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The Effects of a Twelve Week Exercise Program
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THE EFFECTS OF A TWELVE WEEK EXERCISE PROGRAM ON THE RANGE OF JOINT MOTION OF ELDERLY WOMEN SUBJECTS

By

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ABSTRACT

THE EFFECTS OF A TWELVE WEEK EXERCISE PROGRAM
ON THE RANGE OF JOINT MOTION
OF ELDERLY WOMEN SUBJECTS

BY

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The study purpose was to determine the effects of a twelve week exercise program on the joint range of motion of elderly women. Fifty-two subjects (mean age 80.7) were pre- and post-tested on fourteen joint actions: neck flexion, neck extension, neck rotation (right and left), shoulder flexion, shoulder extension, elbow flexion, wrist flexion, wrist extension, wrist pronation, wrist supination, knee flexion, ankle dorsi-flexion and ankle plantar flexion. One experimental group (n=18) exercised twice weekly, a second experimental group (n=18) exercised once a week. Control subjects (n=16) received no treatment. Mean, range and standard deviation were computed for all groups on the dependent variables. Change score means for each group were calculated and analyzed using a one-way analysis of variance technique. Significant differences were found between the three groups on five of the dependent measures at the $p<.01$ level. A Scheffé post-hoc test revealed significant differences between the control group and the experimental groups on the variables of neck rotation-left, wrist extension, wrist pronation and wrist supination. Although a significant F was found between groups in wrist extension, no significant differences were found between the three groups in the Scheffé post-hoc test.

DEDICATION

Dedicated to my mother and father,

with all my love and respect.

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CHAPTER I

Introduction

Aging is thought of as a process of physical and sometimes mental decline. It is seen as a process of deterioration and degeneration, a time when the whole tempo of life seems to slow down. The resulting effects of such thoughts and actions contradict the findings of the "activity theory of aging." This theory proposes that engagement within a society is more beneficial than disengagement from the society (DeCarlo, Castiglione, and Cavusglu, 1977). Activity for the elderly is more productive than inactivity. The fitness needs of the elderly population are beginning to be explored and studied. Increased interest in the link between physical activity and the health and well-being of the elderly individual has prompted new research in this area.

The urgent need for this type of research has also been spurred by recent population trends. Projection data from the United States Bureau of Census (1973) show that 20% of the American population is over the age of sixty. Annually, 325,000 adults will join this group over the next twenty-five years. At this rate nine million people will bring a 28% increase over the current total by the year 2000. Increased longevity and an increase in average age of the population is evident not only in this country but also in other countries (Letounov, 1969; Katsuki and Masuda, 1969). Letounov (1969) cites demographic shifts in population with respect to the elderly as cause to review the whole system of disease prevention for this age group. In a paper expressing Japanese concerns for the elderly population, Katsuki and Masuda (1969) report that improvement of the physical ability of the elderly is a point of interest for many scientists in that country. These population trends and associated concerns for the elderly are evident in a number of countries worldwide (Letounov, 1969).

Several American researchers have conducted studies of physical activity and its effects on the elderly. These studies have investigated the effects of exercise on cardiorespiratory measures, maximal oxygen uptake, body composition, muscle strength and stress adaptation (deVries, 1970; Adams and deVries, 1973; Barry, Daly, Pruett, Steinmetz, Page, Birkhead and Rodahl, 1966 a & b; Perkins and Kaiser, 1962; Wessel and Van Huss, 1969). Research has shown that exercise training is a feasible and physiologically desirable activity for the aging individual.

Most authorities agree that physical activity can increase functional efficiency and help postpone or delay some of the degenerate changes of the aging process (deVries, 1970; Frekany and Leslie, 1975; Munns, 1978; Barry et al, 1966). Nystrom (1974) points out that the concept of maintenance of activity is important and must be taken into account as a means to combat the aging process. The amount of activity that one participates in can directly affect the amount of breakdown or decay of the body. Kamenetz (1977) states that "the human organism, unlike the machine, improves its functions by working." According to Manney (1975) the rate of the individual aging process depends on several factors: genetic inheritance, nutrition and diet, physical activity and the psycho-social environment the individual lives in. It can be seen that some of these factors fall under human control, physical activity being one of them. Bortz (1982) concluded "there is no drug in current or prospective use that holds such a promise for sustained health as a lifetime program of physical exercise." Exercise and activity programs should be included in any planning for the older population.

The prevalence of inactivity among the aged is one of the most important geriatric problems (Ricatelli, 1963). Inactivity and disuse have a disintegrative effect on the body (Mack and LaChance, 1967). Changes in connective tissue due to the aging process may account for some of the loss of mobility of the older person (Wright and Johns, 1961). Inactivity in some may be caused by chronic long-term illness, in others it is self-imposed and unnecessary (Ricatelli, 1963). This resulting decrease in physical activity and loss of mobility becomes a serious problem for the older individual, particularly one who is institutionalized (Clark, Wade, Massey and Van Dyke, 1975).

Flexibility, or range of joint motion dictates the ease with which an individual can move body parts. According to Sigerseth (1970) impairment of movement is one of the most pronounced changes associated with the aging process. The complete loss of or limits in the range of motion of the various joints can seriously affect movement and mobility of the older person. The inability to move body parts can impair independence and limit even the simple activities of daily living. Among older persons such activity limitations are prevalent, occurring in one out of five of those sixty-five years of age or older (Loether, 1975). A person may become incapacitated without the use of body parts which depend on joint action and flexibility. Activities of daily living such as eating, dressing, and personal hygiene become virtually impossible for the individual. The person may become totally dependent on someone else to provide the basic needs for human survival.

Purpose of the Study

This study focused on determining the effects of a specific exercise program on the joint range of motion of elderly subjects. The fitness priorities for older adults determined by the President's Council on Physical Fitness and Sports, as cited in Frankel and Harris (1977) are: 1) flexibility 2) strength and 3) cardiovascular endurance. The assumption is made that fitness programs for the elderly should center on flexibility exercise as a major component of the program. A series of exercises were developed to meet the special needs of this population. Exercises are included to move each joint of the body through its total range of motion actively by the participant. Increases in flexibility can be determined by increased joint range of motion as measured in degrees. Limitations and improvements of joint range of motion can be measured with the use of a measuring device known as a flexometer. The use of two experimental groups with differing frequencies of exercise treatment was not a second dimension of the study but rather a practical problem of subject selection and participation. The primary purpose of the study was to determine the effects of this specific exercise program on joint range of motion of elderly subjects.

Research Hypothesis

This study will attempt to determine if participation in this exercise program will improve joint range of motion of the elderly. The specific research hypothesis that is being tested is:

H_1 The null hypothesis which proposes that there will be no significant differences between the three groups on the fourteen dependent measures after treatment.

Need for the Study

There is at present a minimal amount of research and literature available that deals specifically with flexibility and fitness of the aging population. Chapman, deVries and Swezey (1972) in a study dealing with flexibility state that improvements in range of movement through exercise have been extensively studied in the young, but not much work has been done in this area with the aging population. Many other researchers express the same concern, Bell and Hoshizaki (1981) state "one component of fitness which is not understood with regard to the elderly is flexibility." Data from two cross-sectional studies, Greey (1955) on men and Jervey (1961) on women, found that mean flexibility scores decreased with age for most movements. Jervey (1961) in two of several recommendations for further study suggests investigations to determine the effects of specific exercises on flexibility and studies to determine the effects of old age on flexibility. Frekany and Leslie (1975) reported improvements in two selected measurements of flexibility in elderly subjects after participation in an exercise program. Munns (1978) also observed increases in flexibility measurements of six selected joints after elderly subjects participated in a twelve week program of dance and exercise. These results are incongruent with those cited by Gutman, Herbert and Brown (1977). No significant increases were observed in joint range of motion of elderly subjects after exercise participation in the Gutman et al study.

Several researchers have cited the need for additional research pertaining to the effects of exercise activity on women (Drinkwater, 1973; Espenschade, 1969; Adams and deVries, 1973; Wessel, Small, Van Huss, Heusner and Cederquist, 1966). This study addressed this concern and dealt with a delimited population of elderly women subjects.

A study of this nature could add to the general body of knowledge concerned with exercise activity and the elderly. If a program of exercise does improve joint range of motion of the elderly, the improvements themselves are worth the effort. The secondary benefits of such improvements in joint range of motion are also of importance to the elderly. Reduction of joint stiffness and improved ease of movement could possibly mean greater independence for the older adult. The activities of daily living such as eating, dressing and personal hygiene could be performed independently and with greater ease. The ability to remain self-sufficient would add to and improve the quality of life for this segment of the population.

Definitions

Aged or elderly - refers to those people or persons sixty-five years of age or older

Activities of daily living - are movements made in the course of daily self-care.

Flexometer - a measuring instrument consisting of a circular 360 degree dial scale with a weighted inclination needle which is affected by gravity. This device measures joint range of motion by position of the inclination needle after execution of joint movement.

Range of joint motion - the degree to which articulating segments of the body move about a joint. Range of motion is specific to each joint.

Study Limitations

1. Sample size was limited to 52 subjects by practical considerations.
2. The sample population was non-randomized.
3. Random assignment of subjects to groups was not possible due to specific schedule requests of each individual resident facility.
4. The research was based on volunteer subjects.
5. The sample population was delimited to elderly women.
6. The researcher was responsible for measurement and collection of all data, as well as responsible for treatment (exercise program).
7. Selective sample losses may occur due to the nature of this sample population.

CHAPTER II

Review of Related Literature

A review of related literature and research studies will be presented in this chapter. These studies will be discussed under the following four sections: (1) a brief review of background information on the biological aging process, (2) a review of studies relevant to the effects of exercise activity on the aging individual, (3) a review of pertinent literature dealing specifically with flexibility and exercise effects on joint range of motion and (4) a review of the literature dealing with fundamental principles of exercise programs for the elderly.

Biological Aging

The aging process is inevitable for all living organisms, as most of the body systems and functions can be affected by the degenerative process of aging. Gradual decreases in metabolic processes are characteristic of aging. deVries (1978) described aging as losses in functional capacity at the cellular, tissue and organ levels, and at the level of organization. Pokrovsky (1978) listed these metabolic changes as accompanying the aging process: decreases in oxygen consumption and carbon dioxide expiration, increased lipid accumulation in the tissues, decreased rate of glucose utilization and reduced oxidative activity in the liver, kidneys, heart, brain and skeletal muscle.

There are many measurable biological changes that occur as the body ages. In a longitudinal study Shock (1962) reports that physical capacity at age seventy can decline by as much as 30%. He also indicates a 45% loss in hand strength from age thirty-five to age ninety. This corresponds to the findings of Shephard (1977), who reports an 18-20% loss of strength in adults between forty-five and sixty-five years of age. It is a well documented fact that there is a gradual decrease in speed and power of muscular contraction, as well as decreased capacity for sustained muscular contraction in the aged individual (Hebbelinck, 1978).

Physical changes can also occur in body composition as one ages. In 1963, Wessel, Ufer, Cederquist and Van Huss reported weight gain with a loss of lean body tissue and an increase in the amount of body fat in the older adult. deVries (1977) also found that there is a 3-5% loss of active body tissue per decade of life. Calcium and mineral losses, leading to conditions of osteoporosis and fracture, occur in the aging body (Mack and LaChance, 1967). Disuse and inactivity, including bedrest, contribute to mineral losses, bone fracture and loss of mobility (Saltin, Blomquist, Mitchell and others, 1968; Mack and LaChance, 1967). Several bedrest studies, as well as the studies of the Gemini IV, V and VII space flights show loss in bone mass and density as a result of disuse (Mack and LaChance, 1967). The older individual also experiences decreases in total body potassium, total body water and intracellular fluid (Novak, 1972).

Age-related declines in the efficiency of the cardiovascular system are well documented. Cardiac output and maximal heart rate decline with age, as a result of decreased stroke volume (Novak, 1972). Shock (1962) observed a 30% loss of cardiac function at age seventy-five. Systolic and diastolic blood pressure tend to increase with age (Shephard, 1978).

The declines in the respiratory system include a possible 60% loss in maximal oxygen uptake at age seventy-five (Shock, 1962). Shephard (1966) reports that maximal oxygen uptake declines at about 1% per year in adult men and women. Shock (1962) describes a loss of 44% in vital capacity, as well as a 57% loss in maximum breathing capacity at age seventy-five. In a 1969 study, Wessel and Van Huss observed that oxygen uptake, oxygen pulse and ventilation volume were significantly related to physical activity level and age.

Sensory losses also accompany the physical changes that can occur as the individual ages. According to the United States Public Health Service (1971), 52% of the men and 72% of the women in the age category of sixty-five to seventy-nine have moderate to severe visual defects. Auditory problems are experienced by 34% of the men and 30% of the women in this same age category. Another United States health publication (1970) states that four major chronic diseases cause activity limitations in one out of five of those over the age of sixty-five. These four chronic diseases occurring during the aging years are heart disease, hypertension, diabetes and arthritis (United States Public Health Service, 1970).

The joints and connective tissue experience changes with the aging process. Common features of the aging joint are instability and loss of mobility (Allman, 1974). Increased stiffness with age in the metacarpophlangeal joint was observed by Wright and Johns (1961). In a

1973 study, Wright reported an increased stiffness of 23% in the knee joint from the second to the sixth decade of life. In a study using Archilles tendons from cadavers, LaBella and Paul (1965) found age progressive changes in the collagen fibers of connective tissue. According to Johns and Wright (1962), 98% of the resistance to movement is caused by the connective tissues of muscle, ligament, joint capsule and tendon.

The gradual pattern of the aging process seems to be one of degeneration and decline. The rate of aging varies with the individual and depends on several factors (Manney, 1975). Manney (1975) further states that the process falls under some measure of human control, and that "physical activity and fitness perhaps are the best documented of all the factors that appear to produce long life." A review of studies dealing with physical activity and its effects on the aging individual are presented in the next section.

Exercise and Aging

Physical activity at all ages is an important factor in improving and maintaining functional efficiency of the various systems of the human body (Wessel and Van Huss, 1969). The capacity to improve functioning of the cardiovascular, muscular, respiratory and skeletal systems can be achieved through exercise training (Barry et al, 1966 a & b; deVries, 1970; Adams and deVries, 1973; Perkins and Kaiser, 1962; Frekany and Leslie, 1975; Mack and LaChance, 1967). The results of these studies are reviewed in this section.

Significant improvements in cardiovascular functions were found in elderly subjects after exercise training in two early studies. Barry et al (1966, a) reported decreases in work pulse and systolic blood pressure after exercise training. Benestad (1965) observed decreases in resting heart rate and exercise heart rate in thirteen elderly volunteer subjects after six weeks of exercise training.

The research work of deVries has greatly added to the knowledge of exercise effects on the aging individual. In a 1970 study on the trainability of older men, deVries observed improvements in aerobic capacity, body composition, arm strength and physical work capacity. A total of 112 volunteers were pre- and post-tested on the following measurements: blood pressure, percentage of body fat, resting neuromuscular activation, arm strength and girth, maximal oxygen consumption, oxygen pulse at heart rate = 145, pulmonary function and physical work capacity. The experimental subjects participated in a three phase program of exercise consisting of calesthenics, a jog-walk program, and static stretching or aquatic exercise. Subjects were retested at 6, 18 and 42 weeks. Results included a 8.9% increase in physical work capacity and decreases in both systolic and diastolic blood pressure. Aerobic improvements included a 19% increase in vital capacity, a 29.4% increase in oxygen pulse, and a 35.5% improvement in minute ventilation. Positive change occurred in body composition as percentage of body fat decreased. Arm strength improved by 6.4% at six weeks and 11.9% at forty-two weeks. deVries concluded that the trainability of older men is greater than had been expected, and does not depend upon vigorous training in youth.

A similar study was done by Adams and deVries (1973) using women as subjects. The women participated for three months in the same type of exercise program as the men in the deVries (1970) study. Pre- and post-test measurements included: physical work capacity, maximal oxygen consumption, oxygen pulse, blood pressure, resting heart rate, percentage of body fat and ventilatory mechanics. Improvements were seen in physical work capacity (37%), maximal oxygen consumption (20.8%) and oxygen pulse (19%). Adams and deVries concluded that significant training effects with respect to physical working capacity can be demonstrated in older women.

Female cardiac rehabilitation patients were subjects in a year long study conducted by Oldridge, LaSalle, and Jones (1980). The exercise rehabilitation program produced increases in maximum power output and maximum heart rate. Researchers concluded that physical conditioning plays an important role in the rehabilitation of female coronary heart disease patients.

Exercise activity has also been found to produce positive results in sedentary women. Hanson and Nedde (1974) utilized an eight month program of calesthenics, jog-walking and additional activities of paddleball, swimming and volleyball. Aerobic improvements included a 19% increase in physical work capacity, a 31% improvement in minute volume of ventilation, a 33% increase in maximal oxygen uptake and a 24% increase in carbon dioxide production. The researchers concluded that trainability of non-athletic females and their oxygen transport system does not differ from male counterparts, and women can gain in benefits from regular physical activity.

Two exercise studies of institutionalized geriatric mental patients proved to be beneficial to cardiovascular functioning. Clark, Wade, Massey and Van Dyke (1975) reported decreased heart rates at rest, exercise and recovery measurements. Their study also analyzed daily activity levels before and after exercise participation. Daily activity levels of the experimental subjects increased after exercise participation. Stamford, Hambacher and Fallica (1974) observed decreases in exercise heart rate and systolic blood pressure after exercise participation. The researchers concluded that the decreased exercise heart rate is indicative of the physiological training effect that can occur in elderly subjects.

An investigation by Sidney and Shephard (1977) utilized data from male and female subjects who volunteered for a pre-retirement exercise program. The subjects participated in a program of endurance type activities designed to elicit pulse rates of 120 beats per minute. Results after training produced increases in maximal oxygen uptake and grip strength. Improvements were also shown by decreases in resting heart rate, systolic and diastolic blood pressure. A decrease in total body weight, as well as a decrease in percentage of body fat, occurred after exercise participation.

Strength gains are also possible for the aging individual. Perkins and Kaiser (1962) conducted a study on the effects of isotonic and isometric weight training on older adults. In testing the effects of these two types of progressive resistance exercises, researchers found a 50% gain in leg extensor strength in both groups of subjects. Perkins and Kaiser reported that there is definite value in short-term exercise programs in the production and maintenance of strength in older persons.

A number of research studies have shown that definite improvements can be made in the functioning and efficiency of the various body systems after exercise training for the older adult. The next section will deal specifically with flexibility and exercise effects on joint range of motion of the older adult.

Exercise, Joint Range of Motion and the Elderly

Flexibility is an important factor in human performance and physical fitness (Holland, 1968). It has long been the focus of physical rehabilitation, and of interest and concern to the physical education profession (Cureton, 1941; Leighton, 1942, 1955). A number of studies dealing with flexibility and range of joint motion have been done on children, college students and athletes (Cureton, 1930, 1933; Leighton, 1955, 1956, 1957; McCue, 1953; Hupprich and Sigerseth, 1950). Several researchers have cited the need for studies to investigate flexibility and range of joint motion in older adults (Bell and Hoshizaki, 1981; Munns, 1978; Chapman, deVries and Swezey, 1972). Due to the nature of this study, the review of literature concerning flexibility and range of joint motion will be limited to those studies dealing with adult populations.

Flexibility has been described as the capacity to be flexed or extended without breaking, to be pliant, not stiff or brittle (Cureton, 1941). Cureton emphasized the fact that flexibility is an important component of physical fitness. An early system of lineal measurement of flexibility, as devised by Cureton, used four tests: trunk flexion, trunk extension, shoulder elevation and ankle flexion. Leighton (1942, 1955) defines flexibility as the potential for range of movement of any body segment with respect to another segment. Leighton developed an instrument to measure joint range of motion reliably and objectively (1942, 1955). A definition proposed by the occupational therapy profession defines range of joint motion as the extent of movement possible in body joints (Trombly and Scott, 1977). The terms flexibility and range of joint motion are often used interchangeably. The definition put forth in this study defines range of joint motion as the degree to which articulating segments of the body move about a joint (Munns, 1978).

The specific qualities that determine flexibility have been the focus of several investigators. Harris (1969) studied two types of flexibility measurements; single joint action and composite type measures. Single joint action consists of a direct measure of the movement of a limb where only one joint action is involved. Composite measures utilize the extent of movement of one or more than one type of motion at a single joint. Forty-two single joint action measurements were taken using the Leighton flexometer (Leighton, 1942, 1955). Thirteen composite type measures were taken from various test developers (Fleishman, 1962; Scott and French, 1959; McCloy and Young, 1954; Cureton, 1941). Subjects were not allowed warm-ups, and the room temperature was controlled. Zero or near-zero correlations were found among the variables. Harris stated "there is no evidence that flexibility exists as a single general characteristic of the human body." Results of this study determined that there is no one composite test or one single joint action measure that can give a satisfactory index of the flexibility characteristics of an individual. Composite tests are not satisfactory for assessments of flexibility. Dickinson (1968) in a study of specificity of flexibility found results similar to those in the Harris (1969) study. All intercorrelations failed to show any significant relationship between flexion and extension measurements taken at the wrist and ankle. Dickinson conlcuded that flexibility is not merely specific to joints, but specific to joint actions as well.

Research has been done in attempts to find relationships between flexibility and muscle strength, body composition and length of body segments. Laubach (1969) investigated somatotypes, body composition, anthropometric and physical performance measures. The analysis of these variables found that generally the lowest correlations were between the measurements of range of motion and the anthropometric and body composition items. None of the somatotype components correlated significantly with the range of joint motion measurements. Wear (1963) attempted to determine the relationship between hip and trunk flexibility to length of body segments. Wear reported that flexibility is not significantly related to leg and trunk length. Low correlations were observed between excess of trunk and arm length over leg length in a sit and reach test (Wells and Dillion, 1952) for flexibility.

Chapman, deVries and Swezey (1972) used two groups of males in studying joint stiffness and exercise training. Volunteers from a retirement community formed the older group, and the younger group was comprised of volunteers from a high school class. Right and left index fingers were used for the experimental procedure. The contralateral finger was used as a control measure. Stiffness was measured by a procedure from Wright and Johns (1961). Torque and energy requirements for moving the finger about its axis were recorded. Strength tests consisted of kilograms of tension (force) required to overcome the flexion contraction of the finger. Pre-test measurements indicated that there were no significant differences between the two groups with respect to strength. There was significantly greater stiffness found in the joints of the older men before exercise training. Weights attached to pulley systems were used in doing progressive resistance exercises (DeLorme and Watkins, 1951). After training, significant increases in strength were found in both groups. Significant decreases in torque (stiffness) were seen in both the old and young group. The researchers determined that both young and old subjects responded to strength training, and that joint stiffness may be a reversible phenomenon. The researchers also suggested the need to reexamine ideas concerning the trainability of older individuals.

A team of physical therapists studied exercise effects on subjects with osteoarthritis of the knee joint. Care, Harfield and Chamberlein (1981) observed two groups of subjects using progressive resistance exercises. Assessment after six weeks of training showed improvement in function for both groups. One group continued to exercise for a second six week period. Results of a second assessment indicated that those who continued to exercise maintained or continued to show improvement, while the non-exercise group showed a significant loss of muscle strength and range of movement.

Three cross-sectional studies investigated the trend of flexibility in adult subjects. Greey (1955) measured five selected joints of 510 males and found a general decline in flexibility with age at most joints. Male flexibility was greatest at age 23.5. Greey determined that flexibility is specific to each joint. The factors of participation and non-participation in sports were also analyzed. Greey observed that exercise tends to retard the downward trend of flexibility in the aging process especially in the trunk and upper extremities. A study by Jervey (1961) investigated the trend of flexibility in 407 women subjects. Sixteen measurements of joint range of motion reflected that flexibility declined with age for women. Flexibility is greatest in most joints between the ages of 25-29 in women. Jervey also looked at participation and non-participation in physical activities. Active women in the study had greater flexibility in some of the movements measured, but not at all the joints tested. Radioulnar pronation is one movement that increases in flexibility with age in both men and women. Bell and Hoshizaki (1981) studied the relationship between age, sex and range of motion in male and female subjects. Seventeen joint actions at eight selected joints were measured. Results were similar to those found by Greey (1955) and Jervey (1961). A general decline in flexibility was seen in both sexes as age increased. Females had greater flexibility than males throughout life. Five joints of the upper body showed less of a decline in range of motion than those of the lower body. The researchers suggested that continued use of the upper body during life may be a factor in retention of flexibility in these joints. The researchers concurred with Greey (1955) in that they proposed that activity could help deter the onset of physiological changes that may cause decreases in range of motion of less active joints.

Three studies examined the effects of specific exercise programs on joint range of motion of elderly subjects. The effects of a Feldenkrais exercise program were compared to conventional exercise programs. Gutman, Herbert and Brown (1977) failed to find any significant differences in flexibility measurements between treatment and control groups after exercise participation. Two evident weaknesses of the study included a high attrition rate (50%) and the use of a composite test for flexibility measurement. Improvements in ankle, hamstring and lower back flexibility were found by Frekany and Leslie (1975). Elderly subjects participated in an exercise program (Leslie and McLure, 1974), which utilized composite flexibility tests designed by Johnson and Nelson (1967). The investigators reported an 8.8 degree improvement in left ankle flexibility and a 14.4 degree improvement in right ankle flexibility. A 1 inch improvement in the sit and reach flexibility test was significant and this determined improvement in hamstring and lower back flexibility. The researchers summarized that an exercise program can improve the existing level of flexibility in the elderly. Weakness of the study existed in the use of composite type testing and the absence of a control group. Munns (1978) investigated the effects of a twelve week dance and exercise program on the joint range of motion of elderly subjects. Improvements were observed in all six joint actions that were measured before and after exercise participation. Control subjects decreased in range of joint motion measurements from pre-test to post-test scores. Munns stated that there can be a reversal of the deterioration trend in flexibility of the aging individual through exercise participation.

Improvements can be made in existing levels of flexibility of older adults. Specific exercise programs can be developed to meet the special needs of this population. The next section will review some fundamental principles necessary for exercise program planning for the elderly adult.

Exercise Planning for the Elderly Adult

This review is concerned with the principles that are fundamental in the planning of exercise programs for the elderly. The main focus of this section is on the basic concepts that pertain to flexibility type exercise programs as opposed to cardiovascular and strength training programs.

The basic objective of an exercise program for the elderly should be to improve or maintain those skills which assist the elderly in meeting the demands of the activities of daily living (Smith, 1982; Frekany and Leslie, 1974; President's Council on Physical Fitness and Sports, and the Administration on Aging, 1973). These are activities such as dressing, personal hygiene, eating, going up and down steps, and simple home maintenance. Well-developed exercise programs could contribute to improvements in the quality of life for the elderly by aiding them to keep mobile and independent (Hoffberger, 1980; Crase and Rosato, 1979).

The safety of the elderly individual in exercise participation is a concern of utmost importance. All authorities in the field agree that medical approval is necessary for those elderly considering exercise activity (Hoffberger, 1980; Crase and Rosato, 1979; Frekany and Leslie, 1974; Piscapo, 1979; deVries, 1978). A medical authority should assess the elderly individual for any conditions contraindicating exercise participation. Medical clearance of the elderly adult must precede involvement in any type of physical activity.

The types of exercise recommended most often for the elderly are those which emphasize isotonic and aerobic activities (Piscapo, 1979; Hattlestead, 1979; deVries, 1977). Exercise programs should maximize the rhythmic activity of large muscle masses (deVries, 1977). Isometric type exercises should be avoided as this type of exercise can occlude muscle blood flow and raise the systolic blood pressure (Hattlestead, 1979). The President's Council on Physical Fitness and Sports, in Frankel and Harris (1977), stresses flexibility as a priority for the older adult above strength and cardiorespiratory endurance exercises. deVries (1977) suggests that programs for the elderly should include exercises which focus on all major joints and large muscle groups of the body.

The intensity of exercise should raise the heart rate to between 100-120 beats per minute in the well-conditioned older adult (deVries, 1971). Exercise activity for average and sedentary older adults should raise the heart rate to the mid-90's to 100 beats per minute (Hattlestead, 1979; deVries, 1978; Clark, 1982). In the older adult physical capacity is at a lower level and less exercise stimulus is required to reach overload (Clark, 1982).

The research varies on the determination of frequency and duration of exercise activity for the older adult. Some authorities suggest that a minimum of three sessions per week, of 30-60 minutes, are necessary for improvement (Pollack, 1976; Hattlestead, 1979). The President's

Council on Physical Fitness and Sports and the Administration on Aging (1973), along with deVries (1977) suggest that 30 minutes of daily exercise are necessary for improvement. Frekany and Leslie (1974) and Clark (1982) suggest two sessions per week might produce significant improvement. Clark (1982) states that due to lower structural and functional capability older adults are unable to withstand the high stress levels of intense activity. Inactive older adults may require longer recovery periods, which is an argument for reducing exercise duration and frequency. There is room for additional and more definitive research in this area concerning frequency and duration of exercise for the older adult.

Specific indications and contraindications of exercise activity for older adults provides additional information for program planning. Central to exercise for the older adult is moving the body parts slowly through as much range of motion as possible (Hattlestead, 1979). deVries (1978) also suggests slow cadence in static stretching and calesthenics. This suggestion comes from data reported in an earlier study involving older men (deVries, 1971). Heart rates were monitored during static stretching and calesthenic exercise done to a slow cadence. From the study results, deVries concluded that this type of exercise was suitable for older unconditioned men. Breath-holding during exercise should be avoided (Piscapo, 1979; Hattlestead, 1979). Piscapo (1979) prescribes mild stretching, rhythmical activities and suggests avoidance of activities demanding great strength and rapidity of movement. Also avoided are those activities that demand static body balance movements.

Exercise programs and prescriptions for older adults should be carefully planned with the specific needs of this population in mind. Great care should be taken in insuring the health and safety of all participants. A thorough knowledge of exercise principles, as well as an awareness of the current research in the area of exercise planning for the older adult is a prerequisite in this type of program development.

Summary

Several researchers have shown that the process of aging has a disintegrative effect on the body as a whole and on the specific functioning efficiency of the body systems (deVries, 1978; Pokrovsky, 1978; Shock, 1962; Shephard, 1977; Mack and LaChance, 1967; Novak, 1972; Allman, 1974; Wright and Johns, 1961; LaBella and Paul, 1965; Greey, 1955; Jervey, 1961). Research has been done in the interest of investigating the effects that physical training and activity might have on reversing these degenerative processes associated with aging. Positive and encouraging results have shown that exercise training can improve functioning in the cardiovascular, respiratory, muscular and skeletal systems (Barry et al, 1966; deVries, 1970, 1972; Adams and deVries, 1973; Perkins and Kaiser, 1962; Benestad, 1965; Oldridge, LaSalle and Jones, 1980; Hanson and Nedde, 1974; Stamford, Hambacher and Fallica, 1972; Clark et al, 1975; Sidney and Shephard, 1977).

Flexibility, or joint range of motion in the elderly with respect to exercise training, is an area needful of additional study (Bell and Hoshizaki, 1981; Munns, 1978; Chapman, deVries and Swezey, 1972). The specificity of flexibility in individual joints and joint actions has been shown (Harris, 1969; Dickinson, 1968). Body composition (Laubach, 1969) and length of body segments (Wear, 1962) are not related to flexibility. Researchers have found a decline in flexibility with age (Bell and Hoshizaki, 1981; Greey, 1955; Jervey, 1961). One research study found that exercise training did not improve flexibility in the elderly (Gutman, Herbert and Brown, 1977). Others found that exercise training can significantly improve flexibility in the elderly (Frekany and Leslie, 1975; Munns, 1978; Chapman, deVries and Swezey, 1972).

The development and planning of exercise programs for the older adult demands careful attention be given to the health and safety of all participants. Medical approval is a necessary prerequisite for all older adults considering exercise participation (Hoffberger, 1980; Crase and Rosato, 1979; Frekany and Leslie, 1974; Piscapo, 1979; deVries, 1978). Isotonic and aerobic activities which promote joint flexibility and the use of large muscle groups are suggested (Piscapo, 1979; Hattlestead, 1979; deVries, 1977). Research varies on the frequency and duration of exercise activity for the older adult. Short daily periods of exercise, as well as longer periods of two to three times per week have been suggested (Pollack, 1979; Hattlestead, 1979; deVries, 1977; Frekany and Leslie, 1974; Clark, 1982).

CHAPTER III

Methods and Procedures

The purpose of the study was to determine the effects of an exercise program on the joint range of motion of elderly women. Fifty-two female subjects were pre- and post-test measured on joint range of motion at fourteen single joint actions. Eighteen of the experimental subjects exercised twice a week for twelve weeks, while a second experimental group of eighteen subjects exercised once a week for the twelve week period. Sixteen subjects served as controls and did not receive any type of treatment. The following null hypothesis was tested: in taking into account all fourteen dependent variables, the average performance (joint range of motion) in each of the three groups will be equal.

Study Design

Thirty-six experimental and sixteen control subjects participated in the study. All subjects were pre- and post-tested for joint range of motion at six selected joints encompassing fourteen single joint actions. The specific joints and joints actions were chosen based on their importance in the performance of the activities of daily living. The measurements included neck rotation (right and left), neck flexion, neck extension, shoulder flexion, shoulder extension, elbow flexion, wrist flexion, wrist extension, wrist pronation, wrist supination, ankle dorsi-flexion and ankle plantar flexion. The measurements of hip flexibility were deemed too complicated and involved for practical use in this study. The procedures for such measurements would have been very uncomfortable and adversive for the elderly subjects. Finger joint measurements were also judged to be extremely complicated and very difficult to measure accurately on the subjects. Therefore, due to practical considerations, time constraints, and consideration for the ease and comfort of the elderly subjects, these measurements were not included in the study.

All subjects were residents of the Grand Rapids area and lived in resident homes for the elderly. The five homes chosen for participation were those served by the investigator as part of the Grand Rapids Community Education program. The chosen homes were considered representative of the elderly population served by this city-wide educational program.

The subject population was an available sample of elderly women. The sample was delimited to women for several reasons. Females represented the greater number of those who resided in resident homes for the elderly and also represented the greater proportion of those elderly who participated in the Grand Rapids Community Education program. In a larger scope, on the average females outlive their male counterparts (Piscapo, 1979; Rockstein, 1974). Three facilities participated in the exercise program twice a week. The other two facilities allowed exercise to be scheduled only once a week due to conflicts with other scheduled activities within the home. The control subjects were residents from all five of the homes and were those who had chosen not to participate in the exercise sessions.

Medical approval was a prerequisite for study participation. A doctor's approval was necessary for all subjects, experimental and control, prior to participation and inclusion in the study. Those who were selected for the study were free from serious medical illness. Reasons for exclusion from the study included restrictive cardiovascular conditions and diseases, extreme hypertension, debilitating arthritis and any other condition contraindicating participation in an exercise program.

The methods and procedures used in this study were reviewed by the Michigan State University Committee on Research Involving Human Subjects. Approval to conduct the study was given by this committee. A copy of the approved individual consent form used in this study can be found in Appendix A.

Experimental Treatment

The experimental treatment consisted of a series of exercises developed by the investigator. These exercises were based on the current principles of exercise prescriptions for elderly adults as reported in research literature. The major component of the exercise program concentrated on joint flexibility. Active stretching exercises were performed by the subjects. The program included exercises for the joints of the neck, shoulders, elbows, wrists, hip, spine, knees and ankles. A detailed description of the exercises can be found in Appendix B. The actual narration used during the exercise class can be found in Appendix C. These exercises were specifically chosen because they involved large muscle groups and were rhythmical and progressive. Each specific series of exercises moved the individual joint through its entire range of motion. These joints were chosen in relation to their importance in carrying out the activities of daily living. The following is a list of the specific movements and actions performed at each joint to accomplish movement of that joint through its entire range of motion.

1. Neck exercises included the movements of neck flexion and extension, lateral flexion, rotation to the right and left, and circumduction.
2. Shoulder exercises included movements of shoulder flexion and extension, abduction and adduction, inward and outward rotation, and horizontal flexion and horizontal extension.
3. Elbow exercises included movements of elbow flexion and extension, and forearm pronation and supination.
4. Wrist exercises included movements of wrist flexion and extension, abduction and adduction, pronation and supination, and circumduction.
5. Hip and spine exercises included movements of trunk flexion and extension, lateral flexion, and rotation to the right and left.
6. Knee exercises included movements of knee flexion and extension, and inward and outward rotation.
7. Ankle exercises included movements of ankle plantar flexion and dorsi-flexion, eversion and inversion.

The sessions were 45 minutes in length for both treatment groups and consisted of the identical series of exercises for both groups. The instructions given were the same for all participants. All exercise sessions were conducted by the investigator. The exercises were all done sitting in straight-back chairs. Times and days for the exercise sessions remained constant at each center for the twelve week period. Two centers were given exercise on Monday and Friday, and a third center on Tuesday and Thursday. The subjects in these centers comprised experimental Group 1. Two other centers were given exercise once a week, on Tuesday and Thursday at each respective center. The subjects from these two centers made up experimental Group 2. The control group (Group 3) was comprised of subjects representative of all five centers.

Range of Joint Motion Measurement

Pre-test measurements were taken on all subjects, experimental and control, before exercise treatment began. The investigator measured each subject individually in her room for range of joint motion. The investigator was responsible for the collection and recording of all data. The investigator was familiar with all subjects prior to the pre-test measurement. The investigator's familiarity with the subjects was considered a prerequisite for the study to facilitate ease in the measurement procedure and to create a more comfortable situation for the elderly subjects. This was thought to be an important factor in gaining the confidence and cooperation of the elderly adult. The collection of data by an unknown observer might have created a hesitancy on the part of some of the subjects to participate in the measurement procedure. The physical process of the measurement procedure was done by the investigator to insure completion of the study. Data were recorded on forms adapted from Munns (1978). A copy of the pre-test and post-test form used in this study can be found in Appendix D. Post-test measurements were taken on all subjects after the twelve week period of exercise.

All measurements were taken with the Myrin flexometer. A photograph of the Myrin flexometer is found on the following page. This flexometer is similar in structure and operation to the Leighton flexometer (Leighton, 1942, 1955). The flexometer consists of a circular 360 degree dial scale with a weighted inclination needle which is affected by gravity. Gravity pulls the weighted needle downward in the execution of movement. A compass needle reads measurements in the horizontal plane of movement. The instrument is fastened to the body part being measured by a Velcro fastening strap. The movable dial is aligned with either the inclination needle or compass needle (depending on plane of movement) and set at 0 degrees at the beginning position of movement. At the end of the movement range of joint motion is read in degrees as indicated by position of the needle.

A flexometer was chosen as the method of measurement in this study for several reasons. Simplicity and ease of administration were two important factors. The flexometer takes measurements in units universal to all movements (degrees) and is applicable to measuring actions at all body joints. Gravity is used as the origin with the flexometer and specific positioning over the long bones of the joint is not necessary (as with the manual type goniometer). Several researchers have used the Leighton flexometer as the measuring tool of choice in studies involving elderly subjects and report high reliability in measurement data (Munns,

Figure 1

Myrin Flexometer

1978; Harris, 1969; Greey, 1955; Jervey, 1961). No data have been found on the Myrin flexometer with respect to reliability. The reliability of measurements taken by the investigator using the Myrin flexometer were analyzed by an intra-rater reliability test. Two sets of measurements on 10 subjects were taken on two successive days. The mean of three trials was recorded. The Pearson product-moment correlation was used to determine reliability of measurement scores. The investigator's between-day reliability was found to be $r = .99$. The unavailability and prohibitive cost of a Leighton flexometer were practical problems which led to the use of the Myrin flexometer. This flexometer was determined to be an acceptable and reliable measuring instrument for use in this study.

General Procedures for Measurement

The following general procedures for measurement were used with all subjects in the pre- and post-test measurement sessions.

1. All measurements were taken with the Myrin flexometer.
2. The investigator was familiar with all subjects prior to the pre-test measurements.
3. Each subject was measured individually in her respective room.
4. Subjects were individually notified and told of the pre-set time that measurements would be taken by the investigator.
5. An explanation was given to all subjects prior to the measurement session, describing the measuring instrument, the procedure, and what was expected of them during the session.
6. The investigator took all measurements and was responsible for all data recording and collection.

7. The sequence of measurements were the same for all subjects:
    a. neck rotation left
    b. neck rotation right
    c. neck flexion
    d. neck extension
    e. shoulder extension
    f. shoulder flexion
    g. elbow flexion
    h. wrist extension
    i. wrist flexion
    j. wrist pronation
    k. wrist supination
    l. knee flexion
    m. ankle plantar flexion
    n. ankle dorsi-flexion
8. Instructions given were the same for all subjects.
9. The subjects were asked to execute each movement to the fullest extent possible for all joint measurements.
10. Starting positions for all measurements were set at 0 degrees.
11. All subjects were placed in correct body alignment and specific position for each joint measurement. These are explained in detail in the following section.
12. Each of the subjects performed the joint movements three times in succession. The mean of the three trials was recorded.
13. No warm-ups or practice trials were allowed for any subject.
14. Only the dominant side of each subject was measured due to time

constraints and practical considerations. The dominant side was determined by the handedness of the subject.

15. All subjects were identified only by subject number on the data forms.

16. Room temperature was held constant between 76 and 80 degrees.

No warm-ups or practice trials were allowed because it has been found that exercise immediately preceding movement increases the range of movement possible (Lukes, 1954; Small, 1942). Room temperature was held constant at 76-80 degrees because warmer temperatures have been observed to cause an increase in range of movement and colder temperatures to cause a decrease (Campbell, 1944; Sapega, Quedenfeld, Moyer, and Butler, 1981).

Specific measuring procedures for each of the single joint actions measured in this study are reviewed individually. The procedures for measuring neck, wrist and knee joint actions were taken directly from the Myrin flexometer instruction booklet. The measuring procedures for shoulder, elbow and ankle joint actions were taken from the instructions for use with the Leighton flexometer (Leighton, 1942). The shoulder, elbow and ankle joint measuring procedures were changed to facilitate ease and comfort for the elderly subjects. The individual measuring procedures employed for each joint action measured in this study were as follows:

Neck rotation - the subject sat on a chair with head erect. Straps were fixed around the head and over the vertex. The compass needle was set at zero. The subject rotated the head to the right and left. Position of the needle at the end of each movement was read and recorded.

Neck flexion and extension - the subject sat on a chair with head erect. The strap was fixed around the head with the instrument attached at the side. The inclination needle was set at zero. The subject bent the head forward (flexion) and backward (extension). Position of the needle at the end of each movement was read and recorded.

Shoulder flexion and extension - the Leighton procedure (1942) for measuring shoulder flexion and extension was used in place of the Myrin flexometer procedure. The instrument was fixed to the back of the wrist and the subject stood erect with arms parallel to sides at the corner of a projecting wall so that the arm to be measured extended just beyond the corner. The subject moved the arm backwards and upwards (extension). In flexion, the arm was moved in an arc over the head as far as possible. The inclination needle was set at zero at the beginning of movement. The position of the needle at the end of each movement was read and recorded.

Elbow flexion - the Leighton procedure (1942) for measuring elbow flexion was used in place of the Myrin flexometer procedure. The instrument was strapped to the back of the wrist with the forearm fixed on a level surface. The inclination needle was set at zero. The subject then bends the hand toward the shoulder. Position of the needle was read and recorded at the end of the movement.

Wrist flexion and extension - the instrument was attached to the side of the hand with the strap distal to the thumb. The forearm was fixed on a level surface with the hand over the edge. The inclination needle was set at zero. The wrist was flexed, then extended. Position of the needle at the end of each movement was read and recorded.

Wrist pronation and supination - the instrument was fixed to a right-angled plate. The elbow was held at a right angle to the body and the hand was held forward. The right-angled plate was held between the middle and fore finger. The inclination needle was set at zero. The subject pronated and supinated the wrist. Position of the needle at the end of each movement was read and recorded.

Knee flexion - the instrument was fixed to the lateral side of the lower leg above the ankle. The subject lay prone with the foot extended beyond the edge of the bed. The inclination needle was set at zero. The subject flexed the knee joint. Position of the needle at the end of the movement was read and recorded.

Ankle dorsi-flexion and plantar flexion - the Leighton procedure (1942) for measuring ankle movement was used in place of the Myrin flexometer procedure. The instrument was placed on the instep of the foot. The subject sat on the edge of the bed and extended the foot off the edge. The subject dorsi-flexed and plantar flexed the ankle.

Position of the needle at the end of each movement was read and recorded.

Statistical Treatment of Data

1. Descriptive statistics of the mean, standard deviation and range were calculated for all variables by treatment group for pre- and post-test measurements.

2. A descriptive comparison was made between each treatment group's pre- and post-test range of joint motion measurements to normal range of joint motion standards. This was done to determine if limitations in joint range of motion do exist in elderly subjects.

3. A one-way analysis of variance was done on mean age by treatment group. The purpose was to determine if significant differences in age existed between the three groups.

4. The pre-test scores on the fourteen dependent variables for the three groups were tested statistically using a one-way analysis of variance. This was done to determine if there were any significant differences between the three groups at the beginning of the study.

5. Change scores were calculated for each of the fourteen dependent variables. Change score data were calculated by subtracting the subject's pre-test score from her post-test score on each measurement. The mean change scores of the groups on each of the dependent variables were analyzed by the one-way analysis of variance technique. As subject change score data were used as the dependent measure in the one-way analysis, each subject served as her own control.

6. The F-value was computed and the level of significance for difference between group means was set at the $p < .01$ level. This level

of significance was chosen as a stringent measure to control for the possibility of making a Type I error. The use of fourteen separate tests of analysis of variance increased the probability of this type error; therefore, the $p < .01$ level was set to control for this study limitation.

7. Where significant differences between group means were obtained, the Scheffé post-hoc method of multiple comparisons was employed to determine which group means contributed to the obtained differences.

CHAPTER IV

Analysis of Data

Thirty-six experimental and sixteen control subjects (mean age of 80.7 years) were pre- and post-tested on range of joint motion at fourteen single joint actions. Treatment for the two experimental groups consisted of a twelve week flexibility program of exercise. The control group received no treatment and participated in normal daily routines. The descriptive statistics of mean, standard deviation and range are presented for subject age, pre-test and post-test joint range of motion measurements. A comparison of pre- and post-test joint range of motion mean scores to normal range of joint motion standards is presented in this chapter. Group change score means were calculated for the fourteen dependent variables. The change score means were analyzed by a one-way analysis of variance, data and discussion are presented. The Scheffé post-hoc method of multiple comparisons was employed to determine which group means contributed to the obtained significant differences. These data are presented and reviewed.

Descriptive Statistics

A descriptive summary of the age of subjects by treatment groups is given in Table 1. The mean, standard deviation and range of age are presented by treatment group and for all subjects combined. The age range of subjects was from 65 to 90 years old and the mean age was 80.7

Table 1

Means, Standard Deviations, Ranges of Age By

Treatment Group and Combined

Group	N	Mean	S.O.	Range
1	18	82.0	4.498	71.0 - 89.0
2	18	78.8	5.618	65.0 - 87.0
3	16	81.3	5.335	71.0 - 90.0
All groups	52	80.7	5.250	65.0 - 90.0

years. A one-way analysis of variance was done on mean age by treatment group. There were no significant differences found in mean age between the three groups ($F=1.835$, $df=2,49$, critical value 5.08 needed at the $p<.01$ level).

The data on pre-test joint range of motion measurements are presented in Table 2. Means, standard deviation and ranges of pre-test measurements for each treatment group are reported. It can be observed from the range of scores for each separate measurement that great individual differences occur in joint range of motion among subjects. The control group (Group 3) was observed to have higher range of joint motion pre-test means in 10 of 14 measures. The exceptions were neck extension, shoulder extension, wrist extension and ankle plantar flexion. In a comparison between Group 1 and Group 2, the high mean scores were seen divided equally, seven high mean scores for each group. A one-way analysis of variance was done between the three groups on the 14 pre-test joint range of motion means. There were no significant differences found between the three groups in any of the pre-test means ($F = .038 - 4.698$, $df = 2,49$, critical value 5.08 needed at the $p<.01$ level). The results of the one-way analysis of variance on pre-test scores can be found in Appendix F (Table 11).

The post-test data of mean, standard deviation and range of scores are summarized in Table 3. Results by treatment group and combined results are presented. Group 1 ranked highest in 5 of 14 mean score measurements, while Group 2 ranked highest in 9 of 14 measures. The control group (Group 3) ranked lowest in all 14 post-test measurement mean scores. In the post-test results it was still apparent that great

Table 2
Means, Standard Deviations, Ranges of Pre-Test Flexibility Measurements by Treatment Group and Combined*

Measurements	Group 1 n=18			Group 2 n=18			Group 3 n=16			All Groups n=52		
	M	SD	R	M	SD	R	M	SD	R	M	SD	R
Neck Rot. Left	51.7	17.8	25.6-88.6	50.1	9.9	40.0-80.6	54.6	17.2	26.0-88.6	52.0	15.1	25.6-88.6
Neck Rot. Right	50.6	16.7	24.0-88.6	50.6	11.5	28.6-71.3	56.6	12.5	38.0-78.0	52.4	13.8	24.0-88.6
Neck Flexion	48.0	12.1	27.3-67.3	49.9	10.8	28.6-72.0	48.9	8.7	34.6-72.0	48.9	10.5	27.3-72.0
Neck Extension	53.6	13.2	30.6-71.3	45.1	10.9	21.3-62.6	52.1	11.0	36.6-74.6	50.2	12.2	21.3-74.6
Shoulder Ext.	62.8	12.1	40.8-88.0	65.6	10.6	49.3-86.6	61.8	11.8	48.6-92.0	63.4	11.4	40.0-92.0
Shoulder Flex.	157.0	9.5	140.0-178.0	152.6	11.0	129.3-172.0	160.8	10.3	141.3-180.6	156.6	10.6	129.3-180.6
Elbow Flexion	137.4	7.2	123.3-148.6	144.6	8.0	128.6-159.3	148.7	9.8	126.0-157.3	140.9	8.7	123.3-159.3
Wrist Extension	65.8	11.5	44.6-89.3	74.6	10.9	56.6-93.3	75.8	12.1	54.0-93.3	71.9	12.1	44.6-93.3
Wrist Flexion	58.6	17.1	28.6-91.3	63.5	8.9	41.3-75.3	62.4	11.5	38.6-85.3	61.5	13.0	28.6-91.3
Wrist Pronation	66.8	9.6	51.3-90.0	65.1	11.7	49.3-85.3	75.6	10.3	51.3-89.3	68.9	11.9	49.3-90.0
Wrist Supination	58.4	12.0	40.0-90.0	52.0	13.5	32.6-82.0	58.9	13.7	40.0-92.0	56.3	13.2	32.6-92.0
Knee Flexion	90.8	18.6	51.3-119.3	93.4	15.5	62.0-126.0	97.8	22.9	66.0-154.6	93.7	18.8	51.3-154.6
Ankle Plan. Flex	26.8	6.6	17.3-44.6	30.3	7.5	16.0-40.0	24.7	5.7	17.3-36.0	27.4	6.9	16.0-44.6
Ankle Dorsi-Flex	15.9	4.4	6.6-20.6	16.2	5.6	8.0-29.0	16.6	7.6	6.6-35.3	16.3	5.8	6.6-35.3

*Measured in degrees

Table 3

Post-Test Mean, Standard Deviation, Range of Flexibility Measurements by Treatment Group and Combined*

Measurements	Group 1 n=18			Group 2 n=18			Group 3 n=16			All Groups n=52		
	M	SD	R	M	SD	R	M	SD	R	M	SD	R
Neck Rot. Left	59.2	12.8	71.0-87.3	61.6	11.2	39.3-85.3	50.6	8.6	38.6-68.6	57.5	11.9	38.6-87.3
Neck Rot. Right	57.1	9.9	36.0-72.6	56.7	9.5	40.0-77.3	50.0	10.2	32.6-70.0	54.9	10.2	32.6-77.3
Neck Flexion	52.8	12.9	26.6-76.6	54.4	9.0	40.0-71.3	48.4	9.3	27.3-64.0	52.0	10.7	26.6-76.6
Neck Extension	55.3	11.7	37.3-78.6	53.3	8.2	39.3-68.0	48.7	13.1	30.0-79.3	52.6	11.2	30.0-79.3
Shoulder Ext.	78.5	6.4	62.0-88.3	76.8	5.7	61.3-84.0	71.6	10.2	50.0-88.0	63.4	8.0	50.0-88.3
Shoulder Flex.	157.2	11.2	136.0-158.5	158.5	9.4	139.3-170.6	155.9	9.8	141.3-175.3	157.2	10.0	136.0-175.3
Elbow Flexion	150.1	10.9	118.6-168.6	150.3	5.8	139.3-159.3	145.0	8.6	125.3-153.3	148.6	8.9	118.6-168.6
Wrist Extension	78.0	8.4	57.3-92.0	82.5	10.9	68.0-91.3	70.7	12.4	48.0-92.0	77.3	10.2	48.0-92.0
Wrist Flexion	65.9	10.2	48.6-88.6	73.5	10.8	60.0-94.0	64.6	7.6	50.0-77.3	68.1	10.3	48.6-94.0
Wrist Pronation	74.2	8.3	60.6-90.0	77.3	8.4	60.0-92.0	69.1	9.4	53.3-90.0	73.7	9.2	53.3-92.0
Wrist Supination	59.5	11.4	39.3-88.0	59.4	10.4	40.0-80.0	52.0	9.2	38.6-69.3	57.2	10.8	38.6-88.0
Knee Flexion	91.9	17.9	51.3-120.6	93.5	15.9	67.3-132.0	89.1	15.9	52.6-118.0	91.7	16.3	51.3-132.0
Ankle Plan. Flex	33.6	6.7	22.6-46.6	33.0	4.1	24.6-39.3	26.6	7.4	17.3-42.0	31.3	6.8	17.3-46.6
Ankle Dorsi-Flex	18.1	4.8	12.0-28.6	19.8	5.3	10.6-28.6	16.1	5.9	7.3-28.6	18.1	5.4	7.3-28.6

*Measured in degrees

individual differences occurred among subjects in each range of joint motion measurement. The experimental groups (1 and 2) increased in range of joint motion in all 14 single joint action measurements. Group 3 (control) experienced decreases in joint range of motion in 11 out of 14 measurements. The exceptions were shoulder extension, wrist flexion and ankle plantar flexion. It is noted that Group 3 subjects maintained range of joint motion in wrist flexion and ankle plantar flexion, and in shoulder extension which was within normal range of motion at the onset of the study.

Comparison of Scores to Normal Range of Motion Standards

A comparison of pre- and post-test range of joint motion scores to normal range of joint motion standards is found in Table 4. All pre-test range of joint motion scores for the elderly subjects fell below the norm with the exceptions of shoulder extension, neck flexion and neck extension. All three group mean scores were slightly above the norm in these measurements. The greatest limitation in range of joint motion was observed to be knee flexion which was an average of 41.0 degrees below the normal standard of 135 degrees for the three groups. Ankle plantar flexion followed with an average limitation between the three groups of 22.7 degrees below the norm of 50 degrees. A comparison of post-test mean score results to normal range of joint motion standards showed a trend of increases in joint range of motion toward the norm for Groups 1 and 2. It was observed that post-test mean score results in elbow flexion showed an increase in range of joint motion that achieved the normal standard for both experimental groups. Group 3

Table 4

Descriptive Comparison of Normal Range of Joint Motion to Treatment Group Range of Joint Motion*

Measurements	Normal Range of Motion **	Group 1 n=18		Group 2 n=18		Group 3 n=16		Combined n=52	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Neck Rot. Left	60	51.7	59.2	50.1	61.6	54.6	50.6	52.0	57.5
Neck Rot. Right	60	50.6	57.1	50.6	56.7	56.6	50.0	52.4	54.9
Neck Flexion	45	48.0	52.8	49.9	54.4	48.9	48.4	48.9	52.0
Neck Extension	45	53.6	55.3	45.1	53.3	52.1	48.7	50.2	52.6
Shoulder Ext.	60	62.8	78.5	65.6	76.8	61.8	71.6	63.4	63.4
Shoulder Flex.	180	157.0	157.2	152.6	158.5	160.8	155.9	156.6	157.2
Elbow Flexion	150	137.4	150.1	144.6	150.3	148.7	145.0	140.9	148.1
Wrist Extension	80	65.8	78.0	74.6	82.5	75.8	70.7	71.9	77.3
Wrist Flexion	80	58.6	65.9	63.5	73.5	62.4	64.6	61.5	68.1
Wrist Pronation	80	66.8	74.2	65.1	77.3	75.6	69.1	68.9	73.7
Wrist Supination	80	58.4	59.5	52.0	59.4	58.9	52.0	56.3	57.2
Knee Flexion	135	90.8	91.9	93.4	93.5	97.8	89.1	93.7	91.7
Ankle Plan. Flex	50	26.8	33.6	30.3	33.0	24.7	26.6	27.4	31.3
Ankle Dorsi-Flex	20	15.9	18.1	16.2	19.8	16.6	16.1	16.3	18.1

*Measured in degrees
**Taken from Trombly, C.A. & Scott A.D., 1977

post-test mean score results fell away from the norm in nine measurements, while decreases were shown in 11 of 14 joint measurements. The exceptions were shoulder extension, wrist flexion and ankle plantar flexion. It is noted that Group 3 subjects maintained range of joint motion in wrist flexion and ankle plantar flexion, and were above the normal standard in shoulder extension at the onset of the study.

Change Score Data

Change score data were calculated by subtracting subject pre-test scores from the post-test scores on each variable. Mean change score data are presented in Table 5. The greatest change score mean gain in joint range of motion was 15.7 degrees in shoulder extension experienced by subjects in Group 1. The greatest mean score loss was -8.7 degrees in knee flexion which occurred in subjects of the control group (Group 3). Across the 14 variables, Group 1 averaged an increase of +6.23 degrees per measurement. Group 2 experienced an average increase of +6.93 degrees across each of the 14 measurements. The control group (Group 3) experienced an average loss in range of joint motion of -2.6 degrees across the 14 single joint action measurements. The combined upper extremity joint motion for Groups 1 and 2 showed greater average improvement (+7.01, +8.24) than the combined lower extremity joint motions (+3.26, +2.13). The combined upper extremity joint motions for Group 3 experienced an average loss of -2.69 and a combined lower extremity joint motion average loss of -2.43.

Table 5

Pre-test, Post-test, Change Score Means of Flexibility Measures by Treatment Group*

Measurements	Group 1 n=18			Group 2 n=18			Group 3 n=16		
	Pre	Post	Chg	Pre	Post	Chg	Pre	Post	Chg
Neck Rot. Left	51.7	59.2	+ 7.5	50.1	61.6	+11.5	54.6	50.6	- 4.0
Neck Rot. Right	50.6	57.1	+ 6.5	50.6	56.7	+ 6.1	56.6	50.0	- 6.6
Neck Flexion	48.0	52.8	+ 4.8	49.9	54.4	+ 4.5	48.9	48.4	- 0.5
Neck Extension	53.6	55.3	+ 1.7	45.1	53.3	+ 8.2	52.1	48.7	- 3.4
Shoulder Ext.	62.8	78.5	+15.7	65.6	76.8	+11.2	61.8	71.6	+ 9.8
Shoulder Flex.	157.0	157.2	+ 0.2	152.6	158.5	+ 5.9	160.8	155.9	- 4.9
Elbow Flexion	137.4	150.1	+12.7	144.6	150.3	+ 5.7	148.7	145.0	- 3.7
Wrist Extension	65.8	78.0	+12.2	74.6	82.5	+ 7.9	75.8	70.7	- 5.1
Wrist Flexion	58.6	65.9	+ 7.3	63.5	73.5	+10.0	62.4	64.6	+ 2.2
Wrist Pronation	66.8	74.2	+ 7.4	65.1	77.3	+12.2	75.6	69.1	- 6.5
Wrist Supination	58.4	59.5	+ 1.1	52.0	59.4	+ 7.4	58.9	52.0	- 6.9
Knee Flexion	90.8	91.9	+ 1.1	93.4	93.5	+ 0.1	97.8	89.1	- 8.7
Ankle Plan-Flex	26.8	33.6	+ 6.8	30.3	33.0	+ 2.7	24.7	26.6	+ 1.9
Ankle Dorsi-Flex	15.9	18.1	+ 2.2	16.2	19.8	+ 3.6	16.6	16.1	- 0.5

*Measured in degrees

One-Way Analysis of Variance

A one-way analysis of variance across groups was performed on the 14 dependent variables change score data. These results are presented in Table 6. The $p < .01$ level was set as the level of significance for accepting or rejecting the null hypothesis. Significant differences at the $p < .01$ level were found between the group means on five of the dependent variables. These were neck rotation to the left, neck rotation to the right, wrist extension, wrist pronation and wrist supination. The null hypothesis that the means of the three groups on these five measurements were equal was rejected. The means of the three groups in the remaining nine variables were assumed to be equal and the null hypothesis was accepted for these variables.

Scheffé Post-hoc Test

The Scheffé method of multiple comparisons was employed as a post-hoc test on the five significant dependent variables. This was done to determine which group means contributed to the significant differences. The results of the Scheffé post-hoc test are presented in Table 7. The Scheffé procedure revealed significant differences between the control group (Group 3) and both experimental groups (1 and 2) in the variables of wrist extension and wrist pronation. The post-hoc test identified significant differences between Group 3 and Group 2 in the variables of wrist supination and neck rotation-left. Due to the stringent level set for the Scheffé procedure, even though a significant F was found in neck rotation to the right, no significant difference was found between the three groups in the Scheffé post-hoc procedure.

Table 6

One Way Analysis of Variance on Joint Range of Motion Change Scores

Measurements	df	MS	F-ratio	Probability
Neck Rot. Left	2,48	171.2218	6.063	.0045 *
Neck Rot. Right	2,48	171.0836	5.201	.0090 *
Neck Flexion	2,49	99.2590	1.495	.2343
Neck Extension	2,49	135.8707	4.184	.0218
Shoulder Ext.	2,49	136.6015	1.219	.3043
Shoulder Flex.	2,49	150.9885	3.260	.0468
Elbow Flexion	2,49	118.0259	2.940	.0623
Wrist Extension	2,49	127.6210	10.62	.0001 *
Wrist Flexion	2,49	99.6869	2.625	.0826
Wrist Pronation	2,49	122.7195	12.837	.0000 *
Wrist Supination	2,49	139.8088	6.146	.0042 *
Knee Flexion	2,45	235.4777	1.825	.1729
Ankle Plan. Flex	2,49	42.8857	2.849	.0676
Ankle Dorsi-Flex	2,49	43.7797	1.641	.2043

*Indicates significance at the $p < .01$ level

Table 7

Scheffé Post-hoc Test for Multiple Comparisons

Neck Rotation - Left

Means	Group 1 (7.4833)	Group 2 (11.4556)	Group 3 (-4.0467)
Group 1 (7.4833)		3.9723	-11.53
Group 2 (11.4556)			-15.5023 *
Group 3 (-4.0467)			

* indicates Scheffé critical difference at .01 level = 14.50

Neck Rotation - Right

Means	Group 1 (6.5389)	Group 2 (6.1111)	Group 3 (-6.6333)
Group 1 (6.5389)		.4278	13.1722
Group 2 (6.1111)			12.7444
Group 3 (-6.6333)			

* indicates Scheffé critical difference at .01 level = 14.49

Wrist Extension

Means	Group 1 (12.1889)	Group 2 (7.9389)	Group 3 (-5.1063)
Group 1 (12.1889)		4.25	17.1889 *
Group 2 (7.9389)			13.0452 *
Group 3 (-5.1063)			

* indicates Scheffé critical difference at .01 level = 12.36

Table 7 (continued)

Wrist Pronation

Means	Group 1 (7.37)	Group 2 (12.15)	Group 3 (-6.54)
Group 1 (7.37)		4.78	13.91 *
Group 2 (12.15)			18.69 *
Group 3 (-6.54)			

* indicates Scheffé critical difference at .01 level = 12.13

Wrist Supination

Means	Group 1 (1.1111)	Group 2 (7.3722)	Group 3 (-6.8625)
Group 1 (1.1111)		6.2611	7.9736
Group 2 (7.3722)			14.2347 *
Group 3 (-6.8625)			

* indicates Scheffé critical difference at .01 level = 12.94

Non-statistical Observations

Non-statistical observations revealed that although the means were not statistically different, higher post-test mean values were observed in the exercise groups (Group 1 and 2) in all 14 joint measurements. Positive change score mean values were also observed in all 14 joint measurements for both Groups 1 and 2. Group 3 exhibited lower post-test mean values and negative change score means in 11 out of 14 joint measurements.

CHAPTER V

SUMMARY, DISCUSSION, RECOMMENDATIONS

Summary

It was the purpose of this study to investigate the effects of a twelve week flexibility program of exercise on the joint range of motion of elderly subjects. Fifty-two subjects ranging in age from 65 to 90 years old (mean age of 80.7) participated in the study. Fourteen single joint actions were pre- and post-tested. Three treatment groups were formed. One experimental group (n=18) exercised twice a week, while a second experimental group (n=18) exercised once a week. A control group (n=16) received no treatment and participated in normal daily routines. Comparison of pre-test joint range of motion scores to normal range of joint motion standards found that the elderly subjects fell below the norm in 11 of 14 measurements. A separate one-way analysis of variance was done on the change score means for each of the fourteen dependent variables. Significant differences between change score means were identified and further analyzed by a Scheffé post-hoc test. Statistically significant differences were obtained on five joint actions at the $p < .01$ level. The Scheffé post-hoc test for multiple comparisons was employed to determine the group means responsible for the obtained differences.

Discussion

The use of exercise treatment in this study was an attempt to determine if the deterioration process could be reversed and to see if joint range of motion could be maintained or improved through exercise activity. The comparison of pre-test joint range of motion data to normal joint range of motion standards indicated that the elderly subjects in this study fell below the norm in 11 of 14 measurements. The exceptions were the upper extremity joint actions of neck flexion, neck extension and shoulder extension. These joint motions were slightly above average in pre-test scores compared to the normal joint range of motion standards. The pre-test data in this study support the findings of Greey (1955), Jervey (1961), Bell and Hoshizaki (1981) and Munns (1978). These researchers, in attempting to establish base-line data for flexibility of older adults, found a general decline in joint range of motion with age.

The findings of the present study and this past research indicate a greater loss of motion in the lower extremities when compared to the declines in the upper extremity motions. These lower extremity joint range of motion losses could be due to several factors. Balance problems, arthritis, obesity and a sedentary lifestyle could contribute to a decrease in lower extremity joint use. The greatest loss of joint range of motion was seen in knee flexion in subjects of Group 3. This -8.7 degree loss in knee flexion could lead to less ambulation and movement for the older adult. The resulting inactivity of lower extremity joint motions might possibly cause further loss of joint range of motion in the hip and ankle joints.

Continued use of the upper extremity joint actions throughout life could possibly maintain these joint ranges of motion for a longer period of time. Many of the activities of daily living and leisure time pursuits utilize upper body extremities and joints. The general declines in joint range of motion throughout the body could be due to several factors such as the lack of activity, the biological aging process or degenerative disease.

Exercise participation over the twelve week period produced positive change score means for subjects in Groups 1 and 2 and increases in joint range of motion on all 14 joint actions measured in this study. Statistical treatment using a one-way analysis of variance technique yielded significant differences on five of the dependent variables at the $p < .01$ level. These were the upper extremity joint actions of neck rotation (right and left), wrist extension, wrist pronation, and wrist supination. Each of these five joint actions fell below the norm in pre-test scores compared to normal joint range of motion standards. The increases in range of motion in these joints may be due to the effects of the exercise activity and the continued use of these joints throughout life. The exercises for upper extremity joint actions appear to have been successful in improving range of motion. Positive directional changes toward normal range of joint motion standards were also observed for other upper extremity joint actions measured.

The Scheffé post-hoc test for multiple comparisons was used to determine which group change score means were responsible for the significant differences. In Group 3 the change score mean losses in wrist extension (-5.1) and wrist pronation (-6.5) were significantly different from the change score means gains of both Group 1 (+12.2, +7.4) and Group 2 (+7.9, +12.2). Decreases in neck rotation to the left (-4.0) and wrist supination (-6.9) change score means of Group 3 yielded significant differences between Group 2 change score means (+11.5,+7.4).

In neck rotation to the right change score mean data, no significant differences were found among the three groups. It appears that the negative change score means experienced by Group 3 contributed to the significant differences when compared to the positive change score means experienced by both Groups 1 and 2 after exercise treatment.

The limitations of this study dictated the use of the stringent $p < .01$ level of significance. In the more practical aspect of program application in the field, such strict research standards are not warranted. Acceptable levels of program success would not necessitate the use of such rigid criteria. Non-statistical observations that can be made are that although the means were not statistically different, higher post-test means and positive change score means were shown for all 14 joint measurements in both exercise groups (Groups 1 and 2). In contrast, lower post-test means and negative change score means were found in 11 of 14 joint measurements for the control group (Group 3). The data observations from this study indicate that success can be seen in the general trend of improvement in joint range of motion toward the norm after exercise participation in a short twelve week program. It is also observed that those not participating in exercise activity experienced losses and declines in joint range of motion.

It was found that the control group (Group 3) had the highest group means on 10 of 14 measurements at the onset of the study. In contrast, at the conclusion of the study this group had the lowest group means on all 14 measurements. The effect of exercise upon the joint range of motion of the experimental groups increased flexibility, while the effect of no additional exercise activity resulted in declines in joint range of motion of the control subjects.

The results of this study are in agreement with Frekany and Leslie (1975) and Munns (1978) which support that age-related declines in joint range of motion can be reversed and improvements can be made. The findings of these researchers and the present study indicate that improvement in joint range of motion for the elderly is possible through exercise activity. These results contradict the findings of Gutman (et al, 1977), who found no significant changes in joint range of motion afer exercise participation.

Recommendations

This section includes recommendations for future research in the area of joint range of motion and exercise effects on the older adult. Future studies should address the limitations encountered in this study. Particular study limitations include the small sample size and lack of randomization in subject selection and treatment assignment. This was and will be a difficult task to accomplish due to the nature of the older adult population, living arrangements, attrition and resident home policies. Similar studies, however, should be attempted on larger, randomly selected groups of both male and female population.

A second limitation of this study which could be addressed was the natural bias of the investigator. It was thought necessary in this study that the investigator be responsible for all measuring and data collection to insure project completion. This could be eliminated in a future study by the use of a trained, unbiased observer to measure and collect all study data.

A third recommendation would be the utilization of this exercise program in studying other variables. Separate studies could be done on the effects of longer program duration, increased frequency and repetitions of exercise, and extended program length. This short twelve week program yielded significant results on five of fourteen joint measurements. More conclusive results are needed on programs of longer duration. Frequency of exercise, which was not addressed in this present study, is another area in need of more research. It would be of value to study the effect of these variables on joint range of motion after exercise participation.

It was observed that upper extremity joint actions experienced greater increases in range of motion than did lower extremities. Greatest losses in joint range of motion were seen in the lower extremity joint measurements. With these observations in mind, a recommendation for a future exercise program might be to place a stronger emphasis on exercise activities for the lower extremity joint actions of hip, knee and ankle. Increased frequency of exercise, or increased repetitions of specific exercises for these joints, could be attempted. The introduction of graded walking programs might also be valuable for the older adult.

Based on the present findings of this twelve week program, in which significant improvements were made in five joint actions of elderly subjects, joint range of motion improvement through exercise participation is supported. The observations of trends in range of joint motion toward the norm for the experimental subjects suggest that participation in tested exercise programs does improve flexibility. It is highly recommended that any type of program planning for the older adult should include a program of range of motion exercises.

APPENDICES

APPENDIX A

CONSENT FORM

APPENDIX A

CONSENT FORM

I have been informed as to the nature and extent of this study. The purpose of the project has been explained to me, and I understand my role as a subject. I understand that the treatment consists of a series of flexibility exercises designed to put all the body joints through their entire range of motion. I have been informed that the individual sessions will be 45 minutes in length and that the exercise program will continue for a period of 12 weeks. I am participating freely and voluntarily, and understand that I am able to discontinue my participation at any time without penalty or loss of benefit to which I am otherwise entitled.

I understand that in the unlikely event of physical injury resulting from research procedures, Michigan State University, its agents, and employees will assume that responsibility as required by law. Emergency medical treatment for injuries or illness is available where the injury is incurred in the course of an experiment. I have been advised that I should look toward my own health insurance program for payment of said medical expenses.

I understand that all study results will be held in confidence.

______________________ Signature	______________________ Date
______________________ Patient Advocate	______________________ Date

APPENDIX B

LIST OF EXERCISES

APPENDIX B

LIST OF EXERCISES

Repetitions	Range of motion exercises for the neck
	a. turn head and neck in full circles,
5	to the right,
5	to the left.
5	b. neck extension - stretch head and neck up, chin to the ceiling.
5	c. neck flexion - bend neck down, chin to chest.
	d. shake head loosely,
5	"yes" motions,
5	"no" motions.
	e. stretch neck sideways, trying to touch ear to shoulder,
5	to the right,
5	to the left.
	f. turn head and neck in full circles,
5	to the right,
5	to the left.

Repetitions	Range of motion exercises for the shoulders
10	a. shoulder shrugging, shoulders up to ears.
	b. shrug alternate shoulders up and down,
5	right shoulder,
5	left shoulder.
	c. move shoulders in a circular motion,
5	forward,
5	backward.

Repetitions	
	d. arm swinging, forward and back,
5	with right arm,
5	with left arm.
	e. arm circles,
10	forward circles,
10	backward circles.
5	f. stretch right arm up behind head and touch left shoulder.
5	g. stretch left arm up behind head and touch right shoulder.

Repetitions	Range of motion exercise for the elbows
	a. flex and extend arms, touching shoulders with each movement,
5	with right arm,
5	with left arm,
5	with both arms together.
	b. extend arms in and out, as in "sawing" motion,
5	with right arm,
5	with left arm,
5	with both arms together.
	c. roll hands around one another,
10	forward,
10	backward,
10	forward,
10	backward.
10	d. with both hands, punch a pretend punching bag.

Repetitions	Range of motion exercises for the wrists
	a. wrist circles,
5	right wrist, clockwise,
5	right wrist, counterclockwise,
5	left wrist, clockwise,
5	left wrist, counterclockwise.
	b. wrist extension and flexion, as far as possible,
5	right wrist extension,
5	right wrist flexion,
5	left wrist extension,
5	left wrist flexion.
	c. turn wrist side to side as far as possible,
10	right wrist,
10	left wrist.
	d. pronate and supinate wrist with a closed fist,
5	right wrist supination,
5	right wrist pronation,
5	left wrist supination,
5	left wrist pronation.

Repetitions	Range of motion exercises for the fingers
10 secs.	a. wiggle fingers of both hands loosely.
	b. snap fingers,
5	right hand,
5	left hand.
	c. touch each finger to the thumb, one at a time,
3	with right hand fingers,
3	with left hand fingers.

Repetitions	
	d. touch each finger to center of the palm, one at a time,
3	with right hand fingers,
3	with left hand fingers.
Repetitions	**Range of motion exercises for the hip and spine**
	a. twist sideways to the left and right from the waist,
5	to the right,
5	to the left.
	b. arms at sides, bend sideways to the left and right, trying to touch the floor,
5	to the right,
5	to the left.
	c. alternate arms, bend forward to touch opposite toe,
5	with right arm to left toe,
5	with left arm to right toe.
	d. waist circles,
5	to the right,
5	to the left.
6	e. bend forward touching the nose to each knee.
Repetitions	**Range of motion exercises for knees, hips and legs**
	a. leg circles, action from the hip,
5	with the right leg,
5	with the left leg.
25	b. marching steps to a progressive count.
30 secs.	c. jogging steps to a progressive time limit.

Repetitions	
25	d. bicycling motion with the legs to a progressive count.
100	e. flutter kick with the legs to a progressive count.
50	f. keep legs together, raise and lower without touching the floor, to a progressive count.
Repetitions	Range of motion exercises for the ankle
	a. ankle circles,
5	right ankle clockwise,
5	right ankle counterclockwise,
5	left ankle clockwise,
5	left ankle counterclockwise.
	b. extend and stretch ankles, pointing toes away from the body,
5	with the right ankle,
5	with the left ankle.
	c. flex ankles, bringing toe back towards the body,
5	with the right ankle,
5	with the left ankle.
10	d. both feet on floor, rock back and forth, heel and toe movement.

APPENDIX C

DETAILED EXERCISE INSTRUCTIONS

APPENDIX C

DETAILED EXERCISE INSTRUCTIONS

The first 5-10 minutes before class is a good time for socializing. It is also an excellent opportunity for the instructor to become more familiar with the elderly participants and to gain their confidence. Straight-back chairs should be arranged in a circle or semi-circle so that all participants have an unobstructed view of the exercise instructor. Those with vision or hearing problems should be seated closer to the instructor. Medical approval is a prerequisite for all subjects before exercise participation. Any participants experiencing difficulty with the sessions should be advised to discontinue with the program. Specific instructions for each exercise will be listed in detail. Rest breaks are indicated, but can be taken at any time at the instructor's and/or participant's discretion.

1. Neck circles

   -"Let's start out with some full, relaxed neck circles, first to the right, nice and easy (5 times), and now to the left, all the way around," (5 times).

2. Neck flexion and extension

   -"Now stretch your neck up, so your chin points to the ceiling, high as you can stretch, and now touch your chin down to your chest," (repeat 5 times).

3. Shake head

   -"Now shake your heads, nice and loose, in 'yes' motions (5 times) and then shake in 'no' motions," (5 times).

4. Stretch neck sideways

-"Now bend your neck sideways, nice and slow, trying to touch your ear to your shoulder. First to the right shoulder and then to the left shoulder," (repeat 5 times).

5. Neck circles

-"Let's end up with the neck circles again. First to the right, nice and slow, and then to the left," (repeat each 5 times).

6. Shoulder shrugging

-"Now let's go down to the shoulders. We'll begin by loosening them up. Shrug them up and down, nice and peppy," (repeat 5 times).

7. Alternate shoulder shrugging

-"Now shrug up your right shoulder, then your left," (repeat alternately, 5 times each).

8. Shoulder circles

-"Now let's get your shoulder blades going in a circle, first forwards (5 times) and then backwards," (5 times).

9. Arm swinging

-"Get your arms swinging forward and back, as far as you can. First your right, and then your left," (repeat with alternate arms, each 5 times).

10. Arm circles

-"Arms out, shoulder high. Do arm circles forward (10 times) and now backwards," (10 times).

**** "Now let's take a breather, and rest a minute before we go on."

11. Arm stretch

-"Let's give those shoulder muscles a stretch. Put your right arm up, now go behind your head and try to touch your left shoulder. Now switch, and put your left arm up, go behind your head and try and touch your right shoulder," (alternate arms, and repeat each 5 times).

12. Elbow flexion

-"Let's do a 'pounding' motion with your right arm (5 times), then your left arm (5 times), and now both arms together," (5 times).

13. Elbow extension

-"Now a 'sawing' motion, make your right arm go in and out (5 times), now your left arm (5 times), and now both arms together," (5 times).

14. Arm rolling

-"Roll your arms and hands around each other forwards (10 times), backwards (10 times) as fast as you can," (repeat twice).

15. Punching bag

-"Punch a pretend punching bag, both hands in and out, nice and peppy," (10 times).

**** "Let's stop a minute before we go on."

16. Wrist circles

-"Just at the right wrist, full clockwise circles (5 times), now counterclockwise," (5 times). Repeat with the left wrist.

17. Wrist extension and flexion

-"Just at the right wrist, bend your hand up as far as you can, now bend your hand down as far as you can," (alternate motions, each 5 times). Repeat with the left wrist.

18. Wrist side-to-side

-"Now just at the right wrist, turn your hand as far as it will go to the right and then to the left sideways," (alternate motions, each 5 times). Repeat with the left wrist.

19. Wrist pronation and supination

-"Make a fist with your right hand, now turn your wrist to the left and right as far as possible," (alternate motions, each 5 times). Repeat with the left wrist.

20. Finger wiggles

-"Wiggle fingers of both hands to loosen them up," (approximately for 10 seconds).

21. Finger snaps

-"Snap finger, right hand (5 times), then left hand," (5 times).

22. Fingers to thumb

-"Now let's touch each finger one at a time to your thumb, right hand (repeat 3 times), then left hand," (repeat 3 times).

23. Fingers to palm

-"Now a little bit harder, touch each finger one at a time to the center of your palm, right hand (repeat 3 times), then left hand," (repeat 3 times).

**** "We'll stop here and rest for a moment."

24. Waist twists

-"We want the whole top part of you to turn side to side, first to the right and then to the left," (alternate, repeat to each side 5 times).

25. Waist sideways

-"Now bend at the waist, nice and easy, go to the right and try to touch the floor, and then to the left and try to touch the floor," (alternate sides, repeat to each side 5 times).

26. Sit-down toe touches

-"Bend forward, try to touch your right hand to your left toe, come back up. Now try to touch your left arm to the right toe," (alternate arms, repeat each 5 times).

27. Waist circles

-"Again, let's get the whole top part of you going around in a circle, from the waist. First to the right (5 times) and then to the left," (5 times).

28. Nose to knee

-"Nice and slow, let's bend forward and try to get our nose close to our knee," (repeat 4 times).

**** "Let's take a quick breather before we start the leg exercises."

29. Leg circles

-"From the hip, let's do some leg circles with the right leg (repeat 5 times), then with the left leg," (repeat 5 times).

30. Marching steps

-"Raise up those knees, and do marching steps," (start with a 25 count and progressively raise by 5 when participants are able).

31. Jogging steps

-"Here we go, quick, little steps, jogging as fast as you can," (start with 30 seconds and progressively raise by 5 when participants are able).

**** "Let's catch our breath before we go on."

32. Leg raisers

-"Both legs together, raise them up and down together, without touching the floor," (start with 25 count, progressively raise by 5 when participants are able).

33. Ankle circles

-"Just at the ankle turn your right foot in a circle to the right, and then to the left," (alternate motions, 5 to each side). Then repeat with the left ankle.

34. Ankle flexion and extension

-"Just at the ankle point your right foot out as far as you can (5 times), now bring it back toward you as far as you can," (5 times). Repeat with the left ankle.

35. Ankle, heel and toe

-"Loosen up your ankles by rocking them back and forth, heels up as far as they will go, then toes up as far as they will go, trying to keep your feet on the floor," (alternate motions, repeat each motion 5 times).

36. Flutter kick

-"Let's end up with the flutter kick. Raise both legs off the floor, alternately kicking right and left legs," (start with a count of 50, progressively raise by 10 as participants are able).

APPENDIX D

RANGE OF MOTION DATA

PRE- AND POST-FORMS

APPENDIX D

RANGE OF MOTION DATA

PRE- AND POST-TEST FORMS

______________________________ Subject Identification

______________________________ Date

NECK

	L			R	
Rotation	______			______	
	______	______ ave.		______	______ ave.
	______			______	
Flexion	______		Extension	______	
	______	______ ave.		______	______ ave.
	______			______	

SHOULDER

Extension	______	
	______	______ ave.
	______	
Flexion	______	
	______	______ ave.
	______	

ELBOW

Flexion	______	
	______	______ ave.
	______	

WRIST

Flexion ______

______ ______ ave.

______

Extension ______

______ ______ ave.

______

Pronation ______

______ ______ ave.

______

Supination ______

______ ______ ave.

______

KNEE

Flexion ______

______ ______ ave.

______

ANKLE

Dorsi-flexion

______

______ ______ ave.

______

Plantar flexion

______

______ ______ ave.

______

APPENDIX E

RAW DATA ON SUBJECTS

Table 8

Raw Data on Subjects in Group 1

Subject	Age	NRL		NRR		NF		NE		SE		SF	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	83	25.6	50.0	24.0	55.3	41.0	52.0	39.6	37.3	50.0	78.0	154.0	147.3
2	82	33.3	44.6	28.0	36.0	36.0	26.6	41.3	41.3	58.6	74.0	155.3	157.3
3	86	47.3	60.0	34.0	60.0	48.0	48.6	46.0	51.3	58.0	83.3	153.3	151.3
4	83	34.0	49.3	39.3	49.3	27.3	38.6	30.6	44.0	48.6	76.6	148.6	148.6
5	79	40.0	61.3	38.0	68.3	40.6	52.0	56.6	45.6	40.0	62.0	156.0	150.6
6	80	74.6	70.6	80.0	70.6	62.0	73.3	61.3	64.0	69.3	73.3	148.6	175.3
7	87	36.6	46.6	56.6	51.3	41.3	38.6	44.0	58.0	59.3	78.6	148.6	146.0
8	89	71.3	61.3	61.3	59.3	62.6	51.3	70.0	60.6	68.6	80.6	178.0	173.3
9	80	50.0	80.6	48.6	68.6	63.3	51.3	38.6	68.0	61.3	83.3	163.3	166.0
10	71	88.6	87.3	88.6	72.6	40.0	40.6	68.6	61.3	88.0	82.0	176.7	173.3
11	85	74.6	61.3	59.3	51.3	67.3	55.3	71.3	65.3	62.0	72.0	152.0	159.3
12	73	30.6	40.0	40.6	40.0	41.3	60.0	49.3	40.0	66.6	74.6	152.0	144.0
13	86	44.6	52.6	51.3	58.6	62.6	76.6	44.6	40.0	60.0	84.6	161.3	152.6
14	84	58.0	70.0	59.3	60.0	49.3	48.6	69.3	60.0	62.0	87.3	154.6	168.0
15	81	58.6	71.3	57.3	60.0	49.3	49.3	62.0	54.0	66.6	83.3	160.0	161.3
16	83	63.6	50.6	45.3	62.0	56.6	73.3	56.6	64.0	71.3	76.6	160.0	156.0
17	83	58.0	59.3	59.3	55.3	45.3	61.3	44.0	62.0	52.0	74.0	163.3	163.3
18	81	42.0	49.3	40.0	50.0	29.3	52.6	71.3	78.6	87.3	88.3	140.0	136.0

Table 8 (continued)

	EF		WF		WE		WP		WS		KF		AP		AD	
Subj.	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	136.6	118.6	45.3	81.3	36.0	60.0	68.6	81.3	53.3	43.3	00.0	00.0	18.0	39.3	18.0	20.0
2	146.3	156.0	44.6	77.3	35.3	48.6	59.3	71.3	53.3	62.0	88.6	71.3	17.3	22.6	10.6	12.0
3	148.6	153.3	67.3	61.3	48.6	60.0	68.6	72.6	60.6	59.3	61.3	51.3	28.6	36.0	19.3	20.0
4	140.0	156.6	62.6	76.0	28.6	58.6	51.3	68.6	46.6	39.3	89.3	101.3	28.6	28.0	19.3	22.6
5	143.3	148.6	68.0	81.3	58.6	72.0	57.3	80.0	69.3	66.0	94.0	101.3	29.3	26.0	20.0	22.0
6	133.3	149.3	67.3	79.3	69.3	76.6	90.0	90.0	90.0	88.0	91.3	101.3	25.3	35.3	11.3	20.0
7	138.6	144.6	89.3	76.0	44.0	58.6	71.3	68.0	53.3	50.6	88.0	90.0	30.6	39.3	12.0	14.0
8	123.3	157.3	58.0	85.3	69.3	72.0	61.3	90.0	69.3	51.3	72.6	94.0	44.6	46.6	17.3	12.6
9	130.6	168.6	62.6	88.6	48.6	50.0	70.6	76.0	61.3	68.6	119.3	120.6	20.6	32.6	20.6	12.6
10	141.3	143.3	72.0	77.3	91.3	88.6	77.3	69.3	66.6	74.0	111.3	112.0	30.0	28.0	6.6	12.6
11	142.6	159.3	65.3	71.3	80.6	70.0	63.3	62.0	65.3	59.3	97.3	84.6	22.0	31.3	17.3	12.6
12	129.3	145.3	57.3	57.3	62.6	74.6	63.3	70.0	42.0	54.0	51.3	65.3	23.3	33.3	17.3	16.6
13	131.3	150.0	83.3	92.0	69.3	68.6	66.6	79.3	50.0	64.0	99.3	84.6	18.6	23.3	18.0	28.6
14	146.0	163.3	77.3	76.6	63.3	77.3	57.3	79.3	56.0	63.3	118.0	101.3	28.0	38.6	19.3	21.3
15	130.0	150.0	58.6	84.6	50.0	60.0	62.0	60.6	48.0	55.3	111.3	111.3	29.3	28.6	7.3	16.6
16	130.0	143.3	65.3	81.3	74.6	57.3	60.0	66.6	60.6	56.6	89.3	101.3	32.6	42.6	20.0	21.3
17	144.0	155.3	63.3	80.0	50.0	64.0	71.3	71.3	40.0	50.0	85.3	92.0	31.3	39.3	16.0	17.3
18	138.6	139.3	77.3	77.3	75.3	68.6	82.6	78.6	66.0	66.6	76.0	79.3	24.0	34.6	16.6	23.3

Table 9

Raw Data on Subjects in Group 2

Subject	Age	NRL		NRR		NF		NE		SE		SF	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	79	40.6	60.6	49.3	60.6	34.0	49.3	38.0	58.6	59.3	72.0	155.3	150.6
2	82	61.3	63.3	44.6	53.3	61.3	71.3	36.0	47.3	60.6	71.3	140.6	160.6
3	82	49.3	62.0	37.3	62.6	42.0	51.3	46.6	52.0	50.6	80.0	151.3	159.3
4	82	46.6	62.0	52.0	67.3	43.3	58.6	43.3	39.3	49.3	78.6	162.6	147.6
5	85	80.6	85.3	71.3	77.3	72.0	66.0	21.3	59.3	71.3	81.3	152.0	157.3
6	78	49.3	68.0	57.3	60.0	49.3	56.0	31.3	47.3	66.6	79.3	140.6	170.6
7	65	47.3	59.3	52.0	68.0	66.6	63.3	48.6	59.3	70.0	74.6	172.0	170.6
8	72	40.6	64.0	50.6	51.3	43.3	55.3	49.3	49.3	53.3	72.0	162.0	139.3
9	87	40.0	60.0	40.6	60.0	44.0	49.3	58.6	58.6	58.0	79.3	165.3	162.0
10	73	59.3	77.3	50.0	60.0	56.6	69.3	34.6	39.3	78.6	83.3	158.6	170.0
11	75	50.6	65.3	58.6	58.6	48.6	50.6	50.6	45.2	74.0	61.3	129.3	149.3
12	80	54.0	71.3	58.0	60.6	48.0	44.6	46.0	53.3	77.3	77.3	142.6	149.3
13	84	50.6	52.6	54.0	49.3	50.6	50.0	46.6	64.0	63.3	82.0	149.3	157.3
14	79	47.3	39.3	69.3	55.3	62.0	51.3	62.6	62.6	62.6	84.0	168.0	159.3
15	80	40.0	66.6	32.6	42.6	47.3	50.0	56.6	57.3	76.6	79.3	155.6	169.3
16	79	54.6	52.0	62.0	40.0	52.3	42.0	36.0	51.3	86.6	71.3	145.6	160.6
17	85	42.0	40.0	43.3	44.6	28.6	40.0	44.6	46.8	54.0	81.3	145.3	149.3
18	72	48.0	59.3	28.6	50.0	50.0	60.6	60.6	68.0	68.0	73.3	150.0	170.0

Table 9 (continued)

Subj.	EF Pre	EF Post	WF Pre	WF Post	WE Pre	WE Post	WP Pre	WP Post	WS Pre	WS Post	KF Pre	KF Post	AP Pre	AP Post	AD Pre	AD Post
1	150.6	151.3	79.3	82.6	60.0	62.6	60.6	68.6	50.0	59.3	100.6	106.6	32.6	38.0	20.0	19.3
2	142.6	146.0	62.0	84.6	62.6	60.6	52.6	75.3	39.3	58.0	80.6	75.3	16.0	31.3	14.6	14.0
3	142.0	143.3	68.0	90.6	41.3	64.0	52.0	70.0	36.6	40.0	88.6	91.3	20.0	31.3	14.6	14.0
4	140.6	146.0	66.6	79.3	69.3	80.0	62.0	68.6	57.3	55.3	90.0	72.6	33.3	24.6	8.0	19.3
5	146.6	152.6	76.6	88.6	71.3	94.0	64.0	79.3	56.0	68.0	00.0	00.0	31.3	32.6	24.0	28.6
6	136.6	150.0	74.0	78.0	57.3	70.0	54.0	81.3	57.3	49.3	71.3	94.6	21.3	29.3	12.6	22.6
7	141.3	156.6	77.3	68.0	75.3	80.6	61.3	76.0	66.6	70.6	86.6	92.0	34.6	34.6	8.6	10.6
8	150.6	139.3	64.0	86.0	64.0	80.0	49.3	69.3	49.3	69.3	111.3	132.0	34.0	33.3	20.6	17.3
9	146.0	153.3	71.3	81.3	58.6	60.0	50.6	70.0	32.6	49.3	126.0	109.3	38.6	37.3	10.0	27.3
10	128.6	149.3	69.3	76.0	70.6	77.3	89.3	80.0	52.0	80.0	91.3	88.6	40.0	37.3	15.3	27.3
11	159.3	150.6	82.0	84.0	64.6	73.3	64.0	90.0	33.3	46.6	62.0	104.0	36.0	32.6	19.3	18.0
12	159.3	154.6	56.6	80.6	60.6	66.6	62.6	81.3	57.3	59.3	98.6	106.0	36.6	39.3	14.6	14.0
13	132.0	158.0	73.0	81.3	70.0	60.6	71.3	80.6	43.3	54.0	89.3	67.3	29.3	37.3	11.3	26.0
14	148.0	159.3	61.3	74.6	72.6	88.8	83.3	80.6	82.0	68.0	99.3	91.3	22.6	34.6	22.0	21.3
15	148.6	149.3	86.0	91.3	72.6	77.3	79.3	88.6	71.3	68.6	85.3	98.6	24.6	32.6	15.6	16.0
16	147.0	141.3	91.3	82.0	56.6	68.0	80.6	79.3	39.3	48.6	88.6	85.3	36.6	25.3	18.0	22.6
17	139.3	146.6	90.6	88.6	48.6	68.6	77.3	60.0	48.6	58.0	105.3	77.3	20.0	31.3	29.0	16.0
18	143.3	158.0	93.3	88.0	66.6	91.3	62.0	92.0	64.0	66.6	112.6	96.6	37.3	32.0	14.6	22.6

Table 10

Raw Data on Subjects in Group 3

Subject	Age	NRL		NRR		NF		NE		SE		SF	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	86	60.6	44.6	62.0	44.0	60.0	56.0	56.6	63.3	92.0	72.0	156.0	163.3
2	88	59.3	48.0	60.0	50.0	50.0	56.0	56.6	30.0	58.6	70.6	158.6	165.3
3	79	88.6	68.6	78.0	70.0	55.3	48.6	60.0	36.6	61.3	79.3	160.6	169.3
4	75	00.0	00.0	00.0	00.0	34.6	50.6	52.6	57.3	50.6	79.3	160.6	149.3
5	71	59.3	56.0	52.6	69.3	72.0	56.6	43.3	52.0	60.0	71.3	141.3	161.3
6	80	60.0	54.6	70.0	51.3	48.0	42.6	52.6	43.3	59.3	83.3	154.6	163.3
7	90	49.3	40.0	78.0	41.3	52.6	52.0	58.0	41.3	48.6	50.0	180.0	154.0
8	83	40.0	50.0	40.0	42.6	47.3	40.0	36.6	43.3	64.0	76.0	159.3	160.0
9	85	51.3	51.3	58.6	47.3	48.6	54.0	42.0	41.7	56.0	73.3	158.6	150.0
10	81	88.6	44.6	58.6	51.3	42.6	48.6	74.6	79.3	62.6	76.6	180.6	150.0
11	85	45.3	56.6	39.3	32.6	44.0	34.0	41.3	30.6	50.6	56.6	162.6	144.0
12	82	40.0	50.0	49.3	52.0	46.6	27.3	46.0	59.3	53.3	62.6	152.0	141.3
13	79	36.6	50.0	50.0	50.6	48.6	52.6	66.0	46.6	51.3	58.6	159.3	144.0
14	72	53.3	64.6	57.3	58.6	50.6	64.0	64.6	60.6	72.0	88.0	172.6	175.3
15	80	61.3	38.6	57.3	39.3	38.6	42.0	42.0	40.6	80.0	70.0	166.0	150.0
16	84	26.0	41.3	38.0	49.3	43.3	49.3	40.0	54.0	69.3	78.6	149.3	154.0

Table 10 (continued)

	EF		WF		WE		WP		WS		KF		AP		AD	
Subj.	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	157.3	146.6	82.6	74.6	64.0	70.0	82.6	80.0	60.6	52.0	104.0	82.6	30.0	27.3	26.6	28.6
2	142.6	138.0	87.3	92.0	51.3	62.0	77.3	78.0	57.3	68.6	116.6	117.3	18.0	17.3	21.3	8.6
3	141.3	150.6	89.3	70.6	72.0	61.3	84.0	90.0	92.0	50.0	88.0	80.6	20.6	32.6	35.3	20.0
4	139.3	150.6	77.3	78.0	60.0	54.0	80.0	62.6	60.6	40.0	111.3	93.3	21.3	17.3	17.3	9.3
5	151.3	151.3	75.3	82.6	63.3	69.3	70.0	68.6	41.3	58.6	154.6	118.0	22.0	32.6	18.0	18.0
6	131.3	151.3	88.0	80.6	59.3	63.3	86.0	63.3	80.0	59.3	85.3	83.3	19.3	24.6	9.3	21.3
7	149.3	147.3	80.6	70.6	67.3	73.3	80.0	66.0	64.6	46.0	112.0	86.0	29.3	21.3	10.6	12.0
8	155.3	153.3	70.6	64.0	60.6	59.3	79.3	68.6	42.0	50.0	68.6	78.6	20.0	30.6	8.6	10.0
9	130.6	141.3	60.0	48.0	66.6	64.0	80.6	72.6	50.6	44.6	00.0	00.0	22.0	20.0	20.0	23.3
10	150.0	153.3	54.0	53.3	72.0	71.3	68.0	53.3	53.3	38.6	102.6	90.6	31.3	35.3	12.0	15.3
11	126.0	143.3	60.6	70.0	38.6	50.0	51.3	58.0	40.0	50.6	66.0	90.6	24.6	26.0	6.6	14.0
12	130.6	144.6	64.3	61.3	61.3	56.0	60.6	69.3	58.6	44.0	90.6	89.0	23.0	20.6	22.6	19.3
13	128.6	125.3	70.0	54.0	52.6	63.3	69.3	68.6	52.6	51.3	100.0	93.3	17.3	17.3	9.3	7.3
14	138.6	152.0	70.0	69.3	47.3	66.6	66.6	59.3	57.3	69.3	96.0	92.0	36.0	42.0	17.3	18.0
15	139.3	127.3	93.3	73.3	76.6	73.3	89.3	66.6	60.6	47.3	73.3	52.6	32.6	34.0	18.6	13.3
16	139.3	144.6	89.3	88.6	85.3	77.3	84.6	80.0	70.6	62.0	00.0	00.0	28.6	27.3	12.6	20.0

APPENDIX F

One-Way Analysis of Variance on Pre-Test Range of Motion Scores

Table 11

One-Way Analysis of Variance on Pre-Test Joint Range of Motion Scores

Measurement	df	MS (Within)	F-Ratio	Probability
Neck Rot. Left	2,49	285.5719	.043	.9575
Neck Rot. Right	2,49	249.0151	.133	.8757
Neck Flexion	2,49	114.6430	.154	.8573
Neck Extension	2,49	138.5036	2.666	.0796
Shoulder Extension	2,49	131.8181	.493	.6140
Shoulder Flexion	2,49	105.9615	2.702	.0771
Elbow Flexion	2,49	69.4691	3.315	.0446
Wrist Extension	2,49	132.3036	3.918	.0264
Wrist Flexion	2,49	169.8530	.680	.5116
Wrist Pronation	2,49	112.3389	4.698	.0136
Wrist Supination	2,49	170.7548	1.519	.2291
Knee Flexion	2,49	998.6459	.038	.9630
Ankle Plan. Flex	2,49	44.7174	2.967	.0597
Ankle Dorsi-Flex	2,49	35.2397	.058	.9440

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