifaceted health problems in addition to the myocardial infarction; and, most of the patients had experienced complications early in their recovery from the infarction.

The open-circuit Douglas bag method was used to measure oxygen consumption in the subjects during rest and during bathing. Oxygen consumption was also measured immediately after the shower, during sitting rest, to determine oxygen debt. A Holter monitor was used to record a continuous electrocardiogram during rest and bathing. A conventional cuff sphymomanometer and stethoscope were used to measure blood pressure during rest and after each bath. The systolic blood pressure findings were multiplied by the radial pulse taken immediately before the blood pressure measurement to obtain the resting and after-bath rate pressure products. Cardiovascular response, during rest and during each bath method, was examined by determining resting heart rate, resting rate pressure product, peak bath heart rate, after-bath rate pressure product, presence of dysrhythmia during rest and bathing, and presence of a ST segment change of 1 mm or more during or after the bath as compared to before the bath.

A stop watch was used to measure the duration of each of the three baths. After rest and after each bath, the subject selected a number from the rating of perceived exertion scale to indicate the degree of effort perceived during supine rest and during each of the three baths. After completing all three baths, the subject completed a preference questionnaire in which the subject was asked to rank the three baths for ease, enjoyment, and feeling clean. In the questionnaire, the acute myocardial infarction patients were also asked to rank the three baths for "appropriateness for you at this stage of your recovery."

Discussion of Findings

Oxygen Consumption

One of the most interesting and surprising findings of the present study was that the oxygen consumption (VO_2) of the AMI patients during each of the baths, approximately 6.5 ml/kg/min, was significantly lower than the VO_2 of the normal subjects during bathing, approximately 7.8 ml/kg/min. This finding of significant VO_2 differences between normal subjects and AMI patients, though unexpected, was suggested by a finding in the 1952 study by Gordon, as well as by observations of the investigator during the present study, and is completely logical.

The normal subjects in this study were healthy, active individuals who generally felt and acted energetic. The investigator, during unsystematic observations made at the halfway point in the bath and at the end of the bath, noted that when the normal subject took a bath, the subject made little attempt to conserve energy because he had abundant energy stores. The normal subject appeared to use energy freely and extravagantly. For example, most normal subjects stood while drying themselves; and, to dry their feet they balanced first on one foot and then on the other. By contrast, many AMI patients sat down to dry their legs and feet, and, in some cases, their entire body.

The AMI patients had recently sustained an acute myocardial injury and their activity level had been severely restricted early in their hospitalization. Thus, they were conscious of their increased vulnerability and their need to restrict activity. In addition, the majority of the AMI patients had pre-existing health problems which complicated their recovery from the AMI. Consequently, many of the AMI patients did not feel healthy or energetic, or act that way. The investigator's unsystematic observations suggested that the AMI patients, consciously or unconsciously, used energy conservation techniques. The AMI patients appeared to move more deliberately and slowly than the normal subjects, and to sit down whenever possible.

Significant oxygen consumption differences between the AMI patients and the normal subjects were not found during rest, although the resting VO_2 for AMI subjects was lower than that for normal subjects. Therefore, differences in resting VO_2 cannot explain the significant differences in bathing VO_2 between the two groups. Spearman correlation coefficients for VO_2 and age, and for VO_2 and weight were not significant; therefore, it is unlikely that the age and weight differences between the groups account for the VO_2 differences. The most reasonable explanation for the group differences in VO_2 is that sick individuals, who have limited energy resources, have a tendency to perform activities in a manner which conserves energy.

Few VO_2 studies have been conducted in which heterogeneous groups of subjects have been investigated and compared; therefore, the opportunity for discovering significant VO_2 variations between different groups has not been available. The finding in this study that patients expend less energy for a nonstandardized activity than healthy individuals supports findings of two previous studies. Gordon (1952) measured VO_2 in one ambulatory pulmonary tuberculosis patient and in three healthy subjects during showering. The energy cost of the patient, 12.54 ml/kg/min, was much lower than the energy cost of the three healthy subjects (16.23 ml/kg/min). Gordon explained this finding by the fact that the patient was more deliberate in his actions than the normal subjects.

In a recent study by Winslow and Lane (1982), the energy cost of 87 subjects who were members of four different subject groups (AMI patients, hospitalized medical patients, cardiac outpatients, and normal subjects) was measured during in-bed (bedpan/in-bed urinal) and out-of-bed (bedside commode/standing urinal) toileting. The energy cost of toileting for the AMI patients and the medical inpatients was found to be significantly lower than the energy cost of toileting for the cardiac outpatients and the normal subjects. Thus, findings of three studies, including the present study, suggest that hospitalized patients have a lower $\dot{V}O_2$ during a given nonstandardized activity than healthy individuals.

Bathing, whether by basin, tub, or shower, was found in the present study, to require minimal energy cost in both subject groups, approximately 6 to 8 ml/kg/min, or less than 3 times resting energy cost. Statistical analysis for type effect revealed no significant type effect for normal females and AMI males; however, a significant type effect was found for normal males and AMI females who required a significantly lower energy cost for basin bath as compared to tub bath and shower. The only explanation that can be offered for why basin bath VO_2 was significantly lower is that some normal males and AMI females did not appear very diligent during the basin bath in trying to get themselves clean.

The statistically significant VO_2 difference in normal males and AMI females for basin bath as compared to tub bath and shower, however, represent only 1 ml/kg/min or .2 mets difference in VO_2 between the bath methods. A difference of 1 ml/kg/min has small effects on the oxygen transport system and is clinically unimportant despite statistical significance. Therefore, on the basis of VO_2 findings, no clinically important differences in the energy cost of the three baths were found.

The bathing VO_2 results in this study (6 to 8 ml/kg/min) are lower than the findings of previous bathing studies (Cathcart & Trafford, 1920; Gordon, 1952; Gordon & Haas, 1955; Johnston et al., 1981; Passmore & Durnin, 1955; Passmore et al., 1952) (Table 4). Variations in research protocol, oxygen consumption equipment, and type of subject may explain some of the differences. In the studies by Gordon (1952) and Gordon and Haas (1955), for example, expired air collection was not started until the subject had been in the shower bathing for 2 to 3 minutes; and, the subject was asked to repeatedly bathe himself for approximately 8 minutes or until a suitable volume of expired air had been collected. The VO_2 results in the studies by Gordon (1952) and by Gordon and Haas (1955) were higher and more variable than the VO_2 results in the present study. The obvious differences in research protocols may explain the differences in findings.

The VO_2 research protocol in this study, however, appeared identical to that described by Johnston et al.

(1981) except that the Max Planck method was used in Johnston et al.'s study and the Douglas bag method was used in the present study. The Max Planck and Douglas bag methods have been shown to provide comparable results (Fletcher et al., 1979); therefore, use of the Max Planck method should not have contributed to the higher VO_2 findings in Johnston et al.'s study. The fact that Johnston et al.'s tub bath and shower results were more variable than the tub bath and shower results in the present study may be related to, but does not offer a complete explanation for, the higher VO_2 findings in the Johnston et al. study.

Because Gordon and Haas (1955) reported finding "rather large oxygen debts" in subjects after showering, the investigator in the present study chose to measure oxygen debt immediately after showering to obtain an index of oxygen debt and recovery to baseline VO_2. In the Gordon and Haas study, oxygen debt for a period of 165 to 240 seconds ranged from 100 to 500 ml/min and averaged 276 ml/min; in the present study, oxygen debt over 131 to 195 seconds ranged from 51 to 301 ml/min and averaged 120 ml/min. The mean oxygen debt in the study by Gordon and Haas was more than 2 times the mean oxygen debt in the present study. The rather high oxygen debts found by Gordon and Haas may be related to the fact that the subjects performed repetitive showers over approximately 8 minutes.

The finding of oxygen debts of more than 50 ml/min in every subject in this study following showering suggested either that the VO_2 results in the present study underestimated the energy cost of bathing by an amount proportional to the oxygen debt, e.g., approximately 1.6 ml/kg/min, or else that the bathing stimulated metabolism. Even if the oxygen debt results are interpreted as suggesting that the energy cost of bathing was underestimated, the energy cost of all three baths is still low, less than 3 times resting energy cost, and well within the capabilities of most patients. Consequently, it would be inappropriate to prohibit a patient from taking either a tub bath or shower on the basis of the energy cost requirement for that bath.

Heart Rate

Although the VO_2 findings were interesting and relevant, and some of the findings unexpected, VO_2 is not as sensitive and accurate a measurement of activity intensity and cardiovascular response as heart rate. Heart rate measurement accurately reflects the degree of stress produced by an activity and provides information about the adequacy of physiological responses to the activity (deVries, 1974). Heart rate is an accurate indicator of stress and work load because a direct relationship exists between VO_2 and cardiac output since VO_2 = cardiac output (heart rate x stroke volume) x A-V O_2 difference, and because the increase in cardiac output required for a given activity is accomplished primarily due to the increase in heart rate (rather than due to the increase in stroke volume) (Blomqvist, 1974). Heart rate information, via cardiac monitor or radial pulse, fortunately, is readily available for use in patient assessment; and, heart rate probably provides the most important and helpful information for assessing the intensity of the activity for the patient, and the adequacy of the patient's adaptations.

In the present study, the resting heart rates and peak bath heart rates of the AMI patients were significantly higher than the heart rates of the normal subjects, as expected due to the patient's recent myocardial injury as well as his lack of physical conditioning. The peak heart rate during shower was significantly higher than the peak heart rate during basin bath; no significant difference, however, was found between the peak heart rates for basin bath and tub bath, and between the peak heart rates for tub bath and shower.

In order to determine the clinical significance of the statistically significant peak heart rate differences between basin bath and shower, one needs to examine not only the mean peak heart rate for each bath, but also look at each patient's response to basin bath compared to shower. Looking, first, at the mean peak heart rates for the AMI patients, the difference between a peak heart rate of 105 bpm for basin bath and 112 bpm for shower, though statistically significant, is clinically unimportant in terms of cardiovascular dynamics.

Examination of the individual data indicated that the largest heart rate increase, from basin bath to shower, was 16 bpm (observed in three patients) (Table 21). The individual findings also indicated that the highest heart rate observed during basin bath was 120 bpm (three patients), and the highest heart rates

Table 21

Resting Heart Rate and Peak Heart Rate (PHR) during Basin Bath, Tub Bath, and Shower in 18 Acute Myocardial Infarction Patients by Individual

Patient	Sex	Weight (kg)	Rest and Peak Heart Rate (bpm)			
			Rest	Basin Bath	Tub Bath	Shower
1	M	102	76	88	92	104
3	M	77	64	100	80	108
4	M	106	68	104	100	100
5	F	145	92	120	108	132
6	M	61	80	96	108	100
7	M	54	72	120	112	124
8	F	90	88	100	100	116
9	M	71	84	104	100	108
10	F	52	84	116	144	132
11	M	103	60	--	80	--
12	F	111	100	108	136	116
13	M	116	72	116	112	124
14	F	83	96	112	116	116
15	M	63	84	120	128	132
16	M	75	88	112	120	112
17	M	83	68	100	116	100
18	M	79	56	76	88	84
19	M	92	60	100	112	92
			$\underline{x}$ = 77	$\underline{x}$ = 105	$\underline{x}$ = 108	$\underline{x}$ = 112
			SD = 13	SD = 12	SD = 17	SD = 14
			$\underline{n}$ = 18	$\underline{n}$ = 17	$\underline{n}$ = 18	$\underline{n}$ = 17
Number and Percentage over:			100 bpm	10(59%)	11(61%)	12(70%)
			110 bpm	7(41%)	9(50%)	9(53%)
			120 bpm	0	3(17%)	5(29%)
			130 bpm	0	2(11%)	3(18%)
			140 bpm	0	1 (6%)	0
			150 bpm	0	0	0

Note. Data from Patient 2 were excluded from analysis because the subject was discharged from the hospital before completing all three baths.

observed during shower ranged from 124 to 132 bpm (five patients). Therefore, peak heart rates were higher in more subjects for shower as compared to basin bath. The tachycardia during showering, however, was transient and well tolerated; no subject had any signs or symptoms of cardiovascular distress during showering. The individual data, as well as the mean peak heart rate data, suggested that the peak heart rate differences between basin bath and shower were not clinically significant although statistical significance was found.

The highest heart rate observed during bathing, 144 bpm, occurred during the tub bathing in Patient 10, a 58-year-old female recuperating from an inferior infarction. The peak heart rate of 144 bpm occurred briefly in Patient 10, apparently associated with getting out of the tub; immediately after the tub bath the patient's heart rate had dropped to 128 bpm. Patient 10 had no symptoms associated with the tachycardia and no ST segment change was observed on the electrocardiogram. Patient 10 ranked the tub bath as the bath easiest for her on the preference questionnaire as well as by the RPE scale.

The second highest peak heart rate observed during bathing, 136 bpm, occurred in Patient 12 during her effort to get out of the tub (the assistance of two nurses was required). Patient 12 had no discomfort or signs suggestive of cardiovascular distress associated with her tachycardia, and her heart rate quickly returned to its resting level.

Only two other patients had peak heart rates over 130 bpm at some time during bathing--Patient 5 and Patient 15 had peak heart rates of 132 during showering. Over 50% of the patients had peak heart rates over 100 bpm at some time during the three methods of bathing (compared to about 2% of the normal subjects). However, most of the peak heart rates were less than 120 bpm, and the tachycardia was well tolerated since no patient experienced symptoms of cardiovascular distress such as chest or arm pain, shortness of breath, or dizziness during bathing. The tachycardia, therefore, was a normal, necessary, and well tolerated response to the increased activity which augmented the patient's cardiac output.

Comparing the peak heart rate results in AMI patients during showering in this study with Erickson's (1975) findings is of interest. Erickson investigated cardiovascular response during sitting and standing showering in 10 patients who averaged 56 years of age and 13 days post myocardial infarction. Peak heart rate during standing shower in Erickson's study averaged 119.5 bpm (SD = 25.69) and ranged from 87 to 170 bpm. Peak heart rate during showering in the present study averaged 112 bpm (SD = 11.45) and ranged from 84 to 132 bpm. Therefore, the peak heart rate findings in the present study were lower and less variable than the findings in Erickson's study. Erickson concluded from her cardiovascular findings that "showering is not physiologically dangerous for the patient if his acute phase has been stable and if it is done under controlled conditions with nursing supervision" (p. 93). The findings in the present study also suggested that showering in water at 96°F to 98°F is not physiologically dangerous for the stable, convalescent AMI patient.

Following activity, heart rate should quickly return to its resting level. Generally, the rate of the return of heart rate to the resting level is proportional to the severity of the activity; i.e., the more severe the activity, and the less fit the subject, the slower the return of heart rate to baseline. To assess heart rate recovery, the before-bath heart rate was subtracted from the after-bath heart rate to obtain a heart rate change score. The heart rate change score for the AMI patient, 10-12 bpm, was significantly higher than the heart rate change score for the normal subject, 1-3 bpm. However, a difference in heart rate from before-bath to after-bath of 12 bpm indicated an adequate heart rate recovery and provided additional evidence that bathing was well tolerated by AMI patients.

The radial pulses taken during and after the baths were helpful in assessing the patient's tolerance to the activity and estimating maximal heart rate. However, the radial pulse did not accurately predict the maximal heart rate since the radial pulse was 10 bpm (range 4-20 bpm) lower than the peak heart rate observed on the electrocardiogram.

In summary, no clinically important differences in peak heart rate were found among the three methods of bathing although the mean peak heart rate for shower, 112 bpm, was found, statistically, to be significantly higher than the mean peak heart rate for basin bath, 105 bpm. The peak heart rate during bathing was less than 120 bpm for most patients and never exceeded 144 bpm. The heart rate increase during bathing was a normal and necessary response to the increased activity and was well tolerated by the patients. The heart rate promptly slowed after the cessation of bathing.

Rate Pressure Product (RPP)

Rate pressure product (systolic blood pressure x heart rate/100) correlates well with myocardial oxygen consumption (Kitamura et al., 1972). Therefore, RPP was determined in the present study to provide an estimate of myocardial oxygen consumption after each bath.

The after-bath RPP of the normal subjects for all three baths, approximately 79, was significantly lower than the RPP of the AMI patients, 115 after-basin bath, 120 after-tub bath, and 111 after-shower. The higher RPPs among the AMI patients are readily explained by the AMI patients' higher heart rates and older age, as well as by the fact that 12 (67%) of the AMI patients had a history of hypertension.

The RPP results did not differ significantly among the three baths for the normal subjects or the AMI males; in the AMI females, however, RPP was significantly higher after tub bath than after basin bath or shower. Since the AMI female RPP data were based on the findings from only four subjects, the AMI female RPP results need to be interpreted cautiously. No blood pressures were obtained for the fifth AMI female because the patient's obesity (145 kg) and her large arms (23 inches) made it difficult for the investigator to obtain an accurate blood pressure.

The finding of a significantly higher RPP in the AMI females after the tub bath as compared to after the basin bath and shower might be related to the obesity of the AMI females and the need for isometric activity to pull themselves out of the tub bath. The fact that the highest RPP, 205 (systolic blood pressure of 160 x heart rate of 128) was observed in Patient 12, who was obese and required assistance from two nurses to get out of the tub, supports the obesity-isometric explanation.

The RPP of 205 was an extreme finding in this study. No other RPPs above 167 were observed in this study; and, most of the RPP findings were well below 120 for all three baths reflecting the low myocardial oxygen demand during bathing.

The mean after-shower RPP in AMI patients in the present study, 111, is slightly higher than the mean after-shower RPP of 104 in the Erickson (1975) study. The after-shower mean RPP range for AMI patients in the present study, 77 to 148, is comparable to Erickson's range of 61 to 153.

The RPP findings for the AMI patients in the present study, however, are considerably lower than the RPP findings of Johnston et al. (1981). Johnston et al.'s mean RPP findings after basin bath, tub bath, and shower were 132, 139, and 151, respectively, compared to 115, 120, and 111 in the present study. No reasonable explanation can be offered for the higher RPP findings in Johnston et al.'s study except for subject differences. The RPP findings in the present study, which averaged 111 to 120, reflected low myocardial oxygen demand. The RPP findings provided additional evidence that bathing requires low cardiovascular stress.

Dysrhythmia; ST Segment Change

Many aspects of cardiac function are deranged as a result of an acute myocardial infarction and predispose to the development of the rhythm disturbances. Some of the prodysrhythmic factors in myocardial infarction include: (a) myocardial injury which alters the electrophysiology of the pacemaker tissues, the conduction system, and the myocardium; (b) hypoxia, caused by impairment of the coronary circulation; (c) activation of both vagal and sympathetic reflexes due to many reasons including hemodynamic alterations and anxiety; and (d) the effect of certain cardioactive drugs often used to treat patients with acute myocardial infarction (Bellet, 1972). Consequently, disturbances in cardiac rhythm are the most common complication of an acute myocardial infarction and are observed in 90% of acute myocardial infarction patients (Bellet, 1972).

Premature ventricular beats (PVCs) are the most common dysrhythmia observed following a myocardial infarction; PVCs are also the most common rhythm disturbance observed in the healthy individual (Marriott & Myerburg, 1974). Premature atrial contractions (PACs) are also common following a myocardial infarction; PACs are reported in approximately one-half of the patients with myocardial infarctions (Marriott & Myerburg, 1974). Other rhythm disturbances less commonly observed following a myocardial infarction include atrial tachycardia, atrial fibrillation, ventricular tachycardia, ventricular fibrillation, and first, second, and third degree heart block.

Because of the commonness of rhythm disturbances following acute myocardial infarction (AMI), the finding of a significant difference in presence of cardiac dysrhythmias in AMI patients and normal subjects was expected and predicted. No literature was found suggesting that the presence of a rhythm disturbance would be altered by the type of bath taken; and, the results of the study showed no significant difference in presence of dysrhythmia during the three methods of bathing.

No change in ST segment of 1 mm or more during or after the bath as compared to before the bath was observed on the electrocardiographic tracings of the normal subjects or of the AMI patients. An ST segment change has been shown to be associated with coronary ischemia (Sheffield, 1974). Bathing is a low energy cost activity which should not induce ischemic changes in the convalescing AMI patient unless the bathing is associated with a rapid heart rate. A rapid heart rate increases myocardial oxygen demand and, if the rate is fast enough, ventricular filling may be significantly curtailed, stroke volume decreased, and ischemia will result (Bellet, 1972). Healthy individuals tolerate heart rates of 200 bpm without ischemic changes; AMI patients, with reduced cardiac reserve, however, may demonstrate ischemic changes at much slower heart rates. The highest heart rate observed during the present study was 144 bpm in a 58-year-old AMI patient during the tub bath. Three other AMI patients had peak bath heart rates between 132 and 136 bpm; the peak heart rates of all the other subjects were less than 130 bpm. Therefore, a tachycardic induced ischemic change was unlikely.

Erickson (1975), in her study of 10 convalescing acute myocardial infarction patients during sitting and standing showering activity, used a computer to analyze ST segment change. No ST segment depression of 1 mm or more was observed. The mean ST segment elevation, however, was 1 mm, which was greater than that observed in cardiac outpatients during maximal exercise. Erickson suggested that the ST segment elevation indicated that the patients had myocardial dilatation.

Johnston et al. (1981) found significant ST displacement in 6 of 11 AMI patients after the shower, in

4 of 12 patients after the tub bath, and in 2 of 11 patients after the basin bath. In the study by Johnston et al., a 12-lead electrocardiogram was taken immediately after each bath; the electrocardiograms were interpreted by two cardiologists. Johnston et al. did not determine peak heart rate during bathing.

No significant ST changes were observed in any subject during the present study. However, since only two leads were recorded and the ST segments were not computer analyzed, ST changes may have been present but not picked up by the instruments used in this study. The results from the submaximal exercise tolerance test taken by four of the bath subjects a few days after the bath study, however, helped substantiate the ST segment results of this study since no significant ST segment change occurred during the exercise tests.

Rating of Perceived Exertion (RPE) during Rest and Bathing; Relationship of RPE and Heart Rate

A number of objective, physiological indicators of exertion during bathing were investigated during this study including oxygen consumption, peak heart rate, and after-bath rate pressure produce. The investigator also wanted to examine a subjective indicator of exertion during bathing since the important consideration in human performance is frequently not "what the individual is doing" but rather "what he thinks he is doing" (Morgan, 1973b). Therefore, in the present study the rating of perceived exertion scale was used and the subject was asked to rate the amount of effort perceived during each bath. The subject was also asked to rate the amount of effort perceived during the resting collection to provide baseline RPE information.

The RPE scale, which has been used extensively during multi-stage treadmill and bicycle tolerance tests, has been shown to correlate with heart rate as well as with other physiological indicators of effort such as blood lactate level and relative oxygen consumption during various types of work (Borg & Linderholm, 1967; Ekblom & Goldbarg, 1971). Therefore, the investigator was also interested in learning whether RPE during three low energy cost activities, taking a basin bath, a tub bath, and a shower, correlated with the peak bath heart rate.

Approximately 70% of the subjects selected a RPE of 6 or 7 (very, very light) for rest, as would be expected. About 30% of the subjects, however, selected a RPE of 8 or 9 (very light) for rest. A number of the subjects reported that the strangeness and the discomfort of the oxygen consumption equipment raised the rating of exertion.

The median RPE scores in both groups for all three baths ranged from 9 to 10.5. Determining the highest RPE scores for each bath is of interest. The highest RPE for basin bath, 13 (somewhat hard), was selected by four normal subjects and one AMI patient. The highest RPE for tub bath, 17 (very hard), was selected by an obese AMI female who required the assistance of two nurses to get out of the tub. One other AMI patient chose a relatively high RPE score for tub bath, 13 (somewhat hard); the highest RPE by normal subjects for tub bath, 11 (fairly light), was selected by six normal subjects. The highest RPE score by normal subjects for shower was 12 which was selected by three normal subjects; the highest shower RPE by AMI patients, 13, was selected by one AMI patient. Some of the subjects who chose a relatively high RPE score for shower explained that the score reflected the awkwardness of the oxygen consumption equipment during the shower more than the effort of taking a shower. The equipment was more cumbersome during the shower than during the tub bath and basin bath when the subject was sitting down; therefore, the investigator was surprised that the RPE scores were not higher for shower. Inspection of the median scores, as well as the high scores, showed that bathing, with few exceptions, is perceived by normal and AMI subjects as requiring light exertion.

The RPE scores chosen by the AMI patients for basin bath, tub bath, and shower did not differ significantly; i.e., the AMI patients perceived the amount of effort required to take a basin bath as similar to the effort required to take a tub bath and shower. The normal subjects, however, perceived taking a basin bath as requiring significantly more exertion than taking a tub bath or shower ($p < .05$). The investigator observed the subjects at the halfway point in each bath when the radial pulse was taken, and at the end of each bath. Many of the normal subjects, most of whom had never taken a basin bath before, appeared to try diligently to give themselves a good, total bath. The normal subjects reported that they tried various bathing techniques during the basin bath and that they felt frustrated by the inconvenience and ineffectiveness of the basin bath. The normal subjects also reported that they found it difficult to avoid chilling during the basin bath since the part of the body being washed was exposed and wet.

The AMI patients were accustomed to taking a basin bath since they had been taking a bath from a basin, or from the sink in the bathroom, during most of their hospital stay. The AMI patients did not appear as diligent as the normal subjects in trying to bathe the entire body although both AMI patients and normal subjects spent about 8 minutes taking the basin bath. Instead, the AMI patient appeared to bathe only the dirtiest parts of the body. The energy cost of the AMI patients during the basin bath, 6.14 ml/kg/min (1.82 mets), was significantly lower than the energy cost of the normal subjects during basin bath, 7.57 ml/kg/min (2.13 mets), and probably reflected the AMI patient's less thorough approach to bathing from a basin.

The high RPE scores chosen by normal subjects for taking a basin bath probably reflected the fact that the normal subjects found taking a basin bath more unpleasant, inconvenient, and ineffective than the other baths rather than that they perceived the basin bath as requiring more effort than other baths. The emotional and esthetic aspects of some activities seem to make it difficult for the subject to rank "pure effort." As Rosentswieg et al. (1979) pointed out, RPE scores need to be interpreted carefully since the scores tend to be both task and population specific. Rating of perceived exertion is usually used when a subject performs one activity, such as walking on the treadmill, at different levels of intensity. The RPE scale may be inappropriate for comparing the effort required for different types of activities; i.e., for basin bath, tub bath, and shower.

No significant correlation was found between bath RPE and bath peak heart rate. The lack of a significant correlation between RPE and heart rate in the present study is not surprising for several reasons. First, the emotional, esthetic, and preference factors associated with each type of bath appeared to affect the subject's bath RPE. Second, the exertion level for the three baths was not markedly different; therefore, subjects often reported difficulty rating the exertion. When the RPE scale is used during a multistage exercise test, the subject generally starts exercise at a low intensity level of approximately 3 mets, and progresses to intensity levels of 9 mets or more. The subject has little trouble rating perceived exertion because the intensity level covers a broad range from minimal to moderate, or maximal, intensity. The effort level required by the three baths was very narrow; consequently, it was difficult for subjects to perceive and report different degrees of exertion.

And, finally, although high correlation coefficients of .83 to .94 between RPE and heart rate have been demonstrated in homogeneous healthy subjects doing standardized exercise, correlations measured in age heterogeneous groups and in patient groups have been markedly lower, varying from .40 to .70 (Bar-Or et al., 1972). Even in homogeneous groups, the correlation between heart rate and RPE has been poor for low work loads (Bar-Or et al., 1972). In the present study, a heterogeneous group was studied at low energy cost levels. Therefore, significant correlations between heart rate and RPE were not expected. In summary, it would have been surprising, in the present study, to find a significant correlation between after-bath RPE and peak bath heart rate because emotional and preference factors appeared to alter the RPE, because the exertion range was narrow, and because the subjects were heterogeneous and were studied at low work loads.

Bath Duration; Relationship of Bath Duration to Oxygen Consumption, Heart Rate, and Rate Pressure Product

The bath duration was timed in order to provide descriptive information about the length of each bath for each group of subjects and to provide data for testing the relationship of bath duration to selected variables. Both normal subjects and AMI patients required approximately 8 minutes to take a basin bath; the length of the basin bath, however, was more variable among the normal subjects (*SD* = 179 secs) than among the AMI patients (*SD* = 98 secs). The normal subjects required a significantly shorter time for the tub bath and shower (6 mins) as compared to the basin bath; by contrast, the AMI patients required a significantly longer time for tub bath and shower (9 mins) as compared to the basin bath.

The normal subjects, who were taking the three study baths in 1 day, got into the tub bath or shower, bathed, and got out. The normal subjects were accustomed to bathing by tub and shower and appeared efficient and thorough from the few observations the investigator was able to make.

The length of the AMI patient's tub bath and shower was 3 minutes longer than the duration of the normal subject's tub bath and shower. For all except two of the AMI patients, the study tub bath and shower was the first tub bath and shower the patient had had since admission to the hospital. Most of the patients seemed to thoroughly enjoy the tub bath and shower, in spite of the equipment; and, many of the patients would have taken a longer tub bath or shower if they had been permitted to do so. Since the Douglas bag had a capacity for about 10 to 12 minutes of expired air, depending upon the subject's weight and ventilatory volume, and since it quickly became apparent that the AMI patients tended to take long tub baths and showers, a time limit was placed on the AMI patient's tub bath and shower. Therefore, the tub bath and shower durations for many of the AMI patients should be interpreted cautiously since investigator intervention altered the duration.

The investigator asked a number of the normal subjects and AMI patients to compare the study baths to the tub bath and shower the subject would normally take at home. The subjects' responses indicated that the study bath was a fairly typical bath for them in terms of vigorousness of movements; however, the subjects generally said they preferred longer and hotter baths.

One might expect the duration of the bath to be related to the intensity of the exertion, i.e., the shorter the duration, the higher the intensity. The duration/intensity relationship exists for standardized activities such as running a mile. Running a mile in 6 minutes requires a higher oxygen consumption and cardiovascular response than covering the same distance in 12 minutes. The duration/intensity relationship would not be expected to be present in nonstandardized activities in which each individual performs the activity in his/her own way. Therefore, in the present study, one would not expect duration to be related to the energy cost or cardiovascular response variables. If a standardized bath protocol had been used, however, in which each subject was required to scrub his/her legs 6 times, the arms 3 times, and so on, the duration/intensity relationship might be significant.

In the present study, Spearman correlation coefficients were calculated for bath duration and oxygen consumption, peak heart rate, and peak rate pressure product. As anticipated, no significant correlations were found. Spearman correlation coefficients were also calculated for duration and RPE, and duration and weight; again, no significant correlations were found.

Bath Preference; Relationship of Bath Preference to Type of Bath Taken at Home

The investigator was interested in learning which of the three bath methods the subjects preferred for ease, enjoyment, feeling clean, and appropriateness. The bath preference information would provide useful descriptive date; the preference information would also provide a basis for bath method recommendations if the physiological costs of the three baths were similar.

In the AMI patients, no significant difference in ease ranking was found among the three bath methods. In the normal subjects, however, taking a basin bath was ranked as significantly harder than taking a tub bath or shower. These bath ease findings mimic the RPE findings, as would be expected, since ranking of bath ease and rating of perceived exertion both should measure effort associated with bathing. Asking the subject to rank bath ease by selecting the easiest and hardest bath method is probably a more appropriate approach to measuring bath effort than using the RPE scale. Questioning the subject about bath ease is a more direct way to measure exertion than the RPE; and, the RPE scale may be inappropriate in this setting for the reasons mentioned in the RPE discussion.

The preference responses clearly indicated that the subjects disliked the basin bath. Only 4 subjects chose the basin bath as the easiest bath; while, 25 (63%) of the subjects chose the basin bath as the hardest bath. No one selected the basin bath as first choice for bath enjoyment or feeling clean, and only a few subjects ranked basin bath as second choice for enjoyment and feeling clean. The clear dislike for the basin bath was an expected finding because bathing from a basin, based on the investigator's personal experience as well as on reports from patients, is unpleasant, inefficient, and awkward. In fact, one of the motivations for this study was the numerous complaints from cardiac patients about the difficulty and disagreeableness associated with taking a basin bath.

All of the subjects selected tub bath or shower as the first choice for enjoyment, feeling clean, and appropriateness. As would be expected, subjects who took a tub bath at home selected the tub bath as their first choice for enjoyment and feeling clean; and, subjects who showered at home chose the shower as their first choice for enjoyment and feeling clean. The type of bath taken at home did not have a significant influence on the selection of tub bath or shower as first choice for appropriateness.

The finding that 11 (61%) of the AMI patients preferred the tub bath at home compared to only 1 (4.5%) of the normal subjects was of interest. Every AMI patient who preferred a tub bath at home was Black except for one White female who said she took a tub bath at home although she would prefer a shower if one were available. The one normal subject who took a tub bath at home also said she would prefer a shower if one were available. The Black subjects who took a tub bath had a shower at home, but they liked the tub bath better.

The marked differences in bath preference at home between the two groups of subjects can probably be explained by the racial, socioeconomic, and age differences of the two groups. A 45-year-old Black female, who works as a domestic worker, said that she and most of her Black friends bathe by tub; she noted, however, that many of the younger Blacks seemed to prefer to take showers. She explained the Black patients' preference for tub bath by the fact that when the Black patients were young they probably did not have showers in their homes and became accustomed to taking a tub bath; consequently, they still take tub baths, and prefer tub baths, although a shower is now available.

All except two of the AMI patients were bathing by basin bath at the time the study was initiated. None of the patients, however, selected the basin bath as the most appropriate bath for them at this stage of their recovery; all of the patients chose tub bath or shower as the most appropriate bath for them. When the investigator asked the subjects which method of bathing they thought would have been most appropriate for them the day they were transferred from the coronary care unit, a number of patients chose basin bath although the majority selected tub bath or shower. Comments made by the patients during the study suggested that they thought they could accurately gauge their tolerance and choose suitable activities. It should be noted that the reason most of the patients had not already taken a tub bath or shower during their hospital stay was not because the physician thought the tub bath or shower was inappropriate for the patient, but because the physician had merely neglected to advance the patient's stage on the activity schedule order sheet.

In summary, the preference results of the study show that normal subjects and AMI patients clearly dislike taking a basin bath in terms of ease, enjoyment, feeling clean, and appropriateness; and, the findings show that subjects prefer the type of bath they usually take at home, either tub bath or shower. In addition, comments by the patients suggest that the patients believe they can accurately assess their own activity level capacity and choose activities that are within the limits of safety and tolerance for them.

Conclusions and Implications

The following conclusions and implications were made as a result of the findings of this study. However, caution should be used in generalizing from the findings of this study to subjects who differ substantially from the study subjects or to baths which differ in water temperature, type, or duration from the study baths.

1. Hospitalized AMI patients had a significantly lower energy cost during non-standardized bathing than normal subjects, perhaps because the patients, consciously or unconsciously, used energy conservation techniques during bathing. Use of energy conserving techniques may be a natural tendency in sick individuals with limited energy resources. Therefore, generalizing the energy cost findings of normal subjects during non-standardized activities to hospitalized patients appears inappropriate; and, valuable information about energy conserving approaches may be learned by observing sick individuals engaging in various common activities.

2. The energy cost of all three baths, basin bath, tub bath, and shower, was very low, less than 3 times resting energy cost. An activity which requires less

then 3 mets should be well within the capabilities and within the limits of tolerance and safety for most hospitalized patients. Prohibition of the tub bath or shower, based on the energy cost, would, therefore, be inappropriate.

3. No clinically important differences in peak bath heart rate were found among the three methods of bathing; however, peak bath heart rate was found, statistically, to be significantly higher for shower as compared to basin bath. The conclusion that the statistically significant differences in peak bath heart rate were clinically unimportant was based on the mean peak bath heart rate values, the individual peak bath heart rate values, the heart rate change scores from before bath to after bath, the lack of a significant difference in presence of cardiac dys-rhythmia among the three bath methods, the lack of a ST segment change of 1 mm or more during or after any of the three baths as compared to before the baths, and the fact that no subject had any signs or symptoms suggestive of cardiovascular distress during or after bathing. Therefore, the peak bath heart rate findings, viewed in association with the other cardiovascular

response findings, do not provide a rationale for requiring that the patient take a basin bath and prohibiting him from taking a tub bath or shower.

4. The patients' heart rates increased during bathing. Over one-half of the patients had peak bath heart rates of over 100 bpm at some time during bathing; and, a few patients had peak bath heart rates of 120 bpm or more at some time during basin bath, tub bath, or shower.

The increased heart rate is a normal and necessary response to increased activity which augments the cardiac output. However, a heart rate increase raises myocardial oxygen demand and may not be tolerated in patients with low cardiac reserve. Therefore, any time an AMI patient engages in a new or higher level activity, the nurse should assess the patient before, during, and after the activity to determine the patient's tolerance to the activity and to stop the activity if any signs or symptoms of cardiovascular distress occur. Taking the patient's pulse, questioning the pateint about chest discomfort, dizziness, or other symptoms of distress, and observing the patient for pallor and skin temperature changes will provide the nurse with accurate information about the degree of stress produced by the activity and the adequacy of the patient's physiological adjustments to the activity.

Despite the fact that ways to assess activity tolerance, such as heart rate, are readily available, the patient often progresses from one activity to another without the nurse or physician evaluating the patient's response to the new activity. Assessment of the patient's tolerance to each new activity is necessary to prevent complications, to provide information about the speed with which to progress the patient, and to reduce any anxiety the patient might have about engaging in the activity by providing the patient with tangible evidence that he/she is ready for the new activity.

If the new activity is taking a tub bath or shower, the nurse should explain to the patient the cardiovascular effects of immersion in hot water, and stress the importance of using comfortably warm, not hot, water. The nurse should also probably set the water temperature at 96°F to 98°F for the patient's first tub bath or shower to demonstrate to the patient the acceptable water temperature.

5. The after-bath rate pressure products reflected low myocardial workload during bathing for most patients. In a few patients an after-bath rate pressure product above 150 appeared to be related to the effort and isometric activity required by patients to pull themselves up out of the tub.

Before the patient's first tub bath, the nurse should evaluate the patient for potential difficulty in getting out of the tub; if the patient is obese, weak, or has had difficulty getting out of the tub in the past, the nurse should make sure a tub chair, hand rails, and/or personnel are available to assist the patient in getting out of the tub; or, the nurse should recommend that the patient take a shower. The isometric activity required by some individuals to get out of the tub can cause a sharp rise in both systolic and diastolic pressure which increases the myocardial oxygen requirements; therefore, measures to facilitate getting out of the tub are necessary to prevent the increased myocardial workload.

6. The ST change and dysrhythmia findings showed that all three methods of bathing were well tolerated by the AMI patients. The ST change and dysrhythmia

information can indicate tolerance to an activity. Therefore, when a patient is being monitored by an electrocardiogram, the electrocardiogram should be observed, recorded, and analyzed when the patient engages in a new activity in order to provide ST segment and dysrhythmia information, as well as heart rate information, about the patient's response to the activity.

7. Patients clearly disliked the basin bath, and they liked the tub bath and shower. Therefore, if the patient wants to take a tub bath or shower and his/her condition is stable, the nurse should advance the patient's activity level to permit a supervised tub bath or shower, if patient activity prescription is a nursing responsibility at the institution. If patient activity prescription is a physician responsibility, the nurse should ask the physician to advance the patient's activity level to permit a supervised tub bath and shower, perhaps sharing with the physician the results of the present study.

Twenty years ago AMI patients who were in the coronary care unit were not allowed to feed themselves; the nurse had to feed them. Not allowing the patient to feed himself now seems ludicrous. Perhaps 10 years from now requiring that the stable AMI patient take a basin bath, and prohibiting him from taking a tub bath or shower, will seem ludicrous.

Investigation of the energy cost and cardiovascular response of activities commonly performed by patients is necessary to provide an empirical basis for activity prescription and restriction, and consequently, to promote health. The present study should stimulate questions about the selection and progression of bathing activities, as well as of other activities, for hospitalized patients, and research to answer those questions.

Recommendations for Further Study

The following recommendations for further study were made:

1. A similar study should be conducted to verify the findings, with the following modifications:

(a) Cardiac outpatients and hospitalized AMI patients should be studied and compared instead of normal subjects and hospitalized AMI patients. The cardiac outpatients should be subjects who have had an AMI but have been out of the hospital for 2 or more months. The cardiac outpatients should be similar to the hospitalized AMI patients in age, weight, socio-economic status, and presence of other health problems so that the major difference between the two groups would be acuteness of myocardial injury and hospital status.

(b) Hospitalized patients and outpatients with chronic obstructive pulmonary disease should be studied.

(c) The subjects should bathe from the sink in the bathroom, instead of from a basin at the bed-side (during the basin bath activity) since many hos-pitalized patients take "sink baths" instead of "basin baths" until permitted to bathe by tub or shower.

(d) The electrocardiogram should be computer analyzed in order to provide ST segment, peak heart rate, modal heart rate, and dysrhythmia information quickly and accurately.

(e) The cardiac monitoring system should have oscilloscopic and write-out capabilities so that heart rate and rhythm changes can be immediately recognized and recorded, and so that the changes can be related to the specific bathing activity, i.e., getting out of the tub, or toweling off.

(f) A systematic method of bath observation should be developed and implemented so that the physiological findings can be better explained by, and related to, specific bathing behaviors.

(g) The rating of perceived exertion scale should not be used since the RPE scale may not have been appropriate for this study, and since the RPE findings were very similar to the bath preference findings in terms of "ease of bathing."

2. Oxygen consumption, cardiovascular response, and preference should be studied in appropriate subjects for other common patient activities including:

(a) Staying in bed and using the bedpan for urination; getting out of bed and using the bedside commode for urination; and/or, getting out of bed, walking to the bathroom, and using the toilet for urination.

(b) Staying in bed and using the urinal for urination; getting out of bed and using the urinal while standing beside the bed; and/or, getting out of bed, walking to the bathroom, and using the toilet for urination.

(c) Staying in bed and rolling from one side to the other while the nurse makes the bed; and, getting out of bed, sitting at the bedside while the nurse makes the bed, and then getting back into bed.

(d) Using the Intermittent Positive Pressure Breathing (IPPB) machine for pulmonary care; and, using other similar pulmonary therapy techniques.

3. A Holter monitor should be used to determine the peak and modal heart rates of hospitalized AMI patients at various activity levels in order to provide descriptive information about the AMI patient's heart rate and also to determine whether lower peak and modal heart rates are actually associated with lower activity stages.

4. A study should be conducted in which AMI patients who are permitted to tub bathe or shower on day 4 of their hospitalization are compared to AMI patients who are not permitted to tub bathe or shower until day 9 of their hospitalization. The two groups of AMI patients would be compared in terms of: length of hospitalization; incidence of complications; personality and emotional variables, such as depression, anxiety, and self-confidence; and, length of time from hospital discharge until return to work.

APPENDIX A

Rating of Perceived Exertion Scale
(Borg, 1973)

6	
7	very, very light
8	
9	very light
10	
11	fairly light
12	
13	slightly hard
14	
15	hard
16	
17	very hard
18	
19	very, very hard
20	

Note. The above scale is presented to the subject who is asked to indicate the number which best represents how light or hard the exertion feels to him.

APPENDIX B

TEXAS WOMAN'S UNIVERSITY
Box 23717, TWU Station
Denton, Texas 76204

1810 Inwood Road
Dallas Inwood Campus

HUMAN SUBJECTS REVIEW COMMITTEE

Name of Investigator: Elizabeth H. Winslow Center: Dallas

Address: 4406 Gloster Road Date: 6/17/81

Dallas, Texas 75220

Dear Ms. Winslow:

Your study entitled Oxygen Consumption and Cardiovascular Response During Bathing

has been reviewed by a committee of the Human Subjects Review Committee and it appears to meet our requirements in regard to protection of the individual's rights.

Please be reminded that both the University and the Department of Health, Education, and Welfare regulations typically require that signatures indicating informed consent be obtained from all human subjects in your studies. These are to be filed with the Human Subjects Review Committee. Any exception to this requirement is noted below. Furthermore, according to DHEW regulations, another review by the Committee is required if your project changes.

Any special provisions pertaining to your study are noted below:

_____ Add to informed consent form: No medical service or compensation is provided to subjects by the University as a result of injury from participation in research.

_____ Add to informed consent form: I UNDERSTAND THAT THE RETURN OF MY QUESTIONNAIRE CONSTITUTES MY INFORMED CONSENT TO ACT AS A SUBJECT IN THIS RESEARCH.

_____The filing of signatures of subjects with the Human Subjects Review Committee is not required.

_____Other:

__X__No special provisions apply.

Sincerely,

Dissertation/Theses signature page is here.

To protect individuals we have covered their signatures.

APPENDIX C

THE UNIVERSITY OF TEXAS
HEALTH SCIENCE CENTER AT DALLAS

SOUTHWESTERN MEDICAL SCHOOL
GRADUATE SCHOOL OF BIOMEDICAL SCIENCES
SCHOOL OF ALLIED HEALTH SCIENCES

Basic Sciences Research Building
Department of Pharmacology

5323 Harry Hines Boulevard
Dallas, Texas 75235
214/688-3111

February 9, 1981

F. Andrew Gaffney, M.D.
Elizabeth Winslow, R.N., M.S.
Department of Nursing

Dear Dr. Gaffney and Ms. Winslow:

The Institutional Review Board, at the meeting of February 9, 1981, approved your request for a study entitled "Physiological Stress During Common Patient Care Activities".

The Board asked me to remind you that both the University and the Department of Health, Education and Welfare regulations require that written consents must be obtained from all human subjects in your studies. Informed consent can only be obtained by the principal investigator or co-investigators listed in your protocol. These consent forms must be kept on file for a period of three years past completion or discontinuation of the study and will no doubt be subject to inspection in the future.

HEW regulations require you to submit annual and terminal progress reports to our Institutional Review Board and to receive at least annual approval of your activity by this Board. You are also required to report to this Board any death or serious reactions resulting from your study. Failure to submit the above reports may result in severe sanctions being placed on the Health Science Center.

Furthermore, we have been directed to review any change in your research activity. In other words, should your project change, another review by the Board is required.

You are reminded that all grant applications and any solicitation of funds must be processed through the Office of Grants Management and Development. Funds received as a result of an application having been submitted directly to a granting agency by a faculty member will not be accepted by the institution.

Sincerely,

Andres Goth, M.D.
Chairman
Institutional Review Board

ko

APPENDIX D

AGENCY PERMISSION FOR CONDUCTING STUDY*

THE Parkland Memorial Hospital

GRANTS TO Elizabeth Hahn Winslow, R.N.

a student enrolled in a program of nursing leading to a Ph.D. Degree at Texas Woman's University, the privilege of its facilities in order to study the following problem:

Oxygen Consumption and Cardiovascular Response During Three Methods of Bathing

The conditions mutually agreed upon are as follows:

1. The agency (may) (~~may not~~) be identified in the final report.
2. The names of consultative or administrative personnel in the agency (may) (~~may not~~) be identified in the final report.
3. The agency (~~wants~~) (does not want) a conference with the student when the report is completed. [illegible]
4. The agency is (willing) (~~unwilling~~) to allow the completed report to be circulated through interlibrary loan.
5. Other: ______

Dissertation/Theses signature page is here.

To protect individuals we have covered their signatures.

APPENDIX E

TEXAS WOMAN'S UNIVERSITY

DENTON, TEXAS 76204

THE GRADUATE SCHOOL

October 6, 1981

Ms. Elizabeth Hahn Winslow
4406 Gloster Road
Dallas, Texas 75220

Dear Ms. Winslow:

I have received and approved the Prospectus for your research project. Best wishes to you in the research and writing of your project.

Sincerely yours,

RP:dl

cc Dr. Barbara Carper
Dr. Anne Gudmundsen
Graduate Office

APPENDIX F

Title of Study: Oxygen Consumption and Cardiovascular Response during Three Methods of Bathing

Investigator: Elizabeth H. Winslow, R.N.

Physician Consent for Patient to Act as Subject for Research

______________________________ has my permission to
(name of subject)

participate as a subject, if he/she wishes, in the study "Oxygen Consumption and Cardiovascular Response during Three Methods of Bathing" which is being carried out by Ms. Winslow.

____________________________________ __________________

Signature of Physician Date

APPENDIX G

Title of Study: Oxygen Consumption and Cardiovascular Response during Three Methods of Bathing

Investigator: Elizabeth H. Winslow, R.N.

Lay Summary and Consent to Act as Subject for Research

The purpose of this study is to measure the energy cost, heart rate, heart rhythm, blood pressure, and perceived exertion of subjects during rest and during the following three methods of bathing: basin bath, tub bath, and shower.

During the study you will have a mouthpiece in your mouth and a nose clip on your nose. We will collect the air you breathe out to determine the energy cost of rest and of bathing. You will have electrodes on your chest which connect to an electrocardiogram machine. You will also have a blood pressure cuff around your arm. Your electrocardiogram and blood pressure will be taken during rest and before, during, and after each bath. After each bath we will ask you to tell us how light or hard you felt the exertion was. After you have completed all three baths, we will ask you to fill out a questionnaire about which bath you preferred.

There are no significant risks associated with participating in this study. However, there are some possible discomforts: your mouth and nose could become slightly sore from the mouthpiece and nose clip, and you could become embarrassed if your modesty and confidentiality are not carefully protected.

Possible benefits from participating in this study include: (a) Your findings will help health personnel determine the most appropriate bathing method for the patient. We may find, for example, that patients can tub bathe or shower earlier than we had previously thought. (b) Since you will be closely supervised during the bathing, previously undetected potential problems such as extra heart beats or high blood pressure might be discovered.

No medical service or compensation is provided to subjects as a result of injury from participation in study.

You have the right not to participate in this study without penalty. You have the right to withdraw from this study at any time without penalty. Your health care will not be affected by your decision to participate in the study, or not to participate in the study, or to withdraw from the study.

You are encouraged to ask questions about this study at any time.

I have read and understand the above information and I have had the opportunity to ask questions. I willingly consent to participate in this study with the understanding that I may withdraw from the study at any time without penalty.

______________________________ ________________
Signature of Subject Date

______________________________ ________________
Signature of Witness Date

APPENDIX H

Title of Study: Oxygen Consumption and Cardiovascular Response during Three Methods of Bathing

<u>Information about the Normal Subject</u>

Date:______________

Initials:__________

Date of Birth:___________

Sex: M F

Occupation:______________

Age: ________ years

1. What type of bath do you usually take at home:
   tub bath shower Other______________

2. Do you now have, or have you ever had, any heart problem(s)? No Yes
   If yes, please give more information about the problem(s):

3. Do you now have, or have you ever had, any lung problem(s)? No Yes
   If yes, please give more information about the problem(s):

4. Do you take any medications regularly other than aspirin, vitamins, and birth control pills? It is especially important that you note medications which affect your heart, blood pressure, or metabolism.
   No Yes
   If yes, please list the medications and dosage:

5. Do you exercise regularly? No Yes
If yes, please give more information about the type of exercise, duration, frequency, etc.:

Thank you!

APPENDIX I

Title of Study: Oxygen Consumption and Cardiovascular Response during Three Methods of Bathing

Information about the Patient

Date:________________

Initials:_____________ Chart #____________________

Sex: M F Date of Birth:_____________

Age: ___________ years Occupation:________________

Type of bath usually taken at home:

tub bath shower Other___________

Date Admitted ___________ to___________ for______________

Date Transferred from_________ to_______ for______________

Current Primary Diagnosis:

Current Clinical Problems:

EKG Dates and Findings:

Current Medications:

Relevant Past History:

Activity Levels and Dates during this Hospitalization:

Exercise Habits before this Hospitalization:

APPENDIX J

Oxygen Consumption, Air/Water Temperature, and Rating of Perceived Exertion Data Collection Sheet

Date: ____________________ Study: ________________

Subject: ________________ Group: ________________

Weight: _____ lbs. _____ kg.

Height: _____ inches ____ cm

Age: ________ years

Occupation: ____________________________________

Activity	____	____	____	____	____	____
Air/H_2O Temp	__/__	__/__	__/__	__/__	__/__	__/__
F_1N_2	____	____	____	____	____	____
F_1O_2	____	____	____	____	____	____
F_1CO_2	____	____	____	____	____	____
F_EN_2	____	____	____	____	____	____
F_EO_2	____	____	____	____	____	____
F_ECO_2	____	____	____	____	____	____
$Tissot_F$	____	____	____	____	____	____
$Tissot_1$	____	____	____	____	____	____
Bar Press	____	____	____	____	____	____
Spir Temp	____	____	____	____	____	____
Bag Time (secs)	____	____	____	____	____	____
RPE	____	____	____	____	____	____
ml/min	____	____	____	____	____	____
ml/kg/min	____	____	____	____	____	____
mets	____	____	____	____	____	____
RQ	____	____	____	____	____	____

Comments:

APPENDIX K

Manual Cardiovascular Data Collection Sheet

Date: ____________________ Study: ____________

Subject: __________________ Group: ____________

	Activity	HR	BP	RPP	Comments:
( )	Rest	____	____	____	
( )	Basin Bath				
	before	____	____	____	
	during	____	____	____	
	after	____	____	____	
( )	Tub Bath				
	before	____	____	____	
	during	____	____	____	
	after	____	____	____	
( )	Shower				
	before	____	____	____	
	during	____	____	____	
	after	____	____	____	

( ) indicates order.

APPENDIX L

Holter Monitor Cardiovascular Data Collection Sheet

Date: ______________________________ Study: ________________

Subject: ____________________________ Group: ________________

Activity:	Before/After HR*	Peak HR**	Dysrhythmia	ST	Comments
( ) Rest	_____		_____	_____	
( ) Basin Bath					
before	_____		_____	_____	
during		_____	_____	_____	
after	_____	_____	_____	_____	
( ) Tub Bath					
before	_____		_____	_____	
during		_____	_____	_____	
after	_____	_____	_____	_____	
( ) Shower					
before	_____		_____	_____	
during		_____	_____	_____	
after	_____	_____	_____	_____	

( ) indicates order.

*HR during the 15-second period immediately after the before and after signals.

**Fastest HR observed during a 15-second period during or after the bath.

APPENDIX M

Subject: ______________

Date: ________________

Bath Method Preference Questionnaire

Instructions: Circle the method of bathing (basin bath, tub bath, or shower) which you think best answers each question.

1. a. Which method of bathing was the EASIEST for you?

   basin bath   tub bath   shower

   b. Which method of bathing was the HARDEST for you?

   basin bath   tub bath   shower

2. a. Which method of bathing was the MOST ENJOYABLE for you?

   basin bath   tub bath   shower

   b. Which method of bathing was the LEAST ENJOYABLE for you?

   basin bath   tub bath   shower

3. a. Which method of bathing made you feel the MOST CLEAN?

   basin bath   tub bath   shower

   b. Which method of bathing made you feel the LEAST CLEAN?

   basin bath   tub bath   shower

4. (For hospitalized subjects only)

   a. Which method of bathing do you think is MOST APPROPRIATE for you at this stage of your recovery?

   basin bath   tub bath   shower

   b. Which method of bathing do you think is LEAST APPROPRIATE for you at this stage of your recovery?

   basin bath   tub bath   shower

5. Comments:

thank you!

APPENDIX N

DALLAS COUNTY HOSPITAL DISTRICT

DALLAS, TEXAS

CARDIAC REHABILITATION ACTIVITY SCHEDULE

PHYSICIAN'S ORDER SHEET

Date		
________	Stage 1: (Admission)	Date of chest pain: Bedrest and Evaluation. ________________________ M.D. Signature
________	Stage 2: (Suggested) (Day 1 & 2)	Wash face and hands, feed self, brush teeth. Teach patient active plantar and dorsoflexion of ankles to do 5 x day, listen to radio. ________________________ M.D. Signature
________	Stage 3: (Day 3)	Dangle at bedside 5 min. BID. Bedside commode or stand to weigh with pivot technique. Read, write, or listen to radio. Active exercises all extremities (5 x each). ________________________ M.D. Signature
________	Stage 4: (Day 4)	Dangle at bedside 15 min. BID. Shave self. Active range of motion (5 x each). Diversional activities, watch TV, or listen to radio. Continue above activities. ________________________ M.D. Signature
________	Stage 5: (Day 5 & 6)	Chair with pivot technique 20-30 min. BID. Bathe self at bedside with assistance. Continue above activities. ________________________ M.D. Signature
________	Stage 6: (Day 7 & 8)	Up in chair 45 min. 3-4 x day. Bathe self at bedside. Walk back and forth in room. Active exercises all extremities (10 x each). May attend cardiac education classes in wheel chair. To bathroom for commode privileges. only. ________________________ M.D. Signature

003

Form No.

PHYSICIAN'S ORDER SHEET

Date

______ Stage 7: (Day 9) — Up in chair ad/lib. Walk to bathroom as needed. Stand at sink to brush teeth, shave, comb hair. Walk in hall 50 ft. (1/3 length of hall) BID. While standing: arm circling (5 x each), toe raising (5 x each), leg abduction (5 x each).

____
M.D. Signature

______ Stage 8: (Day 10) — Shower or tub bath. Walk 100 ft. (2/3 length of hall) BID. May walk to cardiac education classes. Add lateral trunk bending (5 x each), knee raises (5 x each).

____
M.D. Signature

______ Stage 9: (Day 11) — Walk 100 ft. (2/3 length of hall) TID. Add trunk twisting (5 x each), toe touching (5 x each).

____
M.D. Signature

______ Stage 10: (Day 12 & 13) — Continue warm up exercises Walk 150 ft. (length of hall) TID.

____
M.D. Signature

______ Stage 11: (Day 14) — Continue warm up exercises. Walk 150 ft. (length of hall) QID

____
M.D. Signature

______ Stage 12: (Until discharge) — Continue warm up exercises. Gradually increase walking distance.

____
M.D. Signature

Cardiac Rehabilitation Discharge Teaching (initiate on transfer to nursing unit).

1. Place patient on a (4 · 6 · 8 · 10 · 12) week schedule after discharge · circle
2. Teach patient and family about a low cholesterol, low saturated fat diet or ______________________
____
3. Discharge medications to be taught:
____
____
____

____
M. D. Signature

REFERENCE NOTES

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