AN INVESTIGATION OF ANTHROPOMETRIC PHYSIOLOGICAL AND STRENGTH RESPONSES OF PHYSICALLY DISABLED ADULT MALE WHEELCHAIR BASKETBALL PLAYERS DURING TRAINING

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ABSTRACT

Title of Thesis: An Investigation of Anthropometric, Physiological and Strength Responses of Physically Disabled Adult Male Wheelchair Basketball Players During Training

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The purpose of this study was to monitor anthropometric, physiological and strength responses of six physically disabled adult male wheelchair basketball players during training. An intra-subject case study research design was selected because of differing levels of disabilities and individual variability of responses during training. A repetitive bi-weekly testing schedule for anthropometric measures, cardiopulmonary function, grip strength, arm flexion and extension strength was followed. The six-week wheelchair basketball training schedule was two evenings per week of two hour duration. This study was descriptive, and nonstatistical in nature. Results were presented in tabular and graphical form so individual responses could be observed. The results indicated individual variability of responses to test parameters. However, consistent responses noted were: a reduction in body weight, a decreased mean heart rate response to the same power out-put on a wheelchair ergometer, a decreased initial heart rate in supine and sitting positions, and an increase in grip, arm flexion and extension strength tests.

To my Mom and Dad

Science has established two facts meaningful for human welfare: first, the foundation of the structure of human personality is laid down in early childhood; the second, the chief engineer in charge of this construction is the family.

Meyer Francis Nimkoff

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I would like to share a favourite verse by Booker T. Washington with you:

> Success is to be measured not so much by the position that one has reached in life as by the obstacles which he has overcome while trying to succeed.

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INTRODUCTION

Statement of the Problem

The purpose of this study was to monitor anthropometric, physiological and strength responses of physically disabled adult male wheelchair basketball players throughout a training period.

Significance of the Study

McPherson (1979) described the disabled individual participating in sport as an athlete. McPherson stated: the common bond in sport at all levels is to measure the athlete's abilities and skills, not the athlete's disabilities. As such, the disabled competitor has the same rights and privileges as his able-bodied counterpart, they are both athletes (p. 8).

Guttmann (1976) found sport invaluable in restoring paralyzed persons' strength, coordination, and endurance. Ward (1980) stressed the importance of a coach understanding the physical capabilities of an athlete or team and having a sound technical knowledge.

The objective of this study was to monitor individual anthropometric, physiological and strength responses throughout a period of training in wheelchair basketball. Further objectives were to: 1) provide experience in conducting anthropometric, physiological and strength tests on physically disabled adult male athletes and, 2) offer recommendations for further research.

Delimitations

1. The study was delimited to six male athletes, ages ranging from 29 to 30 years, participating in wheelchair basketball.
2. The observation period was from April 5, 1981 to May 17, 1981, and measurements were taken bi-weekly.
3. The study was delimited to assessments of anthropometric measures, grip strength, arm flexion and extension strength, and cardiopulmonary function.

Limitations

1. Athletes participated on a voluntary basis.
2. The participating athletes had not experienced structured training sessions under the direction of a coach for any recorded length of time.
3. The participating athletes had not experienced testing, or an exercise physiology laboratory environment prior to this study.
4. The possibility of involuntary muscle spasm during testing sessions existed.
5. The possibility of illness or injury occurred preventing completion of the training period.
6. The athletes' attendance may be affected by the availability of a specialized vehicle for wheelchairs.
7. The athletes' past and present physical activities might limit responses.
8. The subjects were responsible for their own nutritional

habits and activities.

Definitions

Wheelchair basketball player is an individual, who, because of the severity of his leg disability or disability of the lower portion of the body, will benefit through participation in wheelchair sports (Johnstone, 1978). This individual would be denied the opportunity to play basketball were it not for wheelchair basketball (National Wheelchair Basketball Association Official Rules 1980-81).

Poliomyelitis is a virus disease characterized by upper respiratory and gastro intestinal symptoms, which may progress to involve the central nervous system. The result is a non-paralytic or paralytic form of disease, the latter being paralytic spinal poliomyelitis (Blakiston's Gould Medical Dictionary, 1972).

Paraplegia is paralysis of the lower limbs and in varying degree, of the trunk, as a result of disease or trauma.

Amputee is an individual with partial or complete loss of one or more limbs.

Specificity of conditioning is defined as the property of having effects that are directly linked to the particulars of training (Fox, 1979).

Official classification is a scheme based on muscular function to develop fairness of competition and is a prerequisite for competition. The testing procedure is conducted by a physician and/or paraprofessional who is familiar with the muscular tests required by the sports governing bodies and the category within each (see Appendix G).

Sports governing bodies are organizations which set policy on rules, establish qualifying standards, sanction events, and other sport related matters for each category of disability, e.g., wheelchair, cerebral palsy, blind and amputee.

Initial heart rate is the heart rate recorded prior to exercise.

Initial blood pressures are the systolic and diastolic blood pressures recorded prior to exercise.

Skinfold is defined as a pinch of skin and subcutaneous fat from which total body fat may be estimated (Fox, 1979).

Muscular strength is the force that a muscle or muscle group can exert against a resistance in one maximal effort (Fox, 1979).

Pulmonary function is the entire process of inspiring and expiring air, exchange of gases, distribution of oxygen to the cells, and collection of carbon dioxide from the cells.

Vital capacity (VC) is the total amount of air that can be forced out of the lungs following a maximal inspiration (Jensen & Fisher, 1979).

Forced vital capacity (FVC) is the vital capacity performed with expiration as forceful and rapid as possible.

Percent vital capacity (% VC) is percentage $(\frac{\text{FVC}}{\text{VC predicted}} \times 100)$ of FVC against VC predicted. If the value is less than 75%, the subject is diagnosed as having restrictive ventilatory impairment.

Predicted vital capacity (VC pred.) is the average value of vital capacity determined by the age, height and sex.

Forced expiratory volume in one second (FEV_1) is the volume of

gas exhaled over a one second interval during the performance of forced vital capacity (Åstrand & Rodahl, 1977).

Percentage forced expiratory volume in one second (% FEV_1) is expressed as a percentage of the forced vital capacity over a one second interval and is represented by the formula:

$$\frac{FEV_1}{FVC} \times 100$$

If the value is less than 70%, the subject is diagnosed as having obstructive ventilatory impairment.

Systolic pressure is reached when blood is ejected into the arteries (Fox, 1979).

Diastolic pressure is reached when the blood drains from the arteries (Fox, 1979).

Mean arterial pressure is the average pressure pushing blood through the systemic circulatory system (Guyton, 1977).

Chapter 2

REVIEW OF LITERATURE

Wheelchair Athletics

The age of wheelchair athletics has begun. The movement has provided the individual confined to a wheelchair, opportunity for competitive experiences previously available only to able-bodied persons (Dawson, William & Rape, 1980). Until recently, it appeared that wheelchair athletes in Canada have not been trained using coaching procedures based upon scientific principles. Research concerning the effects of physical activity on wheelchair athletes is still in its infancy. Most research dealing with training principles on physically disabled has been based upon the data collected on able-bodied persons. Activities and sports of a dynamic nature such as basketball, swimming and distance wheeling have been recommended as suitable means for maintaining physical fitness in paraplegics (Jochheim & Strohkendl, 1973).

The results of a study by Dawson et al. (1980) on heart rate intensity required in wheelchair basketball, revealed peak heart rates of 175-195 beats per minute (bpm). According to Dawson et al. (1980) it is apparent that exercise at this intensity for persons not properly trained is potentially dangerous. Wheelchair basketball encompasses endurance requirements with short intervals of power work. Jochheim & Strohkendl (1973) stated that wheelchair basketball fulfilled the requirements necessary for cardiovascular training using different muscle groups.

Characteristics of Wheelchair Performance

Propulsion

Fitness to operate a wheelchair may vary due to one's disability(ies), muscular strength and endurance, cardiorespiratory capacity, and propulsion technique (Glaser, Foley, Laubach, Sawka & Suryaprasad, 1978-79). Local arm fatigue rather than cardiorespiratory factors, may be a limiting factor in manual wheelchair propulsion (Hjeltnes, 1977). This places the individual at a disadvantage because of the limited physical work capacity (PWC) of the arms (Voigt & Bahn, 1969). Wheelchair-dependent persons with a limited physical work capacity are required to use weak upper body musculature to propel themselves and a 14 to 28 kilogram (kg) wheelchair (Glaser, Sawka, Young & Suryaprasad, 1980b). Davies and Sargeant (1973) pointed out that the arms have only one-third the muscle mass of the legs. Glaser, Barr, Laubach, Sawka and Suryaprasad (1980a) stated that:

> Operating a manual wheelchair at a given rate would most likely require a larger percentage of the user's peak aerobic power than that used by an able-bodied individual during lower body locomotion. Such metabolic stress for wheelchair exercise could lead to early onset of muscular fatigue and excessive cardiopulmonary responses.
>
> (p. 179-180).

Driving a wheelchair up an incline or ambulating with crutches places heavy demands on arm strength and cardiovascular capacity (Brattgard, Grimby, Hook & Cronquist, 1970). The daily amount of wheelchair propelling is not intense enough to facilitate training effects in the circulatory system. Therefore, it is necessary to increase the capacity of the wheelchair-dependent individual by additional physical exercise (Hildebrandt, Voigt, Bahn, Berendes & Kroger, 1970). The results from a study by Hjeltnes and Vokac (1979) supported that daily life activities were not intense enough to maintain the circulatory and physical fitness of paraplegics. Zwiren, Huberman and Bar-Or (1973) stressed that disabled persons not actively involved in wheelchair sport programs, showed less cardiovascular endurance, and higher body weight and fat percentage than sedentary able-bodied subjects.

Specificity of exercise

Subcellular adaptations to training for competitive events are specific. For example, adaptations within the muscle are dependent upon the specific program employed. The concept of specificity of exercise is supported by both metabolic specificity and the contribution of different muscle fiber types (McCafferty & Horvath, 1977). Comparing the heart rate response of arm and leg training, Clausen, Trap-Jensen and Lassen (1970) found training effects to be specific to the particular muscles utilized. McCafferty and Horvath (1977) also suggested that meaningful evaluation of wheelchair performance requires wheelchair-type activity as an exercise mode. Wheelchair ergometry has been shown to be reliable and simulate actual wheelchair locomotion (Glaser, Ginger & Laubach, 1977). The adaptation of the circulatory system to exercise varies depending on muscles involved (Åstrand, Ekblom, Messin, Saltin & Stenberg, 1965). In armcycloergometry, Marincek and Valencic (1977-78) found heart rate responses to increased power output were of a higher value compared to the same power output performed with lower limbs. Therefore, for the same work performance, more marked contraction of upper than lower limb muscle is necessary (Marinçek & Valencic, 1977-78). Arm exercise in comparison with leg exercise is accompanied by a larger rise in heart rate, blood pressure and pulmonary ventilation. This difference has been attributed to a more dominating sympathetic vasoconstrictor tone during arm exercises (Åstrand, Guharay & Wahren, 1968). Research has shown that circulatory reactions occur while exercising small muscle groups. This finding prompted further research regarding the improvement of physical fitness of paraplegics by the use of arm exercises. Results from an investigation by Odéen (1972) revealed a period of arm training usually resulted in an improvement in work performance. Clausen et al. (1970) suggested training programs include types of exercise which correspond to those required for the individual's daily activities.

Power output

Power output of wheelchair locomotion is, in part, influenced by body weight of the user, velocity of propulsion, floor surface and incline (Glaser, Sawka, Laubach & Suryaprasad, 1979b). Previous research by Glaser and Chao (1976) indicated that 30 kilopond metres per minute (kpm/min) is the approximate power output required for a 70 kilogram (kg) individual to operate a manual wheelchair at 3.5 kilometers per hour (km/hr) over a smooth level surface. The higher power output of 60 kpm/min approximates that required for wheelchair locomotion up a 0.5

degree incline and over higher resistance floor surfaces such as carpet (Voigt & Bahn, 1969). Glaser, Laubach, Sawka and Suryaprasad (1979a) found 150 kpm/min a reasonable upper limit for wheelchair ergometry (WERG) because of the high stress encountered.

Wheelchair ergometry has allowed laboratory evaluation of physiological responses associated with wheelchair activities at controlled power output levels (Voigt & Bahn, 1969). The power output level completed during a wheelchair ergometry test provides information on muscular strength and endurance components.

Mechanical efficiency

Limited research exists on the mechanical efficiency of bicycle ergometer exercise at power output levels less than 300 kpm/min. Åstrand (1960) reported mechanical efficiency increased from approximately 10 percent at 50 kpm/min to 19 percent at 150 kpm/min during bicycle ergometer exercise. Davies and Sargeant (1973) concluded that, provided the seating position of the subject was standardized, the mechanical efficiency of submaximal arm or leg cranking was the same. The trunk muscles of paraplegics contribute only slightly to the locomotion of their wheelchairs, depending on the level of disability. Brattgard et al. (1970) found mechanical efficiency values of seven to eight percent for able-bodied females operating a wheelchair ergometer at 65 and 110 kpm/min. These low mechanical efficiency values obtained during wheelchair activity were attributed to the energy waste characteristic of the hand-rim propulsion system.

Work capacity of paraplegics

An investigation by Knutsson, Lewenhaupt-Olsson and Thorsen

(1973) showed paraplegic individuals had a lower work capacity compared to able-bodied persons. Two factors described by Nilsson, Staff and Pruett (1975) which influence the aerobic work capacity of paraplegics are stated below.

1. Site of injury - the level of spinal cord lesion may affect the sympathetic regulation of heart rate. In individuals with lower thoracic or upper lumbar lesions the muscles of the arms and trunk are unaffected.
2. Muscle atrophy - persons ambulating with crutches and/or long-leg braces have to use the muscles of their arms and trunk with greater regularity. This results in additional development of these muscle groups thereby preventing atrophy.

Knutsson et al. (1973) reported arm work in an able-bodied subject implied a relatively low degree of strain on the circulatory system. However, arm work was described as adequate for conditioning persons with a low physical fitness level.

Physiological Responses

Physiological responses to a specific submaximal exercise task are considered to be inversely related to one's fitness to perform that activity; the higher the responses, the lower the fitness (Glaser et al., 1978-79). Currently, there are few well-established techniques to objectively evaluate an individual's fitness to perform wheelchair activities (Glaser et al., 1978-79). Most fitness evaluations of wheelchair-dependent individuals have been performed using arm cranking techniques or modified bicycle ergometers (Pollock, Miller, Linnerud, Laughridge, Coleman & Alexander, 1974; Zwiren & Bar-Or, 1975).

Heart rate

Wolfe, Waters and Hislop (1977) found wheelchair propulsion tended to produce high heart rates compared to values for normal walking. Using a wheelchair ergometer (WERG), Brattgard et al. (1970) found that propelling a wheelchair required a high amount of energy when compared to other exercises using the same muscle masses. Heart rates tended to be more elevated, particularly at higher work loads than when subjects used conventional ergometers or treadmills. This finding confirmed the hypothesis that upper extremity work produces higher heart rates than lower extremity work (Stenberg, Åstrand, Ekblom, Royce & Saltin, 1967). In many types of work, the increase in heart rate is higher with the increase in work load (Åstrand & Rodahl, 1977). Heart rate and power output relationships and the maximal power output level completed are two variables which provide information concerning fitness for wheelchair locomotion. To effectively exercise the heart, the rate at which the heart beats must be increased (Arviko, 1978). Hjeltnes and Vokac (1979) observed subjects in their home environment and found heart rates of 80 bpm which increased to 110 bpm while ambulating on crutches. Another subject from the same study, recorded a heart rate of 160 bpm while propelling a wheelchair up an incline. The highest heart rate recorded by Hjeltnes and Vokac (1979) was 170 bpm during a wheelchair basketball game. In basketball the mean heart rate was 144 bpm. Results from the Glaser et al. (1978-79) study revealed heart rates of 76-136 bpm at 30 kpm/min, 74-144 bpm at 60 kpm/min, 81-168 bpm at

90 kpm/min, 94-170 bpm at 120 kpm/min, and 102-172 bpm at 150 kpm/min. Research indicates that with improvement in physical fitness, the heart beats less frequently and more efficiently (Glaser et al., 1978-79).

Heart rates for arm work in paraplegic subjects were generally higher than reported values on able-bodied subjects (Nilsson, Staff & Pruett, 1975). The results from this study showed that maximal aerobic power, maximal work capacity, mechanical efficiency and subjects' feeling of well-being could be improved by physical training.

Zwiren and Bar-Or (1974) suggested that conditioning of the healthy upper limbs and trunk muscles aided in compensating for the lack of use of a large muscle mass. The authors found this true for heart rate response to submaximal exercise and aerobic capacity.

A study by Ekblom and Lundberg (1968) involving a six-week conditioning program resulted in a drop in submaximal heart rate and a rise in mechanical work output. The authors explained the lower heart rate was the result of reduced oxygen uptake, and partly by an improvement in cardiovascular function. The training heart rate for the paraplegic group averaged 140 beats per minute (bpm) (Ekblom & Lundberg, 1968). In a study by Pollock et al. (1974) the training heart rate averaged 155 to 165 bpm (80 to 85 percent of maximal heart rate).

A study by Shoenfeld, Shapiro, Ohry, Levy, Udassin, Drory, Rozin and Sohar (1978) on orthostatic hypotension, reported the least increase in heart rate following the tilt position of the subject was in the amputee group. The highest heart rate at rest and after tilting was found in the paraplegic subjects.

Blood pressure

In able-bodied subjects, the systolic pressure is approximately 10 mmHg higher in standing than in recumbent posture (Schneider, 1920).

A study by Shoenfeld et al. (1978) to observe orthostatic hypotension using a tilt table was performed on amputees, paraplegics and able-bodied subjects. The authors suggested that orthostatic reaction in able-bodied subjects was due to blood pooling in the legs as well as in the splanchnic system on assuming the erect position. As a result, effective blood volume was reduced. Findings from this study showed both systolic and diastolic blood pressure slightly higher at rest in amputees, and did not drop significantly with assumption of the erect position. Shoenfeld et al. (1978) concluded that this lesser orthostatic reaction in amputees was accounted for by the lesser degree of blood pooling in the lower limbs. The paraplegics showed greater changes in orthostatic reaction. This was shown by a significantly larger drop in systolic blood pressure. A further finding by Shoenfeld et al. (1978), was the higher the spinal cord injury, the greater the orthostatic reaction. Hüllemann, List, Matthes, Wiese and Zika (1975) reported values of indirectly measured blood pressure (141 ± 19/96 ± 12 mmHg) at rest were markedly higher in the disabled group compared to able-bodied. The authors explained this elevation as a result of the larger arm size of the disabled due to weight lifting or in combination with other sports. In four disabled subjects who engaged in light athletics, blood pressure was markedly lower (136 ± 10/89 ± 10 mmHg).

Åstrand and Rodahl (1977) found arterial blood pressure significantly higher in arm exercise than in leg work.

Pulmonary function

Zwiren and Bar-Or (1974) reported pulmonary function values at rest for wheelchair athletes (swimming and wheelchair basketball) of: FVC equalled 4.96 litres (1), $FEV_{1.0}$ equalled 4.08 1, $FEV_1\%$ equalled 82% and maximal breathing capacity (MBC) equalled 157.3 1. Zwiren and Bar-Or (1974) concluded that wheelchair athletes had a larger FVC (4.96 1) than wheelchair sedentary persons (4.29 1), which reflect a more efficient functioning of the respiratory muscles. The authors concluded that the study did not indicate major differences in static or dynamic lung functions between able-bodied and wheelchair-dependent men. Hüllemann et al. (1975) found that vital capacity increased the lower the transverse lesion location in the spinal cord. Maloney (1979) found evidence of an increased breathing rate in paraplegics when work loads on an arm ergometer were above normal. Research by Zwiren and Bar-Or (1974) suggested a decrement was evident in pulmonary functions in individuals whose lower limbs had been immobilized for several years. However, a reversed trend was shown for paraplegics who regularly activated upper limbs and trunk muscles.

Anthropometric Measures

Boelter, Hosler and Orr (1978) indicated that the weight of body fat of able-bodied athletes was related to performance and type of event in which an individual participates. Therefore, in the Boelter et al. (1978) study, an estimation of body fat of wheelchair men was derived. The authors assumed that due to the confining nature of a wheelchair and the resulting low level of physical activity, disabled males would have a larger measure of fat weight than the group of able-bodied used as reference. A 0.9 millimetre (mm) difference was found between the disabled and able-bodied subjects. The total wheelchair summation equalled 91.2 and the total able-bodied equalled 90.3 mm. The body weight of the wheelchair group was 7.6 pounds less than the able-bodied male subjects. Pollock et al. (1974) were aware of the problem of estimating percentage fat from skinfold measures, more specifically, using a formula derived from data on able-bodied. The authors further speculated that the estimation of body fat may be different from that in able-bodied persons. Zwiren and Bar-Or (1974) presented data on skinfold measurements with some reservation, suggesting that subcutaneous fat distribution in paraplegics may be different than able-bodied subjects. Body composition results in Pollock et al. (1974) showed a reduction in body weight, skinfold measures, and estimated percentage body fat after a training period. Keys (1955) analyzed body weight and composition changes of able-bodied athletes resulting from vigorous muscular exercise. This study reported a decrease in body fat and an increase in muscular mass, with variations in total body weight. Thompson (1959) concluded that athletes participating in basketball experienced exercise-induced changes in body composition.

Strength

Strength is an important component in daily living of the spinal cord injured individual. Strength is required for balance, mobility of the trunk, maintenance of upright posture, and adequate ventilation (Chawla, Bar, Creber, Price & Andrews, 1979-80). Boelter et al. (1978)

used a Cybex Power Bench Press for strength evaluation. Classes II and III achieved the higher summation of strength scores, 691.7 centimetres (cm). Zwiren and Bar-Or (1974) found grip strength values of 51.4 kg for wheelchair athletes, resulting in no notable difference between the groups tested (wheelchair athletes and sedentary, able-bodied athletes and sedentary). Jones (1949) found a high correlation between grip strength and other static strength measures. Clarke (1966) found a correlation of 0.80 between hand-grip strength and the summated muscular strength in the average subject who had not developed his arm muscles specifically through sport or work. Jones (1949) also found grip strength to be indicative of general body strength.

Summary

The purpose of this chapter was to outline the research to date dealing with wheelchair subjects involved in physical activity.

There is a lack of research concerning the effects of physical activity on wheelchair athletes. Training principles on physically disabled individuals have been based upon data collected on able-bodied persons.

Fitness to operate a wheelchair may vary due to one's disability(ies), muscular strength and endurance, cardiorespiratory capacity, and propulsion technique (Glaser et al., 1978-79).

The power output for wheelchair locomotion is influenced by body weight of the user, velocity of propulsion, floor surface and incline (Glaser et al., 1979c). Wheelchair propulsion involves the relatively weak upper body musculature. The arms have one-third the muscle mass of the legs.

Research supports that daily amounts of wheelchair propelling are too low to facilitate training effects in the circulatory system. Therefore, it is necessary for the wheelchair confined individual to participate in additional physical exercise. Research results revealed periods of arm training usually resulted in an improved work performance.

Arm exercise in comparison with leg exercise was accompanied by a larger rise in heart rate, blood pressure, and pulmonary ventilation (Åstrand et al., 1968). Two factors influenced aerobic work capacity of paraplegics. These were the site of injury and muscle atrophy (Nilsson et al., 1975).

Wheelchair ergometry allows laboratory evaluation of physiological responses associated with wheelchair activities at controlled power output levels (Voigt & Bahn, 1969). A wheelchair ergometer upper limit of 150 kpm/min was recommended as a reasonable power output due to the high stress encountered by arm work, and 30 kpm/min as the lower limit.

Chapter 3

METHODS AND PROCEDURES

Research Design

This investigation was based on an intra-subject case study design (Hersen & Barlow, 1976). This method was used because of the differing levels of disability and individual response to training. Bi-weekly repetitive test sessions were used to observe and record responses during training.

Subjects

Subjects in this study were male physically disabled adult wheelchair basketball players from the Thunder Bay team. The subjects were volunteers who expressed interest in the study. The characteristics of subjects are shown in Table 1. The training sessions were conducted by the investigator. All subjects signed a consent form (see Appendix B) indicating an understanding of test procedures and the willingness to participate in testing sessions and the training period. All subjects completed a background information sheet (see Appendix A) prior to the first test session.

Subject 1 (S1) is 29 years of age. His physical disability is post poliomyelitis and mode of ambulation is with the aid of crutches. He is a Class V for wheelchair basketball competition. The subject's past athletic activities were wheelchair basketball, swimming and field events, shotput, discus and javelin. He has competed at the National level and has been a member of various track clubs. His present sporting involvement is in wheelchair basketball only.

Table 1

Characteristics of Wheelchair Basketball Subjects

Subject	Age (yr)	Height (cm)	Mode of Ambulation	Class	Disability Trauma or Disease
1	29	174.0	Crutch	V	Poliomyelitis
2	30	200.0	Wheelchair	III	Trauma 1968
3	30	155.0	Unassisted	V	Poliomyelitis
4	30	163.0	Unassisted	V	Poliomyelitis
5	29	179.0	Prosthesis	V	Trauma 1977
6	30	166.0	Wheelchair	II	Trauma 1960

Subject 2 (S2) is 30 years of age. He is a paraplegic with a lesion at the eleventh thoracic vertebrae level. His physical disability is the result of trauma in 1968. This subject's mode of ambulation is wheelchair. He is a Class III for wheelchair basketball competition. This subject's past athletic activities were wheelchair basketball, 400, 800 metre, and mile track events, shotput, discus and javelin. Training for competition in these events was done without the guidance of a coach. Present athletic involvement is wheelchair basketball only.

Subject 3 (S3) is 30 years of age. His physical disability is post poliomyelitis and mode of ambulation is with the use of his legs, unassisted. He is a Class V for wheelchair basketball competition. This subject's past athletic activities were wheelchair basketball, swimming, 100, 200, 400, and 800 metre track events, club throw, discus, air rifle and pistol. Training for competition in these events was done without the guidance of a coach. Present athletic involvement is wheelchair basketball only.

Subject 4 (S4) is 30 years of age. His physical disability is post poliomyelitis and mode of ambulation is the use of his legs, unassisted. He is a Class V for wheelchair basketball competition. This subject's past athletic activities were wheelchair basketball, shotput, javelin and discus. Training in these events was done without the guidance of a coach. This subject's present athletic activity is wheelchair basketball only.

Subject 5 (S5) is 29 years of age. He is a below knee (left) amputee. His physical disability is a result of a traumatic accident in 1977. This subject's mode of ambulation is with a prosthesis. He is a Class V for wheelchair basketball competition. Prior to his accident, S5 participated in hockey, baseball and swimming. His present activities are wheelchair basketball, archery and golf.

Subject 6 (S6) is 30 years of age. He is a paraplegic as a result of a traumatic accident in 1960. This subject's mode of ambulation is wheelchair. He is a Class II for wheelchair basketball competition. This subject does not have past athletic experience. His present activities are wheelchair basketball and weight training.

Training Schedule

The training period consisted of two weekly sessions each of two hours duration. Monday evening at St. Patrick's School, Thunder Bay, 8:00 until 10:00 p.m., and Thursday evening at Lakeview High School, 7:00 until 9:00 p.m. Each training session schedule had slight adaptations to meet the needs and physical capabilities of individuals. The training session was similar to that outlined in Appendix E.

Testing Schedule

Each subject participated in bi-weekly repetitive testing for anthropometric measures, grip strength, arm flexion and extension strength, and cardiopulmonary function (see Appendix C). These tests were conducted in the Human Performance Laboratory and Biomechanics Laboratory, C. J. Sanders Fieldhouse, Lakehead University. The same tester, techniques, and time of day were used throughout the study for standardization. All equipment utilized for testing was calibrated prior to testing sessions.

Test Descriptions and Procedures

The subjects were previously instructed to avoid vigorous activity, and refrain from eating or drinking two hours prior to testing.

Anthropometric measures

Weight was measured to the nearest one-tenth of a kilogram (kg) using a Toledo Balance Scale (Model No. 101). The subjects unable to assume or maintain a standing position, sat on this wide base scale. If this position was unable to be maintained, the subject was weighed in his wheelchair and then the wheelchair weighed unoccupied. If the subject wore a brace or prosthesis, he was weighed with the aid, and where possible, the aid weighed by itself for the first test session. The weight of the aid was subtracted during later testing sessions. The subject was dressed in long slacks or shorts and t-shirt, without footwear.

Height was measured in centimetres (cm) and recorded during the first testing session only. This measure was taken to complete the subject's characteristics, and to obtain a predicted vital capacity value. The subject remained in supine position, with lower limbs as straight as possible. A tape measure was extended beside the subject and length recorded.

Skinfold measurements were taken from the right side of the body using a Harpenden Skinfold Caliper (No. 470980). The contact surfaces of the caliper exerted a calibrated constant pressure of approximately 10 gm/mm^2 (exerted over a range of 0 to 50 millimetres). This procedure was as follows:

1. Firmly grasp a fold of skin plus subcutaneous fat between the

left thumb and forefinger, and lift up.

2. Place the contact surface of the caliper approximately one centimetre from the fingers.
3. Maintain the pressure exerted by the fingers so the greater pressure will be exerted by the caliper.
4. Release the scissor grip (right hand) and support the weight of the caliper in the right hand.
5. When the needle is steady, take the reading to the nearest tenth of a millimetre.

All skinfold measurements were taken from the right side of the body. This procedure was repeated and the mean of the two measures was recorded.

The four sites measured were:

1. Subscapular located below the inferior border of the right scapula. The skinfold is lifted vertically.
2. Bicep located on the anterior surface of the right upper arm over the prominence of the biceps muscle. The arm is relaxed and the skinfold is lifted parallel to the humerus.
3. Tricep measured midway up the posterior surface of the right upper arm. The arm is relaxed, the skinfold is lifted parallel to the long axis of the humerus.
4. Supra-iliac located above the superior border of the right ilium. The skinfold is lifted 45 degrees along the normal fold line of the pelvis.

The four measurements were summed, and the estimated body fat percentage calculated using the Durnin and Womersley technique (1974).

The reliability of the skinfold test was 0.96.

Physiological measures

Pulmonary function was determined using the autospirometer AS-700 (Minato Medical Science). Three attempts were made with the subject seated, and the higher FVC value readings recorded. The following readings were measured:

1. forced expiratory volume in one second (FEV_1);
2. percentage vital capacity (% VC);
3. forced vital capacity (FVC); and
4. percentage forced expiratory volume in one second (% FEV_1).

The reliability of the pulmonary function test was 0.95.

Instrumentation of Wheelchair Ergometry

The ergometer was constructed at the School of Engineering, Lakehead University. The basic pattern from Glaser et al. (1979c) was followed with slight alterations. The wheelchair ergometer (WERG) is basically an extension of the Monark bicycle ergometer (BERG) (see Appendix D). The wheelchair used was from the Canadian Wheelchair Manufacturing Limited (No. 10848). The wheelchair wheels were mounted on a solid steel axle to the flywheel of the BERG. Standard gearing of the Monark was retained. A revolution counter recorded the number of flywheel revolutions over a period of time. A standard flywheel friction belt was used, but due to the relatively low braking forces required for the WERG, the measuring scale was modified to increase sensitivity. For this, the pendular arm was lightened by removing the weight, and lengthened with Plexiglas. An expanded scale at the end of the pendular arm was calibrated for 0 - 1 kilopond (kp). A constant force of 0.035 kp was added to all readings to account for the internal friction of the ergometer (Glaser et al., 1979c). The reliability of the WERG test was 0.81.

Heart rate measurement

The subject's initial heart rate was taken following a five minute rest in supine position. The reading was counted for 20 seconds until two consecutive 20 second counts were identical while the subject lay supine. This number was multipled by three and recorded (Schneider, 1920). The reliability of the initial heart rate test was 0.81.

Initial blood pressure was taken using the ausculation method. The reliability of the initial blood pressure test was 0.80. The subject maintained a supine position while this recording was taken. Then the subject sat up for three minutes so initial blood pressure and heart rate could be taken again.

Mean arterial pressure in supine and sitting positions was calculated using the formula:

$$\text{mean arterial pressure} = \frac{\text{systolic - diastolic}}{3} + \text{diastolic}$$

(Fox, 1979)

Heart rate response to power output measures were taken using a wheelchair ergometer. The subject sat erect in the wheelchair, feet flat on the foot pedals, and his back resting against the wheelchair back. The wheeling action was accomplished using the hand rim only. The power output (PO) was calculated using the formula:

PO = braking force x flywheel rpm x flywheel circumference.

Power output levels were 30, 60, 90, 120, and 150 kpm/min. To maintain these levels, subjects wheeled at a constant velocity of 180 metres per minute (mpm) (30 wheelchair revolutions per minute). Braking forces were set at 0.164, 0.331, 0.497, 0.664 and 0.831 kp, respectively. A counter recorded flywheel revolutions each minute for each power output level. A progressive resistance increase was used. Exercise at each PO level was of four minute duration (Glaser et al. 1978-79). Heart rate was recorded during the last 10 seconds of each minute using an electrocardiogram (Cambridge VS 4). The electrocardiogram was set on Lead I with a 25 millimetre per second paper speed. Electrodes were placed on the subject's fifth intercostal space and manubrium. Criteria for termination of an exercise test are presented in Appendix F.

Strength measures

Grip strength was measured using a Pacific Medical Tensiometer. The procedures were as follows:

1. The dynamometer was placed in the subject's palm, dial up, fingers curled over, the second and third knuckles touching the grip.
2. The arm was down at the subject's side, away from the body.
3. On the tester's command, the subject squeezed the dynamometer as tightly as possible.

Two attempts were made for each hand and the higher value was recorded.

Arm flexion and extension strength

Subjects unable to transfer themselves from their wheelchair to a mat on the floor were assisted. For flexion the procedures were:

1. The subject lay in supine position, feet touching the foot rest.

2. The upper arm resting on the floor, making a 90 degree angle with the forearm and perpendicular with the armpit.
3. The stirrup strap on the subject's wrist, palm facing him.
4. The subject was instructed to pull his arm into flexion with as much strength as possible.

The Tensiometer (Pacific Medical) recorded the measurements. Two attempts were made using each hand and the higher value was recorded.

For extension the procedures were:

1. The subject lay in supine position, shoulders resting against the support.
2. The palm of the hand facing the subject, the stirrup strap on the wrist.
3. The upper arm remained on the floor with the elbow in flexion.
4. On command from the tester, the subject extended his arm with as much strength as possible.

Two attempts were made using each hand and the higher value was recorded.

The reliability of the grip, arm flexion and extension strength tests were 0.85, 0.81 and 0.78, respectively.

Analysis of Data

Individual data were presented in tabular and graphical form. This was a descriptive study, and nonstatistical in nature.

Chapter 4

RESULTS

Characteristics of subjects are presented in Table 1. The individual subject (S1-S6) responses to anthropometric, physiological and strength test parameters during the observation period are presented in Tables 2 to 13, and Figures 1 to 3.

Subject 1 (S1)

Body weight values for Test 1 (T_1) and Test 4 (T_4) both equalled 85.9 kg. The mean was 86.0 kg.

Estimated percentage body fat decreased 0.2% between T_1 and T_4 values. The mean was 18.4%.

Right arm extension strength increased 0.4 kg between T_1 and T_4 values. The mean was 22.6 kg. Left arm extension strength increased 4.0 kg between T_1 and T_4 values. The mean was 23.2 kg.

Right arm flexion strength increased 1.1 kg between T_1 and T_4 values. The mean was 20.9 kg. Left arm flexion strength increased 4.5 kg between T_1 and T_4 values. The mean was 22.0 kg.

Right hand grip strength increased 10.0 kg between T_1 and T_4 values. The mean was 55.9 kg. The left hand grip strength increased 3.9 kg between T_1 and T_4 values. The mean was 54.9 kg.

Force vital capacity (FVC) increased 0.2 between T_1 and T_4 values. The mean was 5.6 l. Percentage vital capacity (%VC) increased 6% between T_1 and T_4 values. The mean was 131%. Predicted vital capacity (Pred. VC) was 4.3 l. Forced expiratory volume in one second (FEV_1) was equal for T_1 and T_4 values, both were 5.2 l. The mean was 5.1 l.

Table 2

Body Weight of Wheelchair Basketball Subjects

Subject	Test Session				
	1	2	3	4	$\bar{x}$
1	85.9	85.0	87.3	85.9	86.0
2	61.4	63.0	60.2	60.0	61.2
3	50.5	50.8	50.8	49.5	50.4
4	59.8	59.9	58.6	58.6	59.2
5	78.0	79.7	77.7	77.7	78.3
6	60.5	60.0	57.5	57.7	59.0

Unit is kilograms (kg).

Table 3

Estimated Percentage Body Fat of

Wheelchair Basketball Subjects

Subject	Test Session				
	1	2	3	4	$\bar{x}$
1	18.5	18.4	18.3	18.3	18.4
2	15.9	16.2	17.1	16.8	16.5
3	12.2	12.2	12.2	12.2	12.2
4	13.7	13.2	13.4	12.4	19.3
5	13.3	14.8	13.6	13.6	13.8
6	18.8	19.5	19.3	19.5	19.3

Unit is percentage (%).

Table 4

Arm Extension Strength of

Wheelchair Basketball Subjects

Subject	Right					Left				
	Test Session					Test Session				
	1	2	3	4	$\overline{x}$	1	2	3	4	$\overline{x}$
1	21.2	25.0	22.6	21.6	27.6	21.0	24.2	22.7	25.0	23.2
2	15.9	14.4	15.9	18.2	16.1	17.4	15.9	19.7	21.6	18.7
3	20.5	15.9	15.9	19.7	18.0	19.0	19.0	19.7	19.7	19.4
4	20.5	16.7	20.5	19.7	19.4	19.7	19.0	20.5	21.6	20.2
5	15.1	19.0	15.1	15.9	16.3	15.1	15.9	14.4	17.4	15.7
6	18.2	18.2	18.2	19.7	18.6	17.4	19.7	16.7	17.4	17.8

Unit is kilograms (kg).

Table 5

Arm Flexion Strength of

Wheelchair Basketball Subjects

Subject	Right					Left				
	Test Session					Test Session				
	1	2	3	4	$\bar{x}$	1	2	3	4	$\bar{x}$
1	20.5	21.6	19.7	21.6	20.9	19.7	21.6	21.6	24.2	21.78
2	28.4	27.3	34.9	35.6	31.6	30.3	33.0	26.5	29.6	29.9
3	24.0	21.6	25.0	25.8	24.1	23.5	21.6	22.7	26.5	23.6
4	28.4	27.0	33.0	27.1	28.9	28.4	31.1	30.3	31.1	30.2
5	31.8	31.8	34.9	34.9	33.4	27.3	30.3	34.1	34.9	31.7
6	27.3	27.3	27.3	33.0	28.7	17.4	19.0	21.6	19.0	19.3

Unit is kilograms (kg).

Table 6

Grip Strength of Wheelchair

Basketball Subjects

Subject	Right					Left				
	Test Session					Test Session				
	1	2	3	4	$\bar{x}$	1	2	3	4	$\bar{x}$
1	49.1	57.6	57.6	59.1	55.9	51.1	54.6	54.6	55.0	54.9
2	44.3	47.0	47.0	50.0	47.0	48.5	39.4	38.6	37.5	41.0
3	45.5	47.0	44.3	47.0	46.0	40.1	43.2	51.8	50.9	46.5
4	50.9	43.2	45.5	47.0	46.7	42.1	48.5	52.7	52.7	49.0
5	57.6	56.1	59.1	56.1	57.2	54.6	51.8	53.6	59.1	54.8
6	51.8	54.6	62.5	62.5	57.9	44.3	48.4	47.0	52.7	48.1

Unit is kilograms (kg).

Table 7

Pulmonary Function of Wheelchair Basketball Subjects

Subject	FVC (1)					% vc					FEV_1 (1)					% FEV_1 (1)				
	Test Session					Test Session					Test Session					Test Session				
	1	2	3	4	$\overline{x}$	1	2	3	4	$\overline{x}$	1	2	3	4	$\overline{x}$	1	2	3	4	$\overline{x}$
1	5.4	5.8	5.5	5.6	5.61	126	136	131	132	131	5.2	5.3	4.5	5.2	5.11	97	91	82	93	91
2	5.1	5.0	4.8	4.6	4.9	110	103	100	95	102	3.6	4.6	4.2	4.3	4.2	70	93	87	94	86
3	*	3.6	3.1	2.9	3.2	*	88	83	78	85	*	2.4	2.3	2.1	2.3	*	70	73	71	71.3
4	5.4	5.6	5.6	5.4	5.5	135	141	139	125	135	4.1	4.3	4.0	4.2	4.1	76	77	71	78	75.6
5	5.9	5.9	5.4	5.6	5.7	133	134	123	127	129.3	4.2	4.5	4.1	4.5	4.3	72	77	76	80	76.25
6	3.6	3.3	3.2	3.3	3.4	93	82	79	83	84.3	2.7	2.7	2.8	2.8	2.8	77	80	88	85	82.5

* Technical Error

Table 8

Initial Blood Pressure in Supine Position

of Wheelchair Basketball Subjects

Subject	Systole					Diastole				
	Test Session					Test Session				
	1	2	3	4	$\bar{x}$	1	2	3	4	$\bar{x}$
1	120	124	110	116	118.0	58	68	68	66	65.0
2	124	122	118	124	122.0	60	72	74	82	72.0
3	125	110	120	108	115.8	70	68	68	68	68.5
4	120	114	112	112	114.5	63	72	62	70	66.8
5	132	124	126	128	127.5	80	68	88	82	79.5
6	120	128	132	124	126.0	90	90	78	86	86.0

Unit is millimetres of mercury (mmHg).

Table 9

Initial Blood Pressure in Sitting Position

of Wheelchair Basketball Subjects

Subject	Systole					Diastole				
	Test Session					Test Session				
	1	2	3	4	$\overline{x}$	1	2	3	4	$\overline{x}$
1	118	132	118	120	122	74	84	70	84	76
2	128	132	120	112	123	78	88	86	86	84.5
3	120	118	130	124	123	70	72	62	70	68.5
4	120	119	110	112	115.3	63	78	72	72	71.3
5	124	130	136	120	127.5	76	74	94	82	81.5
6	124	138	130	126	129.5	90	100	86	88	91.0

Unit is millimetres of mercury (mmHg).

Table 10

Mean Arterial Pressure in Supine and Sitting

Positions of Wheelchair Basketball Subjects

Subject	Supine					Sitting				
	Test Session					Test Session				
	1	2	3	4	$\bar{x}$	1	2	3	4	$\bar{x}$
1	79	87	82	83	82.75	89	100	86	89	91.5
2	81	89	89	96	88.8	95	103	97	95	97.5
3	88	82	85	81	84.0	87	87	85	88	86.8
4	82	86	79	84	82.8	82	92	85	85	86.0
5	97	87	101	97	95.5	92	93	108	95	97.0
6	100	103	96	99	99.5	101	113	101	101	104.0

Unit is millimetres of mercury (mmHg).

Table 11

Initial Heart Rate in Supine and Sitting

Positions of Wheelchair Basketball Subjects

Subject	Supine					Sitting				
	Test Session					Test Session				
	1	2	3	4	$\bar{x}$	1	2	3	4	$\bar{x}$
1	63	69	63	63	61.5	72	84	66	66	72.0
2	66	63	66	66	65.2	69	72	66	64	67.75
3	96	81	81	75	83.3	90	87	90	75	85.5
4	84	78	81	75	79.5	90	81	81	78	82.5
5	72	75	66	66	69.8	81	81	78	75	78.8
6	72	60	63	63	64.5	69	63	69	69	67.5

Units is beats/min (bpm)

Table 12

Mean Skinfold Measures of

Wheelchair Basketball Subjects

Subject	Bicep					Tricep					Subscapular					Supra-Iliac				
	Test Session					Test Session					Test Session					Test Session				
	1	2	3	4	$\bar{x}$	1	2	3	4	$\bar{x}$	1	2	3	4	$\bar{x}$	1	2	3	4	$\bar{x}$
1	4.2	4.3	3.3	3.1	3.7	16.6	16.5	16.4	16.4	16.5	13.6	13.3	14.0	14.1	13.8	13.5	13.5	13.6	13.5	13.5
2	4.6	5.1	5.5	5.6	5.2	7.2	6.8	9.0	8.8	8.0	10.4	11.9	12.3	11.5	11.5	7.0	6.2	6.1	6.0	6.3
3	2.6	2.6	2.6	2.6	2.6	3.0	3.2	3.0	3.2	3.1	7.0	6.9	7.0	7.1	7.0	4.1	3.9	3.8	4.0	4.0
4	3.6	3.0	3.4	3.4	3.4	5.0	4.5	5.0	4.9	4.9	7.8	7.7	7.4	7.4	7.6	5.3	5.2	5.3	5.0	5.2
5	3.2	3.1	2.8	3.0	3.0	7.4	8.4	8.4	8.2	8.1	12.4	12.5	12.5	12.8	12.6	8.3	8.4	8.3	7.8	8.2
6	4.0	4.5	4.2	4.4	4.3	11.3	12.5	12.1	12.3	12.0	11.1	12.5	11.8	12.0	11.9	12.3	12.2	12.2	12.5	12.3

Unit is millimetres (mm).

Table 13

Skinfold Summation For

Wheelchair Basketball Subjects

Subject	Test Session				
	1	2	3	4	$\bar{x}$
1	47.9	47.6	47.3	47.1	47.5
2	29.2	30.0	32.9	31.9	31.0
3	16.7	16.6	16.4	16.9	16.7
4	21.7	20.4	21.1	20.7	21.0
5	31.3	32.4	32.0	31.8	31.9
6	38.7	41.7	40.3	41.2	40.5

Unit is millimetres (mm).

Percentage forced expiratory volume in one second (% FEV_1) decreased 4% between T_1 and T_4 values. The mean was 91%.

Initial systolic blood pressure in supine position decreased 4 mmHg between T_1 and T_4 values. The mean was 118 mmHg. Diastolic blood pressure increased 8 mmHg between T_1 and T_4 values. The mean was 65 mmHg.

Initial systolic blood pressure in sitting position increased 2 mmHg between T_1 and T_4 values. The mean was 122 mmHg. Diastolic blood pressure values for T_1 and T_4 both equalled 74 mmHg. The mean was 76 mmHg.

Mean arterial pressure in supine position increased 4 mmHg between T_1 and T_4 values with the mean being 82.8. In sitting position, both T_1 and T_4 values equalled 89 mmHg with the mean being 91.

Initial heart rate in supine position, T_1 and T_4 values both equalled 63 bpm. The mean was 65 bpm. In sitting position, initial heart rate decreased 6 bpm between T1 and T_4 values. The mean was 72 bpm.

Mean heart rate response to power output between T_1 and T_4 values, at 30, 60, 90, 120, and 150 kpm/min increased 1 bpm, and decreased 8, 20, 5 and 7 bpm, respectively.

Subject 2 (S2)

Body weight decreased 1.4 kg between T_1 and T_4 values. The mean was 61.2 kg.

Estimated percentage body fat increased 0.9% between T_1 and T_4 values. The mean was 16.5%.

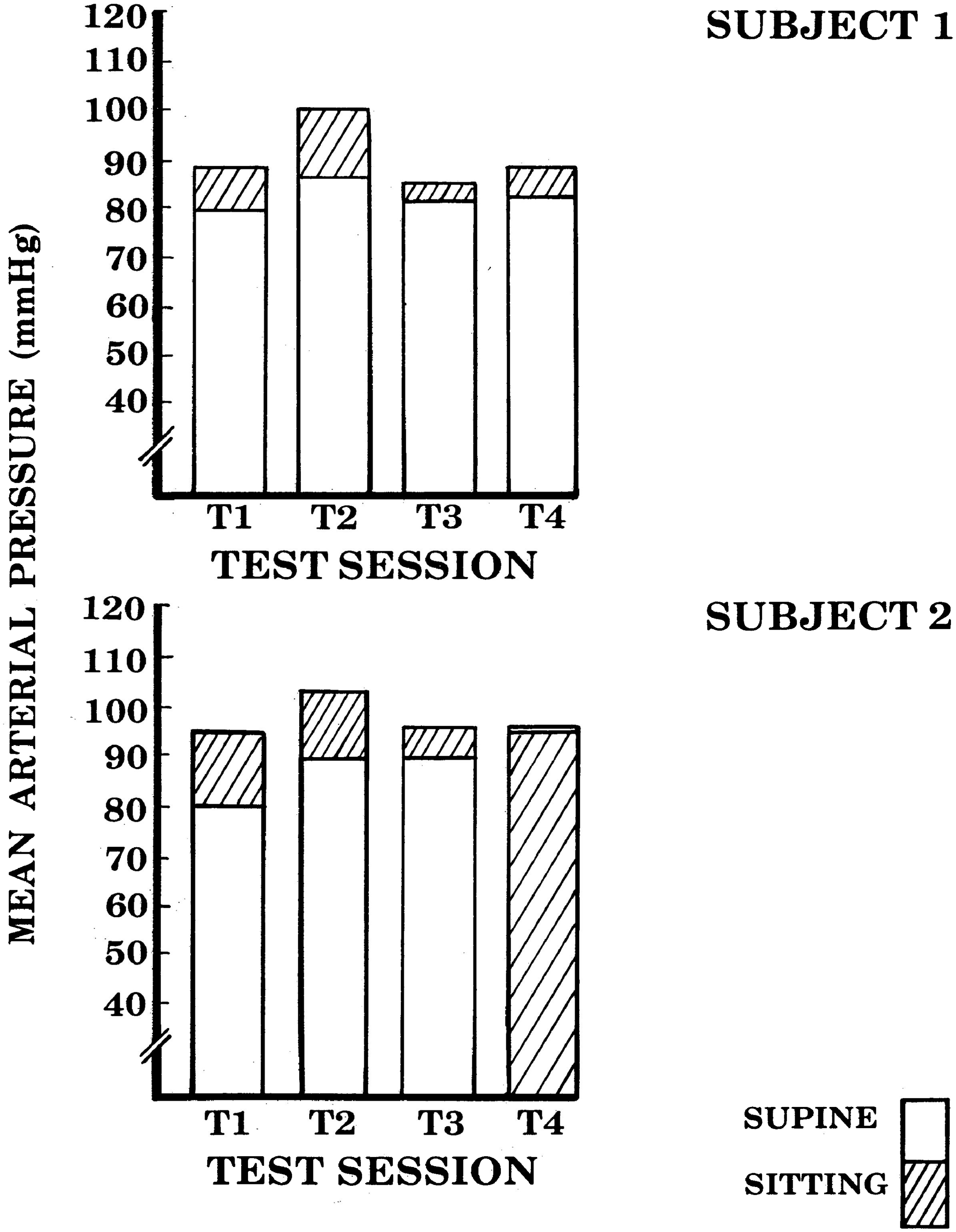


Figure 1. Mean Arterial Pressure in Supine and Sitting Positions of Individual Wheelchair Basketball Subjects

Figure 1. Continued...

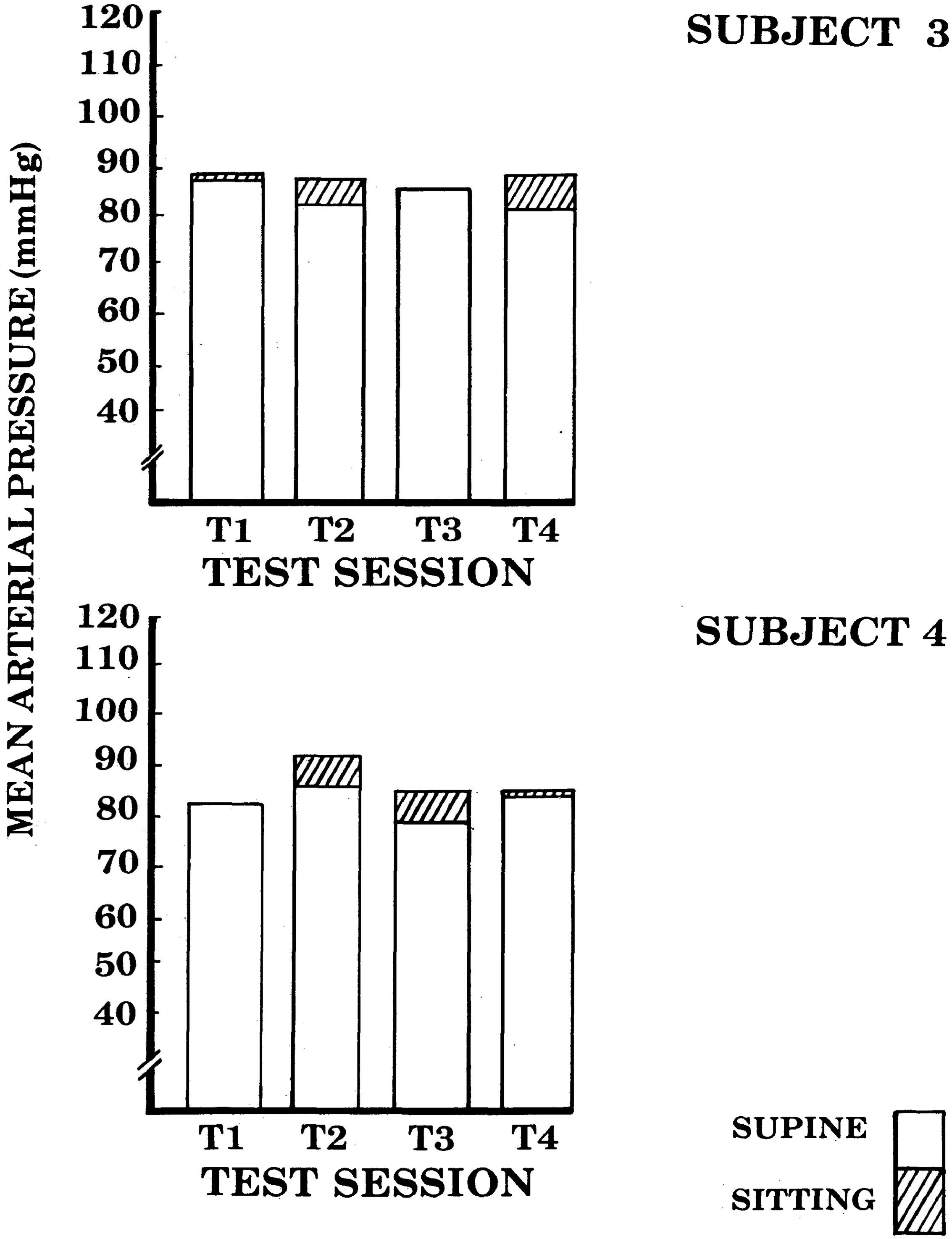
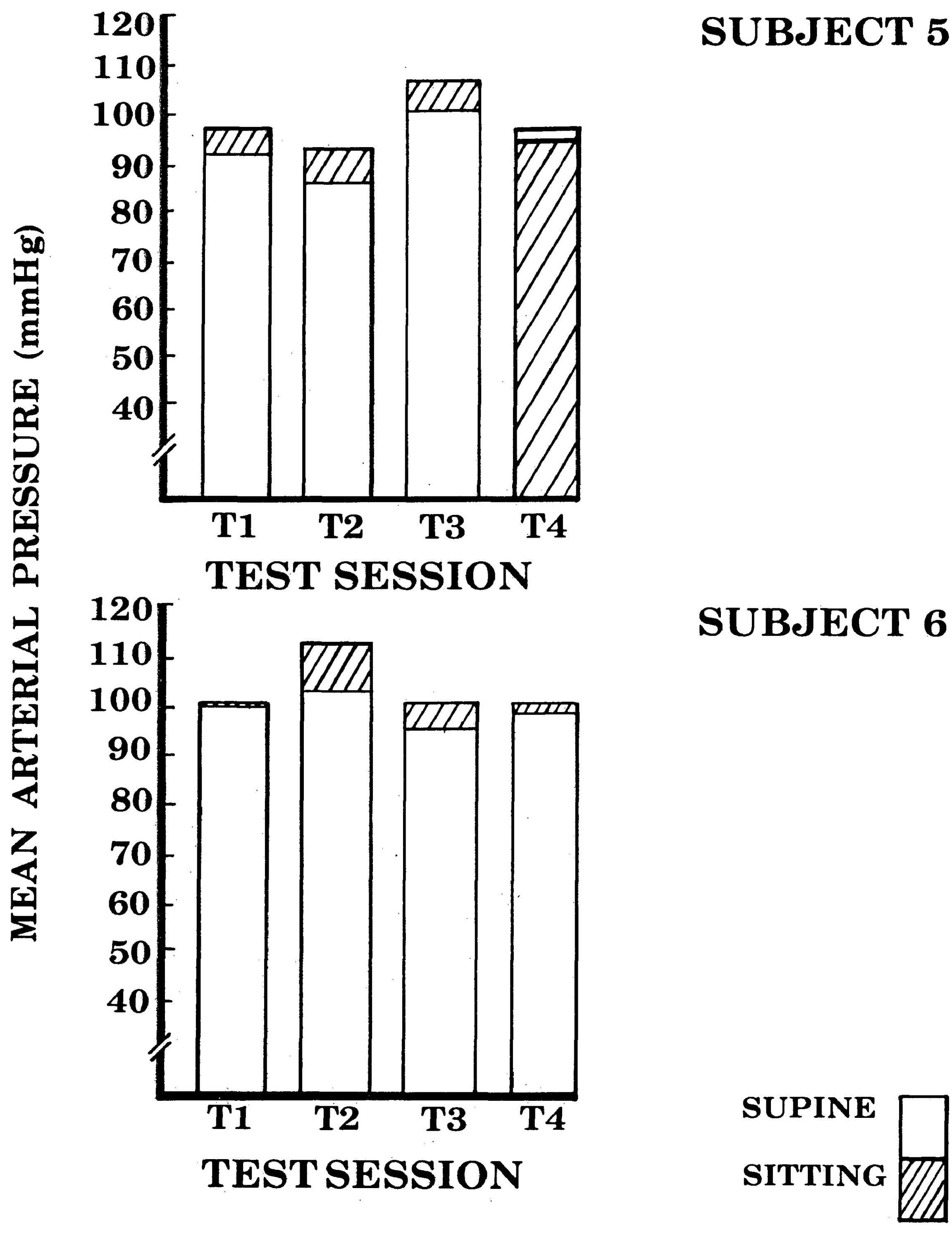


Figure 1. Continued...



Right arm extension strength increased 2.3 kg between T_1 and T_4 values. The mean was 16.1 kg. Left arm extension strength increased 4.2 kg between T_1 and T_4 values. The mean was 18.7 kg.

Right arm flexion strength increased 7.2 kg between T_1 and T_4 values. The mean was 31.6 kg. Left arm flexion strength decreased 0.7 kg between T_1 and T_4 values. The mean was 30.9 kg.

Right hand grip strength increased 5.7 kg between T_1 and T_4 values. The mean was 47.0 kg. Left hand grip strength decreased 11.0 kg between T_1 and T_4 values. The mean was 41.0 kg.

Forced vital capacity (FVC) decreased 0.5 l between T_1 and T_4 values. The mean was 4.9 l. Percentage vital capacity (%VC) decreased 15% between T_1 and T_4 values. The mean was 102%. Predicted vital capacity (Pred. VC) was 4.9 l. Forced expiratory volume in one second (FEV_1) increased 0.7 l between T_1 and T_4 values. The mean was 4.2 l. Percentage forced expiratory volume in one second (%FEV_1) increased 24% between T_1 and T_4 values. The mean was 86%.

Initial systolic blood pressure in supine position, T_1 and T_4 values both equalled 124 mmHg. The mean was 122 mmHg. Diastolic blood pressure increased 22 mmHg between T_1 and T_4 values. The mean was 72 mmHg.

Initial systolic blood pressure in sitting position decreased 16 mmHg between T_1 and T_3 values. The mean was 123 mmHg. Diastole increased 8 mmHg between T_1 and T_4 values. The mean was 85 mmHg.

Mean arterial pressure in supine position increased 15 mmHg between T_1 and T_4 values. In sitting position, T_1 and T_4 values both equalled 95 mmHg.

Initial heart rate in supine position, T_1 and T_4 values both

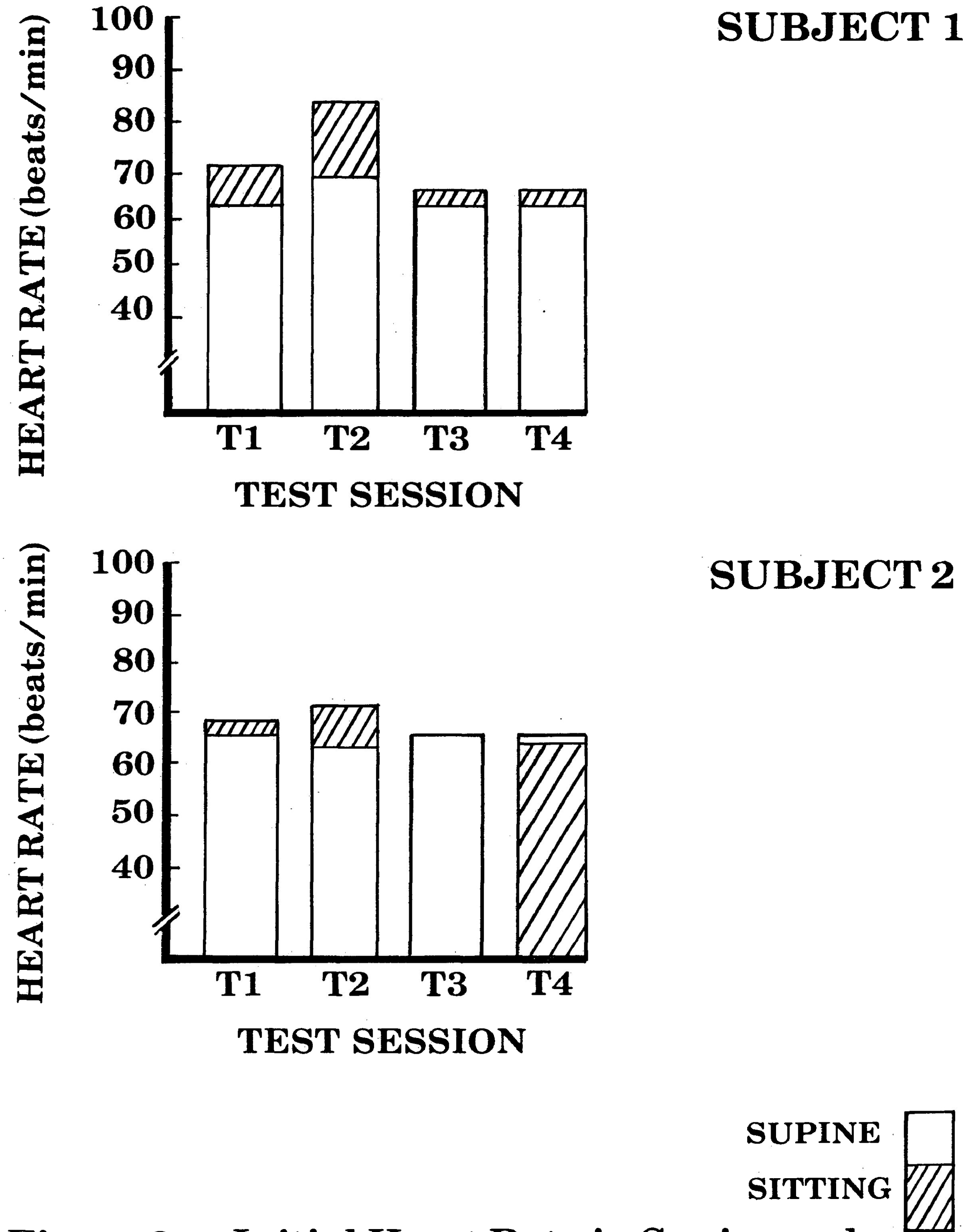
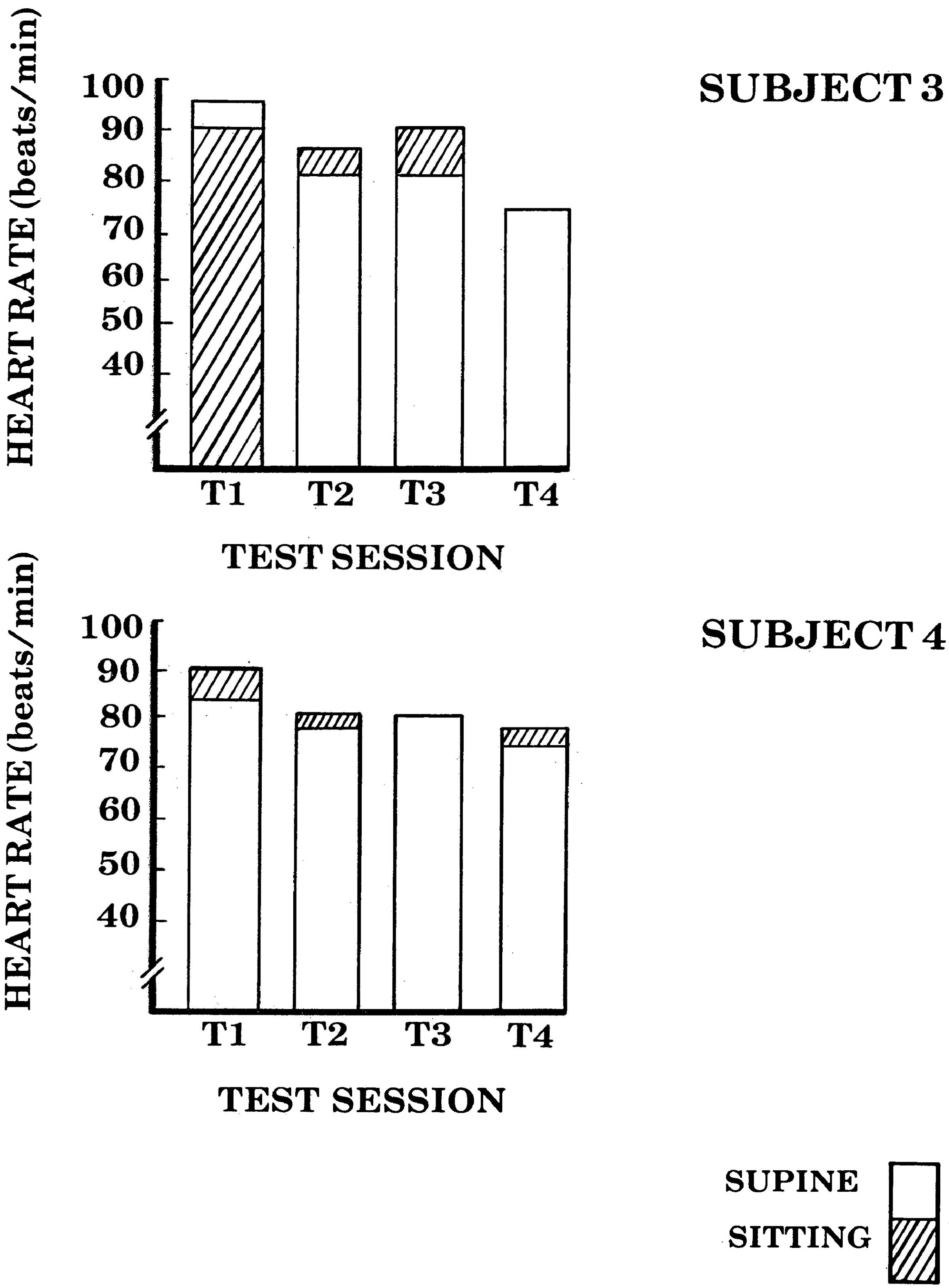


Figure 2. **Initial Heart Rate in Supine and Sitting Positions of Individual Wheelchair Basketball Subjects**

Figure 2. Continued...



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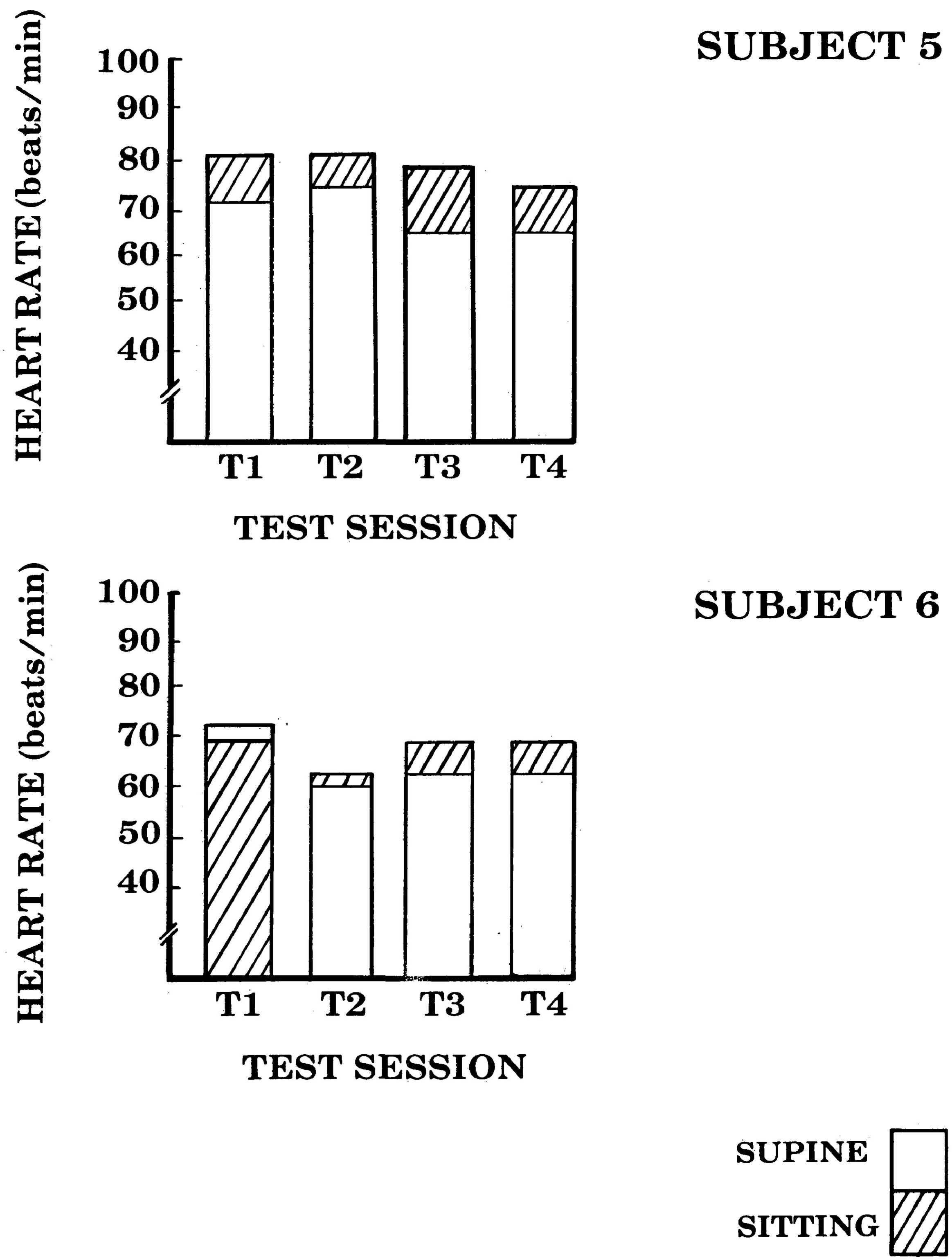


equalled 66 bpm. The mean was 65 bpm. In sitting position, initial heart rate decreased 5 bpm between T_1 and T_4 values. The mean was 68 bpm. Initial heart rate in supine and sitting positions both equalled 66 bpm in T_3 (see Table 11 & Figure 2).

Mean heart rate response to power output between T_1 and T_4, at 30, 60, 90, 120, and 150 kpm/min, increased 24, 25, 15, 15, and 16 bpm, respectively.

Subject 3 (S3)

Body weight decreased 1 kg between T_1 and T_4 values. The mean was 50.4 kg.

Estimated percentage body fat equalled 12.2% throughout the entire study.

Right arm extension strength decreased 0.8 kg between T_1 and T_4 values. The mean was 18.0 kg. Left arm extension strength increased 0.7 kg between T_1 and T_4 values. The mean was 19.4 kg.

Right arm flexion strength increased 1.8 kg between T_1 and T_4 values. The mean was 24.1 kg. Left arm flexion strength increased 3.0 kg between T_1 and T_4 values. The mean was 24.6 kg.

Right hand grip strength increased 1.5 kg between T_1 and T_4 values. The mean was 46.0 kg. Left hand grip strength increased 10.8 kg between T_1 and T_4 values. The mean was 46.5 kg.

Pulmonary function results for T_2, T_3 and T_4 were recorded. T_1 was not included due to technical error (see Table 7). Forced vital capacity (FVC) decreased 0.7 l between T_2 and T_4 values. The mean was 3.2 l. Percentage vital capacity (%VC) decreased 10% between T_2 and T_4 values. The mean was 83%. Predicted vital capacity (Pred. VC) was 3.8 l.

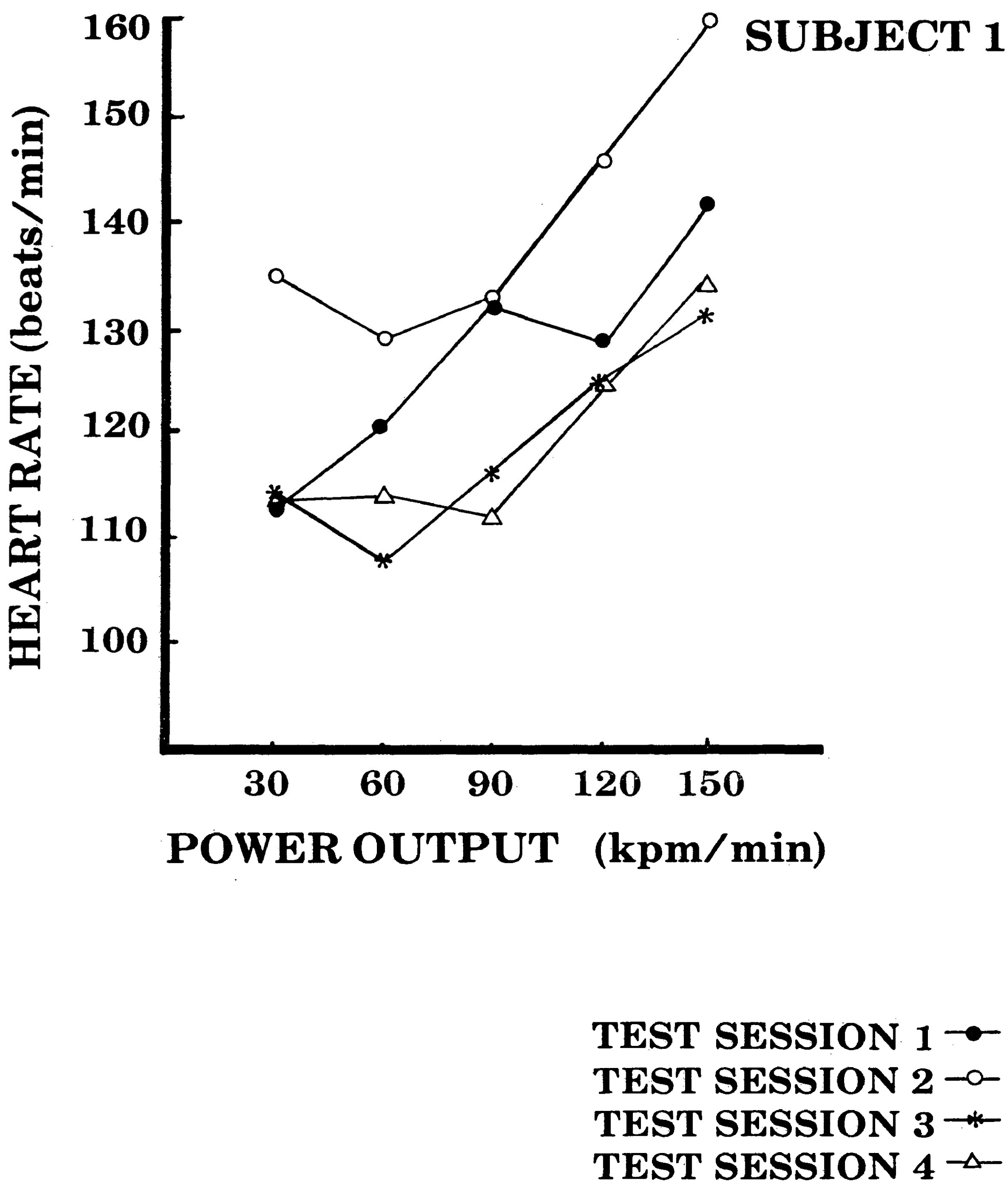
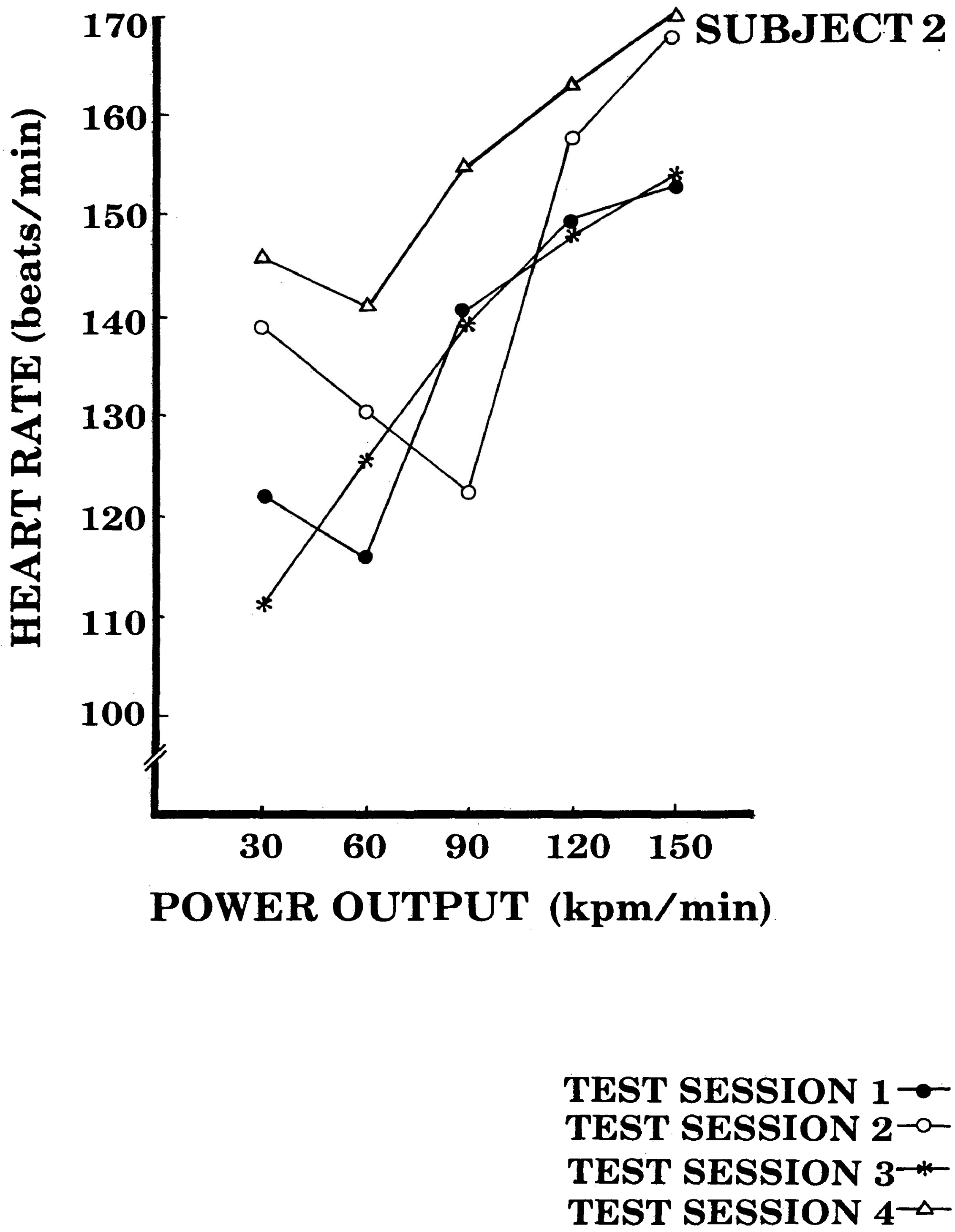


Figure 3. Mean Heart Rate Response to Power Output of Individual Wheelchair Basketball Subjects.

Figure 3. Continued...



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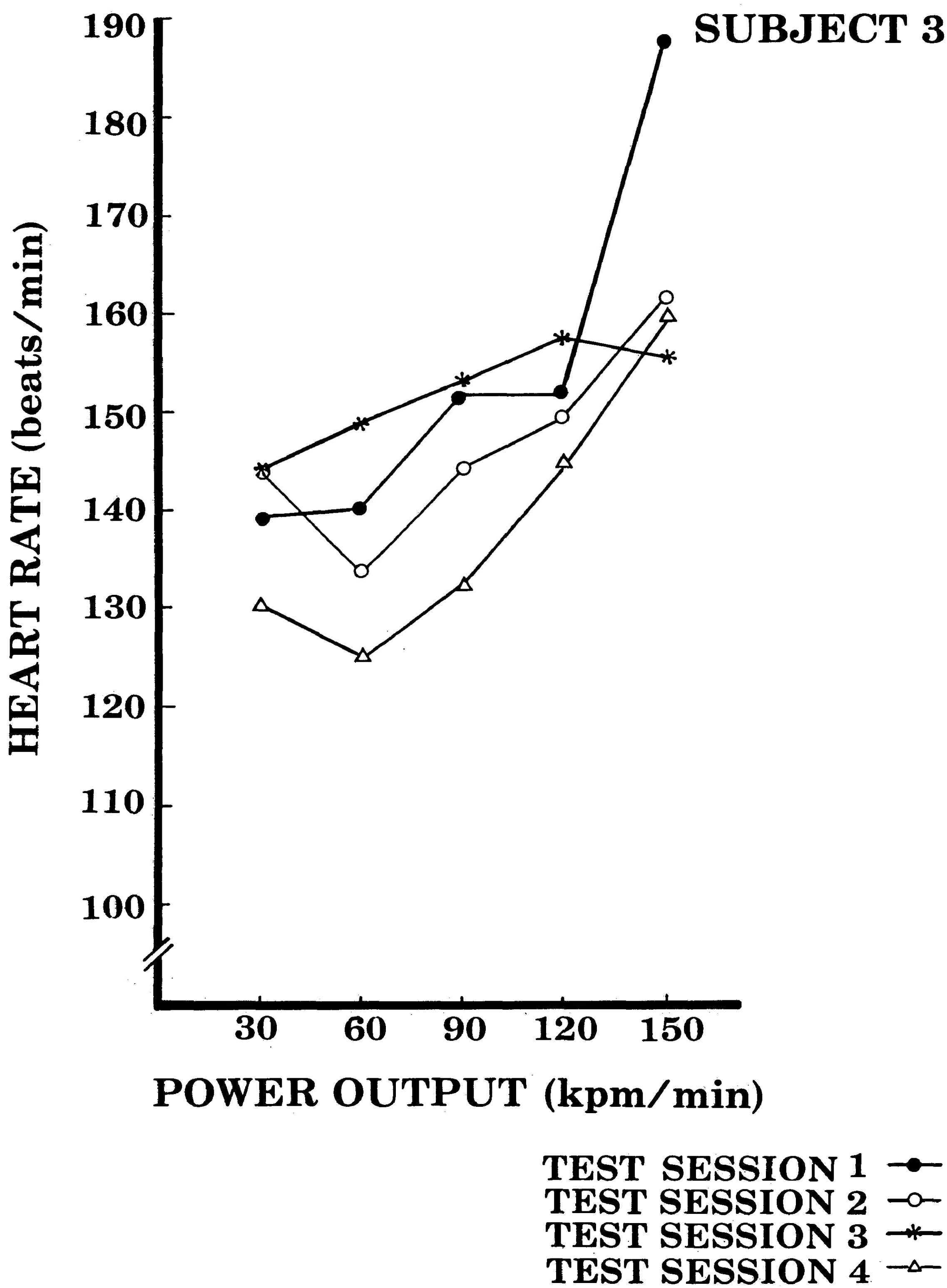

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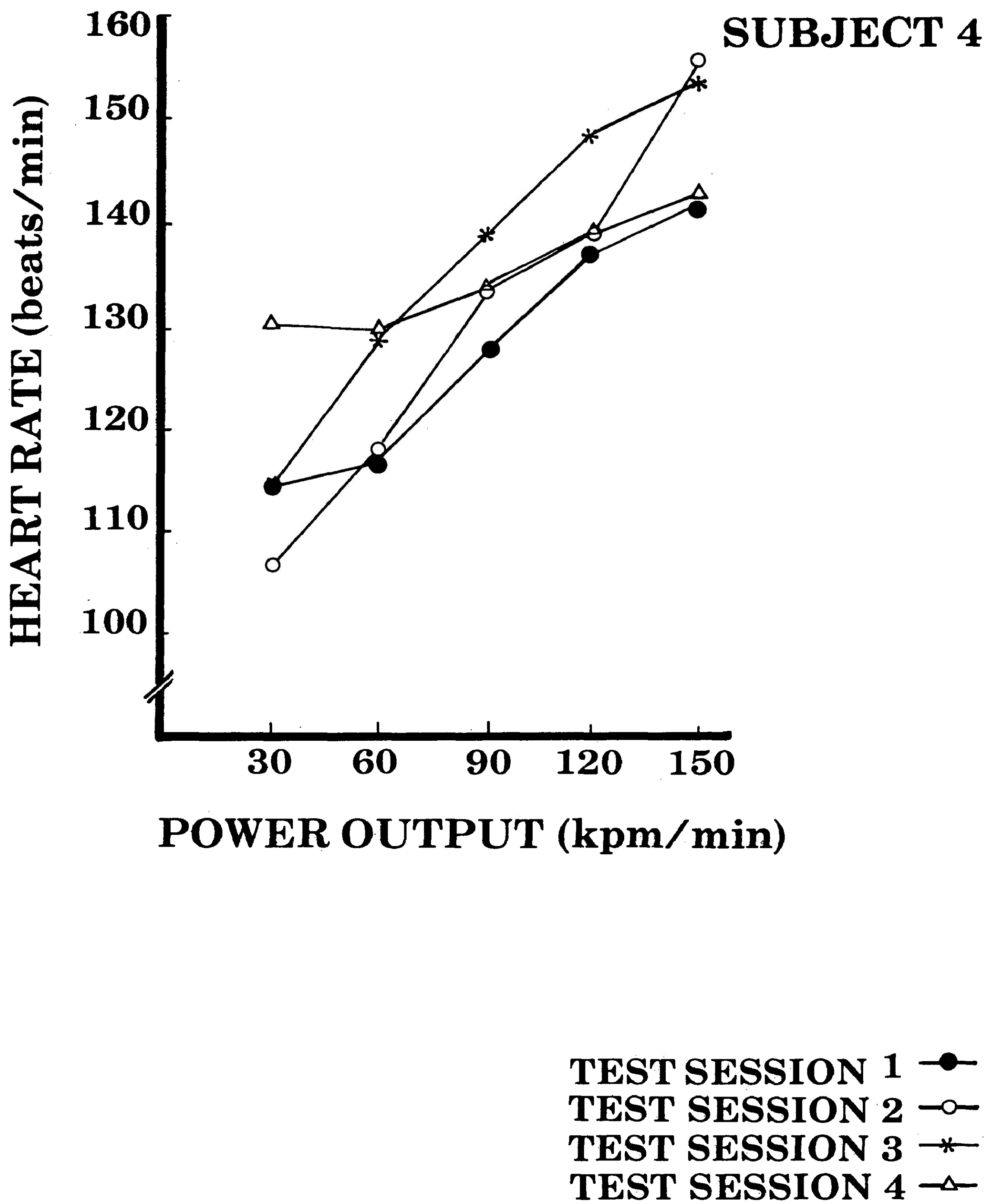

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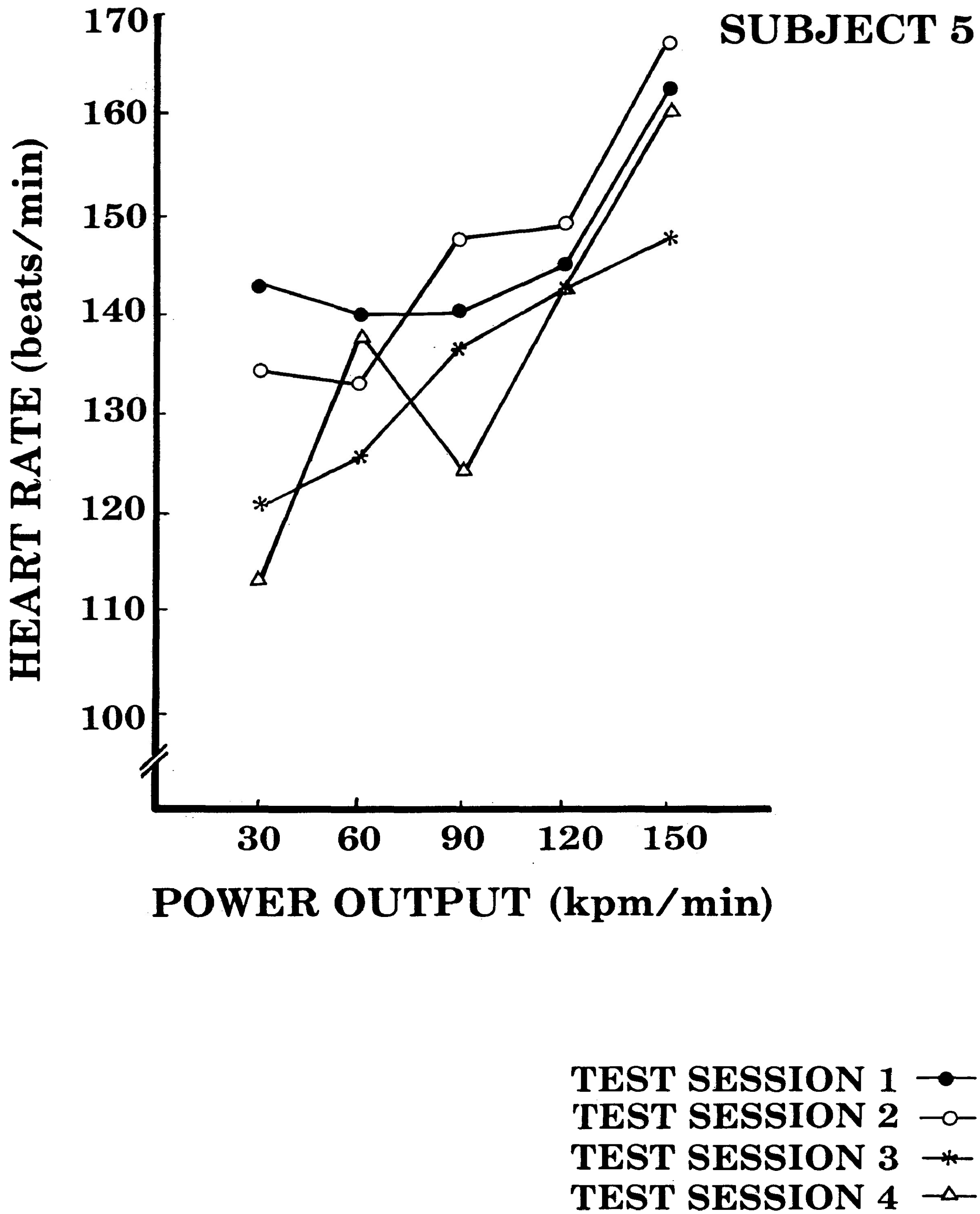
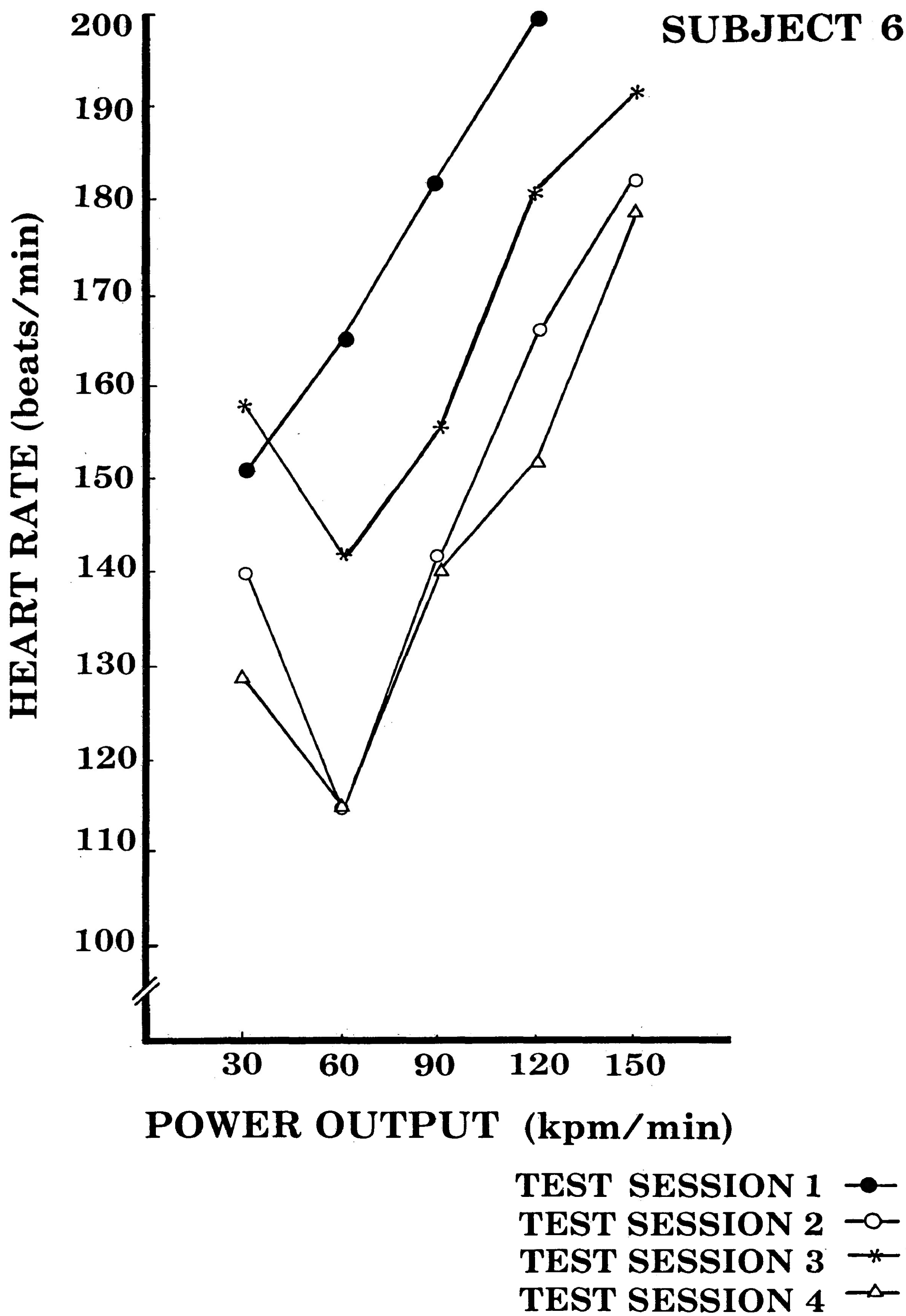


Figure 3. Continued..



Forced expiratory volume in one second (FEV_1) decreased 0.3 l between T_2 and T_4 values. The mean was 2.3 l. Percentage forced expiratory volume in one second (%FEV_1) increased 1% between T_2 and T_4 values. The mean was 72%.

Initial systolic blood pressure in supine position decreased 17 mmHg between T_1 and T_4 values. The mean was 116 mmHg. Diastole decreased 2 mmHg between T_1 and T_4 values. The mean was 69 mmHg.

Initial systolic blood pressure in sitting position increased 4 mmHg between T_1 and T_4 values. The mean was 123 mmHg. Diastole between T_1 and T_4 values, both equalled 70 mmHg. The mean was 69 mmHg.

Mean arterial pressure in supine position decreased 7 mmHg between T_1 and T_4 values. In sitting position, the T_1 and T_4 values increased 1 mmHg. The mean arterial pressure in supine and sitting positions both equalled 85 mmHg in T_3 (see Table 10 & Figure 1).

Initial heart rate in supine position, decreased 21 bpm between T_1 and T_4 values. The mean was 83 bpm. In sitting position, initial heart rate decreased 15 bpm between T_1 and T_4 values. The mean was 86 bpm. Initial heart rate in supine and sitting positions both equalled 75 bpm in T_4 (see Table 11 & Figure 2).

Mean heart rate response to power output between T_1 and T_4 values at 30, 60, 90, 120, and 150 kpm/min, decreased 9, 15, 20, 6, and 29 bpm, respectively.

<u>Subject 4</u> (S4)

Body weight decreased 1.2 kg between T_1 and T_4 values. The mean was 59.0 kg.

Estimated percentage body fat decreased 1.3% between T_1 and T_4 values. The mean was 13.2%.

Right arm extension strength decreased 0.8 kg between T_1 and T_4 values. The mean was 19.4 kg. Left arm extension strength increased 1.9 kg betweeen T_1 and T_4 values. The mean was 20.2 kg.

Right arm flexion strength increased 2.7 kg between T_1 and T_4 values. The mean was 29.9 kg. Left arm flexion strength increased 2.7 kg between T_1 and T_4 values. The mean was 30.2 kg.

Right hand grip strength increased 3.9 kg between T_1 and T_4 values. The mean was 46.7 kg. Left hand grip strength increased 10.6 kg between T_1 and T_4 values. The mean was 49.0 kg.

Forced vital capacity (FVC) for T_1 and T_4 values both equalled 5.4 l. The mean was 5.5 l. Percentage vital capacity (%VC) decreased 10% between T_1 and T_4 values. The mean was 135%. Predicted vital capacity (Pred. VC) was 4.0 l. Forced expiratory volume in one second (FEV_1) increased 0.1 l between T_1 and T_4 values. The mean was 4.2 l. Percentage forced expiratory volume in one second (%FEV_1) increased 2% between T_1 and T_4 values. The mean was 76%.

Initial systolic blood pressure in supine position decreased 8 mmHg between T_1 and T_4 values. The mean was 115 mmHg. Diastole increased 7 mmHg between T_1 and T_4 values. The mean was 67 mmHg.

Initial systolic blood pressure in sitting position, decreased 8 mmHg between T_1 and T_4 values. The mean was 115 mmHg. Diastole increased 9 mmHg between T_1 and T_4 values. The mean was 71 mmHg.

Mean arterial pressure in supine position increased 2 mmHg between T_1 and T_4 values. In sitting position, the T_1 and T_4 values increased

3 mmHg. Mean arterial pressure in supine and sitting positions both equalled 83 mmHg in T_1 (see Table 10 & Figure 1).

Initial heart rate in supine position decreased 9 bpm between T_1 and T_4 values. The mean was 80 bpm. In sitting position, initial heart rate decreased 12 bpm between T_1 and T_4 values. The mean was 83 bpm. Initial heart rate in supine and sitting positions both equalled 81 bpm in T_3 (see Table 11 & Figure 2).

Mean heart rate response to power output between T_1 and T_4 values, at 30, 60, 90, 120, and 150 kpm/min, increased 16, 13, 6, 2, and 1 bpm, respectively.

<u>Subject 5</u> (S5)

Body weight decreased 0.3 kg between T_1 and T_4 values. The mean was 78.0 kg.

Estimated percentage body fat increased 0.3% between T_1 and T_4 values. The mean was 13.8%.

Right arm extension strength increased 0.8 kg between T_1 and T_4 values. The mean was 28.6 kg. Left arm extension strength increased 2.3 kg between T_1 and T_4 values. The mean was 15.7 kg.

Right arm flexion strength increased 3.1 kg between T_1 and T_4 values. The mean was 33.4 kg. Left arm flexion strength increased 7.6 kg between T_1 and T_4 values. The mean was 32.7 kg.

Right hand grip strength decreased 1.5 kg between T_1 and T_4 values. The mean was 57.2 kg. Left hand grip strength increased 4.5 kg between T_1 and T_4 values. The mean was 55.8 kg.

Forced vital capacity (FVC) decreased 0.3 l between T_1 and T_4

values. The mean was 5.7 l. Percentage vital capacity (%VC) decreased 6% between T_1 and T_4 values. The mean was 129%. Predicted vital capacity (Pred. VC) was 4.4 l. Forced expiratory volume in one second (FEV_1) increased 0.3 l between T_1 and T_4 values. The mean was 4.3 l. Percentage forced expiratory volume is one second ($\%FEV_1$) increased 8% between T_1 and T_4 values. The mean was 76%.

Initial systolic blood pressure in supine position, decreased 4 mmHg between T_1 and T_4 values. The mean was 128 mmHg. Diastole increased 2 mmHg between T_1 and T_3 values. The mean was 80 mmHg.

Initial systolic blood pressure in sitting position decreased 4 mmHg between T_1 and T_4 values. The mean was 128 mmHg. Diastole increased 6 mmHg between T_1 and T_4 values. The mean was 82 mmHg.

Mean arterial pressure in supine position, both T_1 and T_4 values equalled 97 mmHg. In sitting position, mean arterial pressure increased 3 mmHg between T_1 and T_4 values.

Initial heart rate in supine position decreased 6 bpm between T_1 and T_4 values. The mean was 70 bpm. In sitting position, initial heart rate decreased 6 bpm between T_1 and T_4 values. The mean was 79 bpm.

Mean heart rate response to power output between T_1 and T_4 values, at 30, 60, 90, 120, and 150 kpm/min, decreased 30, 2, 16, 2, and 1 bpm, respectively.

Subject 6 (S6)

Body weight decreased 2.8 kg between T_1 and T_4 values. The mean was 59.0 kg.

Estimated percentage body fat increased 0.7% between T_1 and T_4

values. The mean was 19.3%.

Right arm extension strength increased 1.5 kg between T_1 and T_4 values. The mean was 19.6 kg. Left arm extension strength values for T_1 and T_4 both equalled 17.4 kg. The mean was 17.8 kg.

Right arm flexion strength increased 5.7 kg between T_1 and T_4 values. The mean was 28.7 kg. Left arm flexion strength increased 1.6 kg between T_1 and T_3 values. The mean was 19.3 kg.

Right hand grip strength increased 10.7 kg between T_1 and T_4 values. The mean was 57.9 kg. Left hand grip strength increased 8.4 kg between T_1 and T_4 values. The mean was 48.1 kg.

Forced vital capacity (FVC) decreased 0.3 l between T_1 and T_4 values. The mean was 3.4 l. Percentage vital capacity (%VC) decreased 10% between T_1 and T_4 values. The mean was 84%. Predicted vital capacity (Pred. VC) was 4.1 l. Forced expiratory volume in one second (FEV_1) increased 0.1 l between T_1 and T_4 values. The mean was 2.7 l. Percentage forced expiratory volume in one second ($\%FEV_1$) increased 8% between T_1 and T_4 values. The mean was 83%.

Initial systolic blood pressure in supine position increased 4 mmHg between T_1 and T_4 values. The mean was 126 mmHg. Diastole decreased 4 mmHg between T_1 and T_4 values. The mean was 86 mmHg.

Initial systolic blood pressure in sitting position increased 2 mmHg between T_1 and T_4 values. The mean was 130 mmHg. Diastole decreased 2 mmHg between T_1 and T_4 values. The mean was 91 mmHg.

Mean arterial pressure in supine position, decreased 1 mmHg between T_1 and T_4 values. In sitting position, mean arterial pressure values for T_1 and T_4 both equalled 101 mmHg.

Initial heart rate in supine position decreased 9 bpm between T_1 and T_4 values. The mean was 65 bpm. In sitting position, initial heart rate values between T_1 and T_4 both equalled 69 bpm. The mean was 68 bpm.

Mean heart rate response to power output between T_1 and T_4 values at 30, 60, 90, and 120 kpm/min decreased 22, 51, 41, and 48 bpm, respectively. This subject completed 120 kpm/min during T_1 only. T_2 and T_4 included completion of 150 kpm/min. Therefore, heart rate decreased 4 bpm between T_2 and T_4 values.

Chapter 5

DISCUSSION

Hildebrandt et al. (1970) concluded that daily wheelchair propelling was not intense enough to facilitate training effects in the circulatory system. Therefore, additional physical activity is necessary to achieve or maintain an improved level of physical fitness. Jochheim and Strohkendl (1973) recommended wheelchair basketball as a suitable sport for maintaining physical fitness in paraplegics. The basketball game was described as having endurance requirements with short intervals of power work, especially during stopping and turning. These characteristics met the criteria for cardiovascular fitness described by the authors.

The subjects in this study had been playing recreational wheelchair basketball twice weekly since January, 1980, which could possibly have had a limiting affect on responses to test parameters in this study. Also, unavoidable limitations of illness and injury, unrelated to training sessions, occurred during the observation period.

There were specific responses which occurred during the six week observation period.

1. Body weight displayed evidence of a minimal reduction in five (S2, S3 S4, S5, S6) of the six subjects ranging from 0.3 - 2.8 kgs. Pollock et al. (1974) showed body weight reductions after a training period. Subject 1 fluctuated in body weight, returning to his original T_1 value at completion of the study. This subject's occupation involves luncheon meeting engagements and social gatherings which could possibly influence his personal dietary habits to a greater degree.

In a healthy able-bodied individual, arm work implies a relatively low degree of strain in the circulation. However, it seems adequate for conditioning individuals with a low physical fitness level (Knutsson et al., 1973). Glaser et al. (1978-79) concluded that physiological reponses to a specific submaximal exercise task are considered inversely related to one's fitness to perform that activity. In a study involving middle-aged able-bodied men, Sime, Whipple, Berkson, MacIntyre and Stamler (1972) noted a consistent trend in decreasing mean heart rate during exercise. The authors offered suggestions such as habituation to the setting and task, learning, and training as possible causes of this phenomenon.

2a) The mean heart rate response to the same power output showed variability among subjects. As shown in Figure 3 the mean heart rate response to the same power output, decreased in four subjects (S1, S3, S5, S6) and increased in two subjects (S2, S4).

b) Hildebrandt et al. (1970) stated that an individuals occupation can assist in determining daily amongs of stress on the circulatory system.

c) In the case of S2, he was unemployed during the observation period, and his daily routine did not involved much physical activity (i.e., wheelchair propelling) to complement training. Subject 4 was a taxi driver, which involves numerous hours sitting, therefore not contributing to his cardiorespiratory fitness. Ekblom and Lundberg (1968) reported a drop in submaximal heart rate, and a rise in mechanical work output after completion of a six-week conditioning program.

The training heart rates were of the age-adjusted technique described by Jensen and Fisher (1979). The training heart rate range of 155 to 165 bpm (80 to 85% of maximal heart rate) was within the average range reported by Pollock et al. (1974).

3. The initial heart rate in supine and sitting positions revealed minimal decreases in five subjects (S1, S2, S3, S4, S5), and no consistency in S6 was noted. Subject 6 was ill between T_3 and T_4 sessions resulting in an interruption in his training, which could have affected his responses.

4. Chawla et al. (1979-80) stressed the importance of the strength component in daily living of the spinal cord injured person. The authors described strength as an important component for balance, mobility, posture, and adequate ventilation. Jones (1949) found studies of grip strength to be indicative of general body strength. The strength test results showed variability in grip, arm flexion and extension strength. Subject's left arm (non-dominant) showed a greater variability than the right. A grip strength value of 51.4 kg was reported by Zwiren and Bar-Or (1974) on wheelchair athletes. S1, S5, and S6 recorded similar, or higher than, grip strength measures of 51.4 kg. S2, S3, and S4 recorded grip strength values lower than the Zwiren and Bar-Or (1974) values of 51.4 kg. Subject 2 complained of arm fatigue during strength tests. This complaint was possibly due to previous strain from physical activity, during the latter part of the observation period. Subject 3 suffered pain in his left arm during T_4. Subject 4 suffered a sore right arm during T_4 as the result of an injury unrelated to wheelchair basketball.

5. One specific test parameter which showed an inconsistency was pulmonary function. S2, S3, S4, S5, and S6 were all heavy smokers.

Raven, Drinkwater, Horvath, Ruhling, Gliner, Sutton and Bolduan (1974), found that the smokers had significantly less inspiratory capacities and mid maximal flows than the nonsmokers. Subject 4 suffered from a cold and nasal congestion during T_2, T_3, and T_4. Subject 5 suffered from a cold and nasal congestion during T_4. Subject 6 was ill during T_3-T_4 which interrupted his training. These unavoidable limitations could have had an affect on individual responses.

Chapter 6

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to monitor anthropometric, physiological and strength responses of physically disabled adult male wheelchair basketball players during a training period.

Utilizing a bi-weekly testing schedule for anthropometric measures, cardiopulmonary function, grip strength, and arm flexion and extension strength, six Thunder Bay wheelchair basketball players were tested. The observation period was six weeks duration while subjects were undergoing wheelchair basketball training.

The investigation was based on an intra-subject case study design. Individual data were presented in tabular and graphical form. This was a descriptive study, and nonstatistical in nature. The results showed a consistent reduction in body weight in five subjects (S2, S3, S4, S5, S6); a decrease in mean heart rate response to the same power output in four subjects (S1, S3, S5, S6); initial heart rate in supine and sitting position decreased in five subjects (S1, S2, S3, S4, S5); and grip strength, arm flexion and extension strength increased.

Conclusions

The following conclusions were made from the results of this study:

1. Varied responses occurred over the six-week observation period of wheelchair basketball training, as evidenced by:
   a) minimal body weight reduction in five subjects (S2, S3, S4, S5, S6)
   b) mean heart rate response to the same power output showed a

variability of responses

c) subject general consensus regarding the WERG test was described as fairly light exercise

d) initial heart rate in supine and sitting position showed a minimal decrease in five subjects

e) grip strength, arm flexion and extension strength showed a variability towards increases

2. There was no pattern of consistency in the following test parameters:

   a) estimated percentage body fat

   b) pulmonary function

   c) systolic and diastolic blood pressure in supine and sitting position

   d) mean arterial pressure

Recommendations

It is recommended to coaches, athletes, and future researchers that:

1. physically disabled individuals begin specifically designed exercise training after completion of the rehabilitation period and continue training indefinitely to gain and/or maintain anthropometric, physiological and strength characteristics of physical fitness.
2. A larger number of participants with similar physical disabilities should be used in future studies to monitor responses and note general trends.
3. A study be carried out employing experimental and control groups to discover whether comprehensive wheelchair basketball training was a contributing factor towards the variability of responses to body weight; mean heart rate response to the same power output; initial heart rate, and grip strength, arm flexion and extension strength.

REFERENCES

Arviko, I. Physical fitness for individuals with ambulatory problems. Leisurability, 1978, 5, 19-25.

Åstrand, I. Aerobic work capacity in men and women with special reference to age. Acta Physiologic Scandinavica Supplement (169), 1960, 49, 90-92.

Åstrand, I., Guharay, A., & Wahren, I. Circulatory responses to arm exercise with different arm positions. Journal of Applied Physiology, 1968, 25, 528-532.

Åstrand, P.-O., Ekblom, B., Messin, R., Saltin, B., & Stenberg, J. Intra-arterial blood pressure during exercise with different muscle groups. Journal of Applied Physiology, 1965, 20, 253-256.

Åstrand, P.-O., & Rodahl, K. Textbook of work physiology (2nd ed). New York: McGraw-Hill, 1977.

Blakiston's Gould Medical Dictionary. New York: McGraw-Hill, 1972.

Boelter, J. G., Hosler, W. W., & Orr, R. E. Classification. Sports 'N Spokes, 1978, 3, 15-17.

Brattgard, S. O., Grimby, G., Hook, O., & Cronquist, A. Energy expenditure and heart rate in driving a wheelchair ergometer. Scandinavian Journal of Rehabilitation Medicine, 1970, 2, 143-148.

Chawla, J. C., Bar, C., Creber, I., Price, J., & Andrews, B. Techniques for improving the strength and fitness of spinal injured patients. Paraplegia, 1979-80, 17, 185-189.

Clarke, H. H. Muscular strength and endurance in man. Englewood Cliffs, New Jersey: Prentice Hall, 1966.

Clausen, J., Trap-Jensen, J., & Lassen, N. The effects of training on the heart rate during arm and leg exercise. Scandinavian Journal of Clinical Laboratory Investigation, 1970, 26, 295-301.

Davies, C. T. M. & Sargeant, A. J. Physiological responses to one- and two-limb work in the sitting position. Journal of Physiology, 1973, 232, 91-92.

Dawson, G. A., William, S. T., & Rape, S. M. Heart rate and athletics. Sports 'N Spokes, 1980, 6, 13-14.

Durnin, J. V. G., & Womersley, J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged 16 to 72 years. British Journal of Nutrition, 1974, 32, 77-97.

Ekblom, B., & Lundberg, A. Effect of physical training on adolescents with severe motor handicaps. Acta Paediatrica Scandinavica, 1968, 57, 17-23.

Fox, E. Sport physiology. Philadelphia: W. B. Saunders, 1979.

Glaser, R. M., & Chao, A. Y. Power output and energy cost of wheelchair ambulation. Federation Proceeding, 1976, 35, 529. (Abstract)

Glaser, R. M., Ginger, J. F., & Laubach, L. L. Validity and reliability of wheelchair ergometry. Physiologist, 1977, 20, 34. (Abstract)

Glaser, R. M., Foley, D. M., Laubach, L. L., Sawka, M. N., & Suryaprasad, A. G. An exercise test to evaluate fitness for wheelchair activity. Paraplegia, 1978-79, 16, 341-349.

Glaser, R. M., Laubach, L. L., Sawka, M. N., & Suryaprasad, A. G. Exercise stress, fitness evaluation and training of wheelchair users. In: Proceedings - International Conference on Life-Style and Health, 1978: Optimal Health and Fitness for People with Physical Disabilities, edited by A. S. Leon, and G. J. Amundson. Minneapolis, MN: University of Minnesota Press, 1979, 167-194. (a)

Glaser, R. M., Sawka, M. N., Laubach, L. L., & Suryaprasad, A. G. Metabolic and cardiopulmonary responses to wheelchair and bicycle ergometry. Journal of Applied Physiology, 1979, 46, 1066-1070. (b)

Glaser, R. M., Barr, S. A., Laubach, L. L., Sawka, M. N., & Suryaprasad, A. G. Relative stresses of wheelchair activity. Human Factors, 1980, 22, 177-181. (a)

Glaser, R. M., Sawka, M. N., Young, R. E., & Suryaprasad, A. G. Applied physiology of wheelchair design. Journal of Applied Physiology, 1980, 48, 41-44. (b)

Guttmann, L. Significance of sport in rehabilitation of spinal paraplegics and tetraplegics. Journal of the American Medical Association, 1976, 236, 195-197.

Guyton, A. Basic human physiology. London: W. B. Saunders Company, 1977.

Hersen, M., & Barlow, D. Single case experimental designs: strategies for studying behavior change. Toronto: Pergamon Press, 1976.

Hildebrandt, G., Voigt, E., Bahn, D., Berendes, B., & Kroger, J. Energy costs of propelling a wheelchair at various speeds: cardiac response and effect of steering accuracy. Archives of Physical Medicine and Rehabilitation, 1970, 51, 131-136.

Hjeltnes, N. Oxygen uptake and cardiac output in graded arm exercise in paraplegics with low level spinal lesions. Scandinanvian Journal of Rehabilitation Medicine, 1977, 9, 107-113.

Hjeltnes, N., & Vokac, Z. Circulatory strain in everyday life of paraplegics. Scandinavian Journal of Rehabilitation Medicine, 1979, 11, 67-73.

Hüllemann, K. D., List, M., Matthes, D., Wiese, G., & Zika, D. Spiroergometric and telemetric investigations during the XXI International Stoke Mandeville Games 1972 in Heidlberg. Paraplegia, 1975, 13, 109-123.

Jensen, C., & Fisher, A. Scientific basis of athletic conditioning. Philadelphia: Lea & Febiger, 1979.

Jochheim, K. A., & Strohkendl, H. The value of particular sports of the wheelchair-disabled in maintaining health of the paraplegic. Paraplegia, 1973, 11, 173-178.

Johnstone, K. Wheelchair competitors' swim 'n, track and field classification. Sports 'N Spokes, 1978, January/February, 16-17.

Jones, H. E. Motor performance and growth. Berkeley: University of California Press, 1949.

Keys, A. Body composition and its change with age and diet. Weight Control (Colloquium Presentation) Ames, Iowa: Iowa State College Press, 1955.

Knutsson, E., Lewenhaupt-Olsson, E., & Thorsen, M. Physical work capacity and physical conditioning in paraplegic patients. Paraplegia, 1973, 11, 205-216.

Maloney, F. P. Pulmonary function in quadriplegia: effects of a corset. Archives of Physical Medicine and Rehabilitation, 1979, 60, 261-265.

Marincek, C. R. T., & Valencic, V. Armcycloergometry and kinetics of oxygen consumption in paraplegics. Paraplegia, 1977-78, 15, 178-185.

McCafferty, W., & Horvath, S. Specificity of exercise and specificity of training: a subcellular review. Research Quarterly, 1977, 48 (2), 358-371.

McPherson, G. National games for disabled athletes. Leisurability, 1979, 6, 8-13.

National Wheelchair Basketball Association Official Rules. Toronto Spitfires Wheelchair Sports Team Yearbook, 1980-81.

Neir, K., & Dobratz, P. Basketball drills handbook, Washington, 1978.

Nilsson, S., Staff, P. H., & Pruett, E. D. R. Physical work capacity and effect of training on subjects with long standing paraplegia. Scandinavian Journal of Rehabilitation Medicine, 1975, 7, 51-56.

Odéen, I. Training of physical work capacity in wheelchair patients. Sollentuna, Sweden: Rahabforlaget, 1972.

Pollock, M. L., Miller, H. S., Linnerud, A. C., Laughride, E., Coleman, E., & Alexander, E. Arm pedaling as an endurance training regimen for the disabled. Archives of Physical Medicine and Rehabilitation, 1974, 55, 418-424.

Raven, P. B., Drinkwater, B. L., Horvath, S. M., Ruhling, R. O., Gliner, J. A., Sutton, J. C., & Bolduan, N. W. Age, smoking habits, heat stress, and their interactive effects with carbon monoxide and peroxyacetylnitrate on man's aerobic power. International Journal of Biometeor, 1974, 18 (3), 222-232.

Schneider, E. A cardiovascular rating as a measure of physical fatigue and efficiency. Journal of the American Medical Association, 1920, 74, 1507-1510.

Sime, W. E., Whipple, I. T., Berkson, D., MacIntyre, W. C., & Stamler, J. Reproducibility of heart rate at rest and in response to submaximal treadmill and bicycle ergometer test in middle aged men. Medicine and Science in Sports, 1972, 4 (1), 14-17.

Shoenfeld, Y., Shapiro, Y., Ohry, H., Levy, Y., Udassin, R., Drory, Y., Rozin, R., & Sohar, E. Orthostatic hypotension in amputees and subjects with spinal cord injuries. Archives of Physical Medicine and Rehabilitation, 1978, 59, 138-141.

Stenberg, J., Åstrand, P -O., Ekblom B., Royce, J., & Saltin, B. Hemodynamic response to work with different muscle groups, sitting and supine. Journal of Applied Physiology, 1967, 22, 61-70.

Thompson, C. W. Changes in body fat estimated from skinfold measures of varsity college football players during a season. Research Quarterly, 1959, 30, 87-93.

Voigt, E., & Bahn, D. Metabolism and pulse rate in physically handicapped when propelling a wheelchair up an incline. Scandinavian Journal of Rehabilitation Medicine, 1969, 1, 101-106.

Ward, G. R. Some thoughts on the athlete and coach. Wheelers Choice, 1980, 2, 6-7.

Wolfe, G. A., Waters, R., & Hislop, H. J. Influence of floor surface on the energy cost of wheelchair propulsion. Physical Therapy, 1977, 57, 1022-1027.

Zwiren, L. D., & Bar-Or, O. Responses to exercise of paraplegics who differ in conditioning level. Medicine and Science in Sport, 1974, 7, 94-97.

Zwiren, L. D., Huberman, G., & Bar-Or, O. Cardiopulmonary functions of sedentary and highly active paraplegics. Medicine and Science in Sport, 1973, 5, 63. (Abstract)

APPENDICES

APPENDIX A

SUBJECT BACKGROUND INFORMATION SHEET

SUBJECT BACKGROUND INFORMATION

Name:

Birthdate:

Physical Disability:

Level of Injury:

Traumatic or Disease: Date:

Classification:

Mode of Ambulation:

Spasms: YES NO

Physician:

Therapist:

Occupation:

Athletic Experience:

Past Activities:

Duration:

Coach:

Present Activities:

Duration:

Coach:

Additional Comments:

Handedness: RIGHT LEFT

NONSMOKER SMOKER

APPENDIX B

CONSENT FORM

CONSENT FORM

Date: ______________________________

I, ________________________________ understand the testing parameters, techniques and training period involved. I am aware of any potential risks involved, and give my permission as a participant in both testing sessions and training period. Lakehead University, the experimenters and investigators are not responsible for any injury or illness which may occur during or as a result of this study. The subject will remain anonymous and confidentiality will be preserved.

Thesis Advisor(s):

Investigator:

Experimenter(s):

APPENDIX C

TEST DATA SHEET

TEST DATA

SUBJECT:

ANTHROPOMETRIC MEASURES

Body Weight

Date	kg

Height (cm)

Skinfold (mm)

Date	Subscap.		Tricep		Bicep		Supra-Il.	
	T1	T2	T1	T2	T1	T2	T1	T2

PHYSIOLOGICAL MEASURES

Pulmonary Function

Date	FEV_1			$\%FEV_1$			FVC			%VC			Pred. VC
	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	

Initial Heart Rate (bpm)

Date	Supine	Sitting

Initial Blood Pressure (mmHg)

Date	Supine	Sitting

Mean Arterial Pressure

Date	Supine	Sitting

Heart Rate Response to Power Output

Power output (kpm/min)	Date: Heart rate (bpm)				Date: Heart rate (bpm)			
	1*	2	3	4	1	2	3	4
30								
60								
90								
120								
150								

* min.

Power output (kpm/min)	Date: Heart rate (bpm)				Date: Heart rate (bpm)			
	1*	2	3	4	1	2	3	4
30								
60								
90								
120								
150								

* min.

STRENGTH MEASURES

Grip Strength (kg)

Date	Right		Left	
	T1	T2	T1	T2

Arm Flexion (kg)

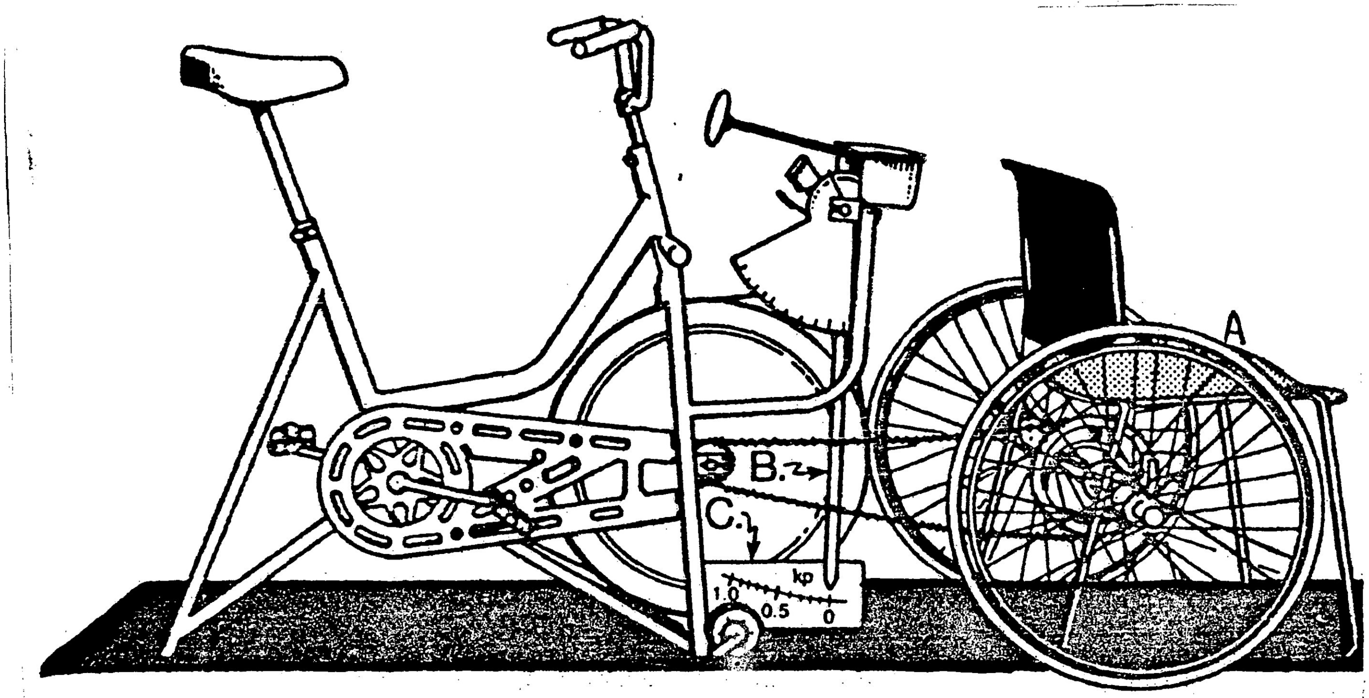
Date	Right		Left	
	T1	T2	T1	T2

Arm Extension (kg)

Date	Right		Left	
	T1	T2	T1	T2

APPENDIX D

A WHEELCHAIR ERGOMETER



(Glaser et al., 1979c)

A Speedometer

B Lengthened Pendular Arm

C Expanded Braking Force Scale

APPENDIX E

TYPICAL TRAINING SESSIONS

TYPICAL TRAINING SESSION

Warm-up (20 minutes)

The warm-up consisted of individual subjects wheeling full court with several sprint intervals. Following this, the players dribbled in place; ball handled around their chair, and down court alternating hands. The dribbling was followed by shooting from designated points surrounding the key.

Skill Development Period (20 minutes)

This period concentrated on individual skill development. Drills involving shooting, passing, speed dribbling, pivoting and rebounding were practiced. These drills were performed in groups, pairs and individually.

Cardiovascular Conditioning Period (2-5 minutes)

This period consisted of maximal sprint efforts performed in 45 seconds, full and half court; sprint-pivot, and fast-break drills. Players took their heart rate by palpitation and this value was recorded. The training heart rate (THR) individual players worked at was 80 percent of their expected maximal heart rate. The formula was:

Expected Maximal Heart Rate = 220 - Age
THR = Expected Maximal Heart Rate x 0.8 (Jensen & Fisher, 1979)

Break Period (5 minutes)

This period was primarily for rest and fluid intake.

Technical Period (10 minutes)

The technical period was used to discuss offense, defence, and rules of wheelchair basketball. Hypothetical game situations were simulated.

Scrimmage Period (50 minutes)

During this period an actual wheelchair basketball game was played. The game was continuous and technical corrections were made during play.

Cool Down Period (5-10 minutes)

This period consisted of slow wheeling and coasting in chairs and individual shooting.

Players were reminded to work at their own level during training sessions. Symptoms such as shortness of breath, chest pain, nausea, feeling faint or dizzy would have resulted in cessation of training for the individual.

Due to sensory loss in paraplegics, there was a possibility of inducing pressure sores by the increased skin strain during exercise. Thus, care was taken to unload the body supporting skin areas at regular intervals (Knutsson et al., 1973).

APPENDIX F

CRITERIA FOR TERMINATION OF AN EXERCISE TEST

CRITERIA FOR TERMINATION OF AN EXERCISE TEST

1. increasing chest pain, suggestive of angina.
2. extreme fatigue.
3. sudden onset of pallor and sweating, or of cyanosis.
4. dizziness or faintness.
5. frequent ventricular premature beats.
6. symmetrical T-wave inversion of 0.3 mV or more not present at rest. S-T segment depressions of 0.2 mV or more with horizontal or downward sloping of the S-T segment, or horizontal S-T segment elevations of 0.2 mV or more.
7. fall of more than 25 mm blood pressure in systolic pressure.
8. systolic blood pressure in excess of 280 mm of mercury.

APPENDIX G

WHEELCHAIR CLASSIFICATION CHARACTERISTICS

WHEELCHAIR CLASSIFICATION CHARACTERISTICS

Athletes are classified by degree of disability and compete in their respective class. This official classification is based on muscular function and is a prerequisite for competition.

INTERNATIONAL MUSCLE TESTING SCALE

0 A total lack of voluntary muscle contraction (complete paralysis)

1 Contraction without mobility (trace or flicker)

2 Contraction with weak movement when gravity is eliminated (poor)

3 Contraction allowing full range against gravity (fair)

4 Contraction allowing movement against manual resistance and gravity (good)

5 Contraction allowing movement against strong manual resistance or normal strength (normal)

Categorization

Spinal Lesion Level	Category	
Cervical	1A	Triceps 0-3 on testing scale
	1B	Triceps 4-5 on testing scale
	1C	
Thoracic $T_1 - T_5$	II	Loss of sensation below nipple line No abdominals Normal uppers
T_6-T_{10}	III	Poor balance - able to maintain the position but cannot resist a challenge to balance Upper abdominal function Thoracic spinal extensors
Lumbar	IV	Good balance - can take moderate resistance in challenge to balance

Spinal Lesion Level	Category	
L_1-L_2	IV	Upper and lower abdominal function May have hip flexors and weak quadriceps - 0-2 on testing scale Therefore, some muscle function in the legs, in two of the four hip muscle groups measured, and in knee extensors. Bilateral Amputees above knee.
Sacral	V	Good balance - the athlete can maintain the position and take good to normal resistance in challenge to balance. Lower extremity power Walkers Quadriceps 3-5 on testing scale.

(Boelter, Hosler & Orr, 1978).