The Effects of Different Forms of Exercise on Body Composition and Cardiorespiratory Fitness in Previously Sedentary Females

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Erratum in the light of Examiners Comments

Amendments

1. Appendix B. 1., new heading 'Pre-training Mean Values and Comparisons of Age, Body Mass, Height, Blood Pressure, Pre-Exercise Heart Rate, Circumferences, Skinfold Measurements and Estimated VO_2max for Control, 'Pump It' and Walking groups, Experiment 2 (Week = 0)'.
   Appendix B.2., new heading 'ANOVA Summary Tables Comparing Groups Prior to Exercise Intervention, Experiment 2 (Week = 0)'
2. Pg. 42, replace incorrectly written formula 'Work = Mass x Vertical height' with Work = Force x Distance (vertical height) and Force = Mass x Acceleration (where acceleration is that due to Gravity, ~9.81 $m.s^{-2}$) as was used for the calibration and calculation of Work on the treadmill.
3. Typographical and spelling errors:

Abstract line 2	add 'physical' before training.
Pg. v 1.1.8	'F' instead of 'f' in Fitness
Pg. xi	VO2 – Volume of oxygen consumption (ml/kg/min), VO2max – Maximal Volume of Oxygen Consumed (ml/kg/min)
Throughout text	V should have a dot over it when it is integrated with time
Pg. 10 pgraph 3	spelling of cardiorespirator<u>y</u>
Pg. 14 pgraph 4	whose rather than who's
Pg. 36 pgraph 3	Replace currently with previously
Pg. 37 pgraph 2	labs should read laboratories
Pg. 41 pgraph 2	replace 'Q' with RER
Pg. 46 pgraph 4	should read 'duration *at which* the exercises'
Pg. 48 pgraph 3	change 'inputed' to 'entered'
Pg. 49 pgraph 2	delete 'also represented' replace with 'in'
Pg. 53 pgraph 2	remove 'for gas'
Pg. 54 pgraph 3	remove 'to'
Pg. 59 pgraph 4	between fifty five *and* sixty minutes
Pg. 74 pgraph 1	remove 'greater'
Throughout text	ACSM's (not ASCM's) Resource Manual for Guidelines for Exercise Testing and Prescription, 3rd Edition (1998)
Throughout text	the correct symbol for the statistical term alpha is α not ∞
Appendix D5	the workload for subject 2 should be Watts not L/min

4. Errors and omissions in the Bibliography

Pg. 84	Baldy et al were contributing authors. Change to ACSM
Throughout text	journal 'Medicine and Science in Sports and Exercise' is incorrectly cited as Exercise & Science in Sports and Exercise.

Abstract

Thirty-five healthy females between the ages of 18 and 45 who had not undertaken any training for at least two months prior to the experiment were studied to determine the effects of six weeks of 'Pump It' aerobics or walking training on body composition and cardiorespiratory fitness, expressed as estimated maximal oxygen consumption (VO_2max). Twelve of the volunteers participated in 'Pump It' aerobics while eleven took part in walking training. The remaining twelve subjects served as controls.

Prior to the training programme, subjects were assessed for their current levels of cardiorespiratory fitness and body composition (fitness test 1). Testing was repeated at the conclusion of the training period (fitness test 2). Estimated VO_2max was determined from heart rate and oxygen uptake during a submaximal treadmill-walking test. This method was validated in a preliminary experiment. Oxygen consumption during 'Pump It' was overestimated by approximately 0.38L/min using the HR/VO_2 relationship obtained during treadmill walking. This was taken into account for the calculation of VO_2 in Experiment 2. Body composition was evaluated from the sum of five skinfolds (triceps, subscapular, suprailiac, abdomen, thigh) and the sum of six circumferences (forearm, upper arm, waist, hips, thigh and calf). Data were analysed using one factor ANOVA and regression analysis.

The training programmmes consisted of three 55-60 minute sessions a week. Massey University 'Pump It' aerobics consisted of a variety of traditional weight training exercises performed using light weights and high repetitions to music. Walking training involved brisk walking as a group, in and around the Massey University, Turitea Campus.

Six weeks of 'Pump It' and Walking training failed to produce significant improvements in cardiorespiratory fitness and body composition compared with the Control group. There were no significant changes in body mass, the sum of skinfolds or the sum of circumferences. It was concluded that the length of the fitness programmes were too short to improve cardiorespiratory fitness and the training intensity of 'Pump It' and Walking were insufficient to improve body composition.

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ATP	adenosine triphosphate
ANOVA	analysis of variance
BF	body fat
BMI	body mass index
BP	blood pressure
bpm	heart rate in beats per minute
CHD	coronary heart disease
CWT	circuit weight training
HDL	high density lipoprotein
HR	heart rate
HRmax	maximum heart rate
HRR	heart rate reserve
HW	hydrostatic weighing
L/min	litres per minute
ml/kg/min	millilitres per kilogram per minute
pre-exercise HR	heart rate prior to submaximal exercise test
Repetition	a single complete action of an exercise from starting position to completion and back to the starting position
RMR	resting metabolic rate
SAID	specific adaptations to imposed demands
SC-6	sum of forearm, upper arm, waist, hip, thigh and calf circumferences
SSK-5	sum of triceps, subscapular, suprailiac, abdomen and thigh skinfolds
VO_2	volume of oxygen consumption
VO_2max	maximal oxygen uptake

Chapter 1

Literature Review

"Begin at the beginning, and go on till you come to the end; then stop". –LEWIS CARROLL, Alice's Adventures in Wonderland.

1.1 Cardiorespiratory Fitness

1.1.1 Benefits of Cardiorespiratory Fitness

There are many benefits to be gained by performing regular physical activity. These include improvements in cardiorespiratory function and body composition, reduction in coronary heart disease (CHD) risk factors, increased longevity, decreased anxiety and depression, enhanced feelings of well-being and an improved performance in work, recreation and sport (Bouchard, Depres, & Tremblay, 1993; Davison & Grant, 1993; Depres & Lamarche, 1993; Utter, Nieman, Shannonhouse, Butterworth, & Nieman, 1998; Shimamoto, Adachi, Takahashi, & Tanaka, 1998).

1.1.2 Specificity of Training

At the onset of exercise, the cardiovascular system adapts with a series of integrated responses to meet the metabolic demands of the exercising muscles (Hughson & Tschakovsky, 1999). Repeated training causes progressive adaptation which increases an individuals ability to perform a particular type of activity with a corresponding reduction in the disturbance of body function for a given intensity and duration of work (Shephard, 1999; Jones & Carter, 2000). The adaptations that occur with training are related to the type of exercise performed (Barnett, Ross, Schmidt, & Todd, 1973; Williams & Jackson, 1977; Perez, 1981; Sale, 1988). This specificity of training is embedded in the 'SAID principle' (Specific Adaptations to Imposed

Demands) which states that "specific exercise elicits specific adaptations, creating specific training effects" (Powers & Howley, 2001).

Aerobic or endurance training is defined as exercise that can be supported by ATP formation from oxidative phosphorylation, as adequate O_2 is available to support the bodies energy demands (Sherwood, 2001). When O_2 delivery to a muscle becomes inadequate to support oxidative phosphorylation, as in high-intensity exercise, there is a shift in energy systems from oxidative phosphorylation to anaerobic glycolysis. Exercise that relies upon ATP formation through anaerobic glycolysis is referred to as anaerobic training (Sherwood, 2001).

Endurance training induces adaptations within the cardiorespiratory and neuromuscular systems that enhance the delivery of oxygen from the atmosphere to the mitochondria improving the control of metabolism within the muscle cells (McMurray, 1999; Jones & Carter, 2000). These adaptations include an increase in sodium-potassium pump concentrations, increased lactate transport capacity, increased oxidative capacity of skeletal muscle, decreased activity of glycolytic enzymes, increased intramuscular substrate stores, increased oxidative enzyme activity, and an increase in the density of capillaries and mitochondria (see: Tanaka & Swensen, 1998; Jones & Carter, 2000, for review). Anaerobic type training enhances muscular strength, power and speed by altering the muscles' fibre composition/structure, its metabolic profile and by enhancing neurological activation of the motor unit (Kraemer, Deschenes, & Fleck, 1988; Sale, 1988).

1.1.3 Cardiorespiratory adaptations to training

Central and peripheral adaptations in the cardiovascular system in response to aerobic training increase the body's ability to deliver oxygen to the exercising muscles during physical activity. This increased cardiorespiratory efficiency is indicated by an increase in maximal oxygen uptake (VO_2max) (Mahler, Froelicher, Miller, & York, 1995; Kukkonen-Harjula, Laukkanen, Vuori, Pasanen, Nenonen, & Uusi-Rasi, 1998; Utter *et al.*, 1998). The direct measurement of VO_2max is considered to be the 'gold standard' for the assessment of cardiorespiratory fitness (Mahler *et al.*, 1995; Powers & Howley, 2001). Other adaptations to exercise, resulting in increased aerobic function, include a reduction in heart rate and blood pressure for a given submaximal intensity of work, an increased anaerobic threshold (identified by a reduction in lactate accumulation at a given submaximal intensity) and an increase in the exercise threshold for the onset of disease symptoms (Swaine, Linden, & Mary, 1992; Mahler *et al.*, 1995). The mechanical efficiency of the body to perform a particular exercise may also improve (Jones & Carter, 2000). This enhanced efficiency is illustrated by an improved exercise economy, defined as the oxygen uptake required at a given absolute exercise intensity (Jones & Carter, 2000).

1.1.4 Recommendations for improving Cardiorespiratory Fitness

Most studies that aim to improve cardiorespiratory fitness, or investigate parameters of it, refer to the recommendations of the American College of Sports Medicine (ACSM) for improving cardiorespiratory fitness (see: Santiago, Alexander, Stull, Serfass, Hayday, & Leon, 1987; Pollock, 1988; Davison & Grant, 1993; Dishman, 1994; Swain, Abernathy, Smith, Lee, & Bunn, 1994; Grediagin, Cody, Rupp, Bernardot, & Shern, 1995; King & Senn, 1996; Bernard, Gavarry, Bermon, Giacomoni, Marconnet, & Falgairette, 1997; Utter *et al.*, 1998; Fiegenbum & Pollock, 1999; Lear, Brozic, Myers, & Ignaszewski, 1999; Branch, Pate, & Bourque, 2000; Pollock, Franklin, Balady, & Chaitman, 2000; Skinner, Wilmore, Krasnoff, Jaskolski, Jaskolska, Gagnon, Province, Leon, Rao, Wilmore, & Bouchard, 2000; Howley, 2001). The ACSM states that a healthy individual may achieve increases in cardiorespiratory fitness, as indicated by improvements in VO_2max, by manipulating the frequency, intensity and duration of exercise to produce an overload stimulus (Mahler *et al.*, 1995; Pollock, Gaesser, Butcher, Depres, Dishman, Franklin, & Barger, 1998). The training frequency accepted as the level that will produce this overload stimulus is between 3-5 times per week at an intensity of training of 55/65%-90% of the subjects maximum heart rate (HRmax) (Pollock *et al.*, 1998). The training duration was recommended to be between 20-60 minutes of continuous exercise. An alternative is intermittent exercise with each session being of at least 10 minutes duration with at least 30 minutes being accumulated throughout the day, depending on the intensity of the exercise (Pollock *et al.*, 1998). The length of the exercise session should be based on the intensity of the activity being performed. Individuals who train at higher intensities should exercise for a minimum of 20 minutes while those who train at lower intensities need to exercise for more than 30 minutes to gain similar benefits (Pollock *et al.*, 1998).

Many studies have shown improvements in VO_2max of 10-15% with endurance type training programmes lasting between six (Carter, Jones, & Doust, 1999) and twenty weeks (Santiago *et al.*, 1987; Marks, Ward, Morris, Castellani, & Rippe, 1995). Carter *et al.*, (1999) found an increase in VO_2max of approximately 10% (from 47.9 ± 8.4 to 52.2 ± 2.7 ml/kg/min) with six weeks of endurance training (3 to 5 sessions per week of 20 to 30 minutes duration at a running speed close to lactate threshold). Franklin, Buskirk, Hodgson, Gahagan, Kollias, & Mendez, (1979) also increased VO_2max in obese (18.9% increase in VO_2max) and normal weight (12.7% increase in VO_2max) females with a 12 week walking and jogging programme of 15-25 minutes of walking or jogging following a 10 minute warm up.

1.1.5 Adherence to Training

Although research strongly supports the idea that regular exercise improves an individuals overall well being, many people still fail to maintain a regular exercise regimen (Pollock, 1988; Pollock *et al.*, 2000). Many individuals may start a regular exercise programme but most do not maintain this exercise on a long-term basis, with the highest rate of drop out from an exercise programme occurring within the first twelve weeks (Pollock, 1988). Studies have indicated that there are a number of perceived barriers that prevent these individuals from implementing a sustained exercise routine (Johnson, Corrigan, Dubbert, & Gramling, 1990; Dishman, 1994). These potential problems include a lack of time for exercise, inconvenient exercise facilities, laziness, obesity, smoking, injury, and low personal motivation along with a lack of support from family and spouses (Johnson *et al.*, 1990; Dishman, 1994). Adherence to an exercise programme was also reduced when high intensity exercise was prescribed (Johnson *et al.*, 1990; Hunter *et al.*, 1998).

1.1.6 Prescription of Exercise for Sedentary People

Mode of exercise may have an impact on adherence when prescribing regular exercise for sedentary people (Pollock, 1988). Evidence has suggested that high intensity exercise may decrease compliance to exercise and also increase the risk of injury for untrained individuals (Pollock, 1988; Marks *et al.*, 1995). Marks *et al.*, (1995) reported a dramatic decline in drop out rate when the intensity of exercise in their study was reduced from 78 to 71%VO_2max, which was a relatively minor change.

The types of exercise commonly prescribed for sedentary people include walking, jogging, cycling (overground and stationary), aquatic activity (swimming and water aerobics) and various forms of resistance training (Pollock, 1988; King & Senn, 1996). Regardless of mode of exercise, it has been stressed that the chosen activity should be one that the individual enjoys and has access to resources that allow regular participation (King & Senn, 1996; Miller, 2001). Walking is recommended to improve general health and well being for sedentary individuals as it is easy to do, requires no special skill or facilities, is achievable by most age groups and has a low risk of injury (Davison & Grant, 1993; Hardman & Hudson, 1994).

1.1.7 Effects of 'Pump It' on Cardiorespiratory Fitness

While the effects of resistance training are well documented in terms of its positive effects on muscular strength and endurance (Broeder, Burrhus, Szanevik, & Wilmore, 1992; Donnelly, Sharp, Houmard, Carlson, Hill, Whatley & Israel, 1993; King & Senn, 1996; Cullinen & Caldwell, 1998; Poehlman & Melby, 1998; Weiss, Coney, & Clark, 1999; Marx, Ratamass, Nindl, Gotshalk, Volek, Dohi, Bush, Gomez, Mazzetti, Fleck, Hakkinen, Newton, & Kraemer, 2001), the role of resistance training on improving cardiorespiratory fitness is not well documented. The only literature to date investigating the role of 'Pump It'/Body Pump aerobics on improving cardiorespiratory fitness is the study by Stanforth, Stanforth, & Hoemeke, (2000). These authors found that individuals taking part in Body Pump did not work at sufficient intensities to improve cardiorespiratory fitness. They also stated that this should not be viewed as a weakness in the Body Pump programme, as the goal was not to improve cardiorespiratory fitness. Circuit Weight training (CWT), that does not include aerobic components, is the next closest in design to 'Pump It' aerobics.

Scott, (1995) investigated the effects of six weeks of CWT on cardiorespiratory fitness and in previously sedentary females. Training consisted of 11 aerobic exercises and a variety of weight training and calisthenic exercises. The training programme involved three 25-40 minute sessions each week. There was no significant increase in estimated VO_2max for the exercise group following the six-week training period. This CWT would be expected to produce greater increases in VO_2max than 'Pump It' aerobics due to the inclusion of aerobic stations.

It can be concluded from the studies by Scott, (1995) and Stanforth *et al.*, (2000) that improvements in cardiorespiratory fitness are unlikely to be observed with a training programme involving 'Pump It' aerobics.

1.1.8 Effects of Walking on Cardiorespiratory fitness

There have been several reports which indicate that regular vigorous walking will improve cardiorespiratory fitness in sedentary females (Franklin *et al.*, 1979; Sale, McCarger, Crawford, & Tauton, 1995) and in both males and females who exercised no more than twice weekly (Kukkonen-Harjula *et al.*, 1998). Unfortunately, these studies only assessed cardiorespiratory fitness levels prior to and following their respective training periods, making it difficult to determine the minimum training period required to improve cardiorespiratory fitness from their work, as progressive increases in VO_2max were not followed.

Increases in VO_2max of 21% have been observed in sedentary females who walked three miles per session, four times per week for 20 weeks on motorised treadmills (Santiago *et al.*, 1987). This improvement in cardiorespiratory fitness was especially significant, as the initial VO_2max (~34 ml/kg/min) was considered to be within the average range for women of the age 20-40 years and physical activity level of those in the study (Pollock, Schmidt, & Jackson, 1980) i.e. they were not particularly 'unfit' at the start of the programme (Table 1).

Table 1. Cardiorespiratory Fitness Classifications for Women based on VO_2max*

Age (yrs)	Low		Fair		Average		Good		High	
	Maximal Oxygen Uptake (ml/kg/min)									
20-29	<24	(6.9)$^{\alpha}$	24-30	(7.7)	31-37	(9.4)	38-48	(12.3)	49+	(14.0)
30-39	<20	(5.7)	20-27	(6.7)	28-33	(8.7)	34-44	(11.4)	45+	(12.9)
40-49	<17	(4.9)	17-23	(5.7)	24-30	(7.7)	31-41	(10.3)	42+	(12.0)
50-59	<15	(4.3)	15-20	(5.0)	21-27	(6.9)	28-37	(9.3)	38+	(10.9)
60-69	<13	(3.7)	13-17	(4.3)	18-23	(5.9)	24-34	(8.3)	35+	(10.0)

* Adapted from Pollock *et al.*, (1980)
α Average MET values

Franklin *et al.*, (1979) demonstrated an improved cardiorespiratory fitness, decreased skinfold measurements, and decreased HR and Systolic BP at a given submaximal workload in sedentary females, aged between 29–47 years, following a 12-week walking-jogging programme. The programme required that the subjects, who were divided into two groups (normal; < 30%BF and obese; > 30%BF), exercised at 75% HRmax for 15–25 minutes four times per week. Both the normal and obese groups showed significant improvements in VO_2max (34.4 to 38.5 ml/kg/min (12.7%), and 26.6 to 31.6 ml/kg/min (18.9%), respectively).

Sale *et al.*, (1995) demonstrated increased estimated VO_2max in overweight, sedentary women, aged 25-49 years, based on a 1-mile walking test, following twelve weeks of moderate-fast walking (60-80%HRmax) three times per week. They reported an increase in VO_2max from 2.42 to 2.68 L/min for the walking group. However, this was only an estimated VO_2max and a control group was not used for comparison of cardiorespiratory fitness. Another group in the study performing resistance training also improved their estimated VO_2max (2.48 to 2.62 L/min) suggesting that improvements in VO_2max were due to familiarisation with the walking test rather than cardiovascular adaptations.

Kukonen-Harjula *et al.*, (1998) produced only minor improvements in VO_2max in 15 weeks of walking at between 74-81%HRmax for 50 minutes, four times per week. The subjects were women, between the ages of 30-55 years, who previously exercised no more than twice per week. VO_2max increased in both the walking and control groups (walking; 40.2 to 45.8 ml/kg/min, P<0.001, control; 39.9 to 42.6 ml/kg/min, P<0.001). Minor improvements in body weight and serum lipoproteins were also observed in the walking group. Although the subjects were not considered 'fit', their initial fitness levels were likely to have been a factor in the modest increase in VO_2max. Kukonen-Harjula *et al.*, (1998) recognised that more significant increases in VO_2max would have been expected had the subjects been sedentary prior to taking part in the study. The increase in VO_2max for the control group was unexpected and it was stated that the control group had increased their physical activity contrary to instruction. However, this extra activity had not been reported in the exercise diaries.

1.1.9 Training Volume

The study by Carter *et al.*, (1999) improved VO_2max by approximately 10% after only six weeks of running training in physical education students (see section 1.1.4). Although the training intensity in this study was considerably higher than that normally prescribed for sedentary people, it is important, in that, improvements in VO_2max can be seen following relatively short amounts of time spent training.

Liang, Alexander, Taylor, Serfass, Leon, & Stull, (1982) also reported significant improvements in VO_2max in subjects with only six weeks of treadmill walking. This study investigated the aerobic training threshold in young (18-26 years), active males. It found the minimum volume of training required to improve cardiorespiratory fitness for this population to be 60 minutes, three days per week, at 40 or 60 %VO_2max for six weeks. The initial fitness levels of the groups were classified as being of 'high average' fitness (50.9 and 53.4 ml/kg/min for the exercising and control groups, respectively). Therefore, it seems likely that greater improvements in cardiorespiratory fitness would be observed in previously sedentary individuals who followed the same exercise prescription.

Branch *et al.*, (2000) reported that similar improvements in VO_2max to those achieved with high intensity exercise (80 %VO_2max) can be achieved with moderate intensity exercise (40 %VO_2max) provided that training volume is held constant. Their exercise programme consisted of cycling on an ergometer, 3-4 sessions per week for 12 weeks at their respective intensities. VO_2max increased by 17% in the moderate intensity group compared to 21% in the high intensity group. The study by Liang *et al.*, (1982) also showed no difference in the improvement in VO_2max between the exercise intensities of 40 and 60 %VO_2max.

In summary, various modes of training have shown improvements in cardiorespiratory fitness with 3-5 training sessions per week, at 65-90 %HRmax for a minimum of 20 minutes. However, the minimum training period required to produce improvements in cardiorespiratoy fitness has not been determined.

1.2 Assessing Cardiorespiratory Fitness

There are a number of considerations that need to be addressed when selecting protocols and equipment for fitness testing. Such considerations include:

1. Which of the major components of fitness are to be assessed. The *ASCM's Resource Manual for Guidelines for Exercise Testing and Prescription, 3rd Edition (1998)* states that the major components of

fitness are: cardiorespiratory fitness, muscular strength and endurance, body composition and flexibility.

2. The characteristics of the population being tested, such as age, gender, current activity levels, health status
3. The specificity of the exercise used in testing to the type of training being undertaken by the subject
4. The intensity and duration of the testing protocol
5. Whether training consists of continuous or discontinuous exercise
6. The cost and availability of the testing equipment

Lear *et al.*, (1999) suggested that for clinical testing, protocols should include a low-intensity warm-up phase followed by progressive continuous exercise. The duration of the test was recommended to last between 8-12 minutes.

1.2.1 Treadmill Protocols

Two commonly used treadmill protocols that are continuous and progressive are the Balke protocol (developed by Balke and Ware, 1959) and the Bruce protocol (see Jones, 1988). Both protocols require the participants to exercise to volitional fatigue, allowing VO_2max to be determined when respiratory gases are measured. VO_2max is defined as the point at which oxygen uptake (VO_2) reaches a plateau despite further increases in work rate (Baba, Kubo, Morotome, & Iwagaki, 1999). The Bruce protocol begins at a speed of 1.7mph and a grade of 10% which is very high for an initial stage (Holly & Krstich, 1997) and as a result is not considered suitable for unfit individuals (Powers & Howley, 2001). The Balke protocol is recommended for unconditioned individuals (Lear *et al.*, 1999; Baldy, Berra, Golding, Gordon, Mahler, Myers, & Sheldahl, 2000) as it starts at a lower intensity and the increments are smaller in comparison to the Bruce protocol.

Bryner, Toffle, ullrich, & Yeater (1997) used a modified Balke protocol to assess VO_2max in a population of women aged between 18-34 years, who had had no involvement in a regular exercise programme for at least 6 months. Holly & Krstich (1997) suggest that the three-minute duration of each stage in the modified Balke protocol allow ill, obese or unfit individuals more time to adjust to each increment in intensity, an important consideration when a steady state is required for gas analysis. The specifics of the Balke and modified Balke protocols are given in Tables 2 and Table 3.

Table 2. Balke Protocol

Stage	Speed (mph)	% Grade	Duration (mins)
I	3.3	1	1
II	3.3	2	1
III	3.3	3	1
IV	3.3	4	1
V	3.3	5	1
VI	3.3	6	1
VII	3.3	7	1
VIII	3.3	8	1
IX	3.3	9	1

Table 3. Modified Balke Protocol

Stage	Speed (mph)	% Grade	Duration (mins)
I	2.0	3.5	3
II	2.0	7.0	3
III	2.0	10.5	3
IV	2.0	14.0	3
V	2.0	17.5	3
VI	2.0	21.0	3

1.2.1 HR/VO_2 relationship

It is widely accepted that a direct linear relationship exists between heart rate and oxygen consumption at submaximal workloads (Wilmore & Haskell, 1971; Vokac, Bell, Bautz-Holter, & Rodahl, 1975; Franklin, 1980; Astrand & Rodahl, 1986; Legg, Dziados, Mello, Vogel, & Doherty, 1988; Maas, Kok, Westra, & Kemper, 1989; Parker, Hurley, Hanlon, & Vaccaro, 1989; Swaine *et al.*, 1992; Swain *et al.*, 1994; Londeree, Thomas, Ziogas, Smith, & Zhang, 1995; Gilman, 1996; Bernard *et al.*, 1997; Holly & Krstich, 1997; Hiilloskorpi, Fogelholm, Laukkanen, Pasanen, Manttari, & Natri, 1999). The relationship has been used as an indicator of training intensity (Franklin, 1980; Parker *et al.*, 1989; Gilman, 1996; McArdle, Katch, & Katch, 1996), energy expenditure (Bernard *et al.*, 1997; Hiilloskorpi *et al.*, 1999) and for the estimation of oxygen consumption during exercise (Wilmore & Haskell, 1971; Franklin, 1980; Legg *et al.*, 1988; Powers & Howley, 2001). The estimation of exercise intensity, energy expenditure and oxygen consumption for an individual using the HR/VO_2 relationship is thought to be accurate when the relationship is determined while performing an exercise specific to that being undertaken (McArdle *et al.* 1996).

1.2.2.1 Prediction of Oxygen Consumption using HR/VO_2 relationship

Investigators use HR to estimate VO_2 from pre-established, subject specific, relationships between VO_2 and HR. (Astrand & Rodahl, 1986; Maas *et al.*, 1989; Bernard *et al.*, 1997). The Regression method, developed by Wilmore *et al.* (1971), requires the measurement of steady state HR and VO_2 during at least two and preferably more submaximal workloads (Franklin, 1980). It has been stated that, for the purpose of estimating oxygen consumption, individual HR/VO_2 regression lines should be derived from laboratory measurements (Hiilloskorpi *et al.*, 1999) under task specific conditions (Legg *et al.*, 1988; McArdle *et al.*, 1996). The measurement of oxygen consumption during some types of exercise is often impractical as the equipment required for gas analysis is large and cumbersome and may interfere with the subject. In these situations, the HR/VO_2 relationship should be established under conditions that are as similar as possible in nature to that being investigated (McArdle *et al.*, 1996).

1.2.2.2 Estimation of VO_2max using the HR/VO_2 relationship

Extrapolation of the HR/VO_2 relationship for an individual allows the estimation of VO_2max from data obtained during submaximal work (Powers & Howley, 2001). For this method of estimating VO_2max, HR is plotted against VO_2 at submaximal workloads, until 70-85% of the age adjusted predicted HRmax is reached. The line relating HR and VO_2 is extrapolated to the estimated HRmax. A vertical line is then drawn from this point to the x-axis to give an estimated VO_2max (Powers & Howley, 2001).

While based on sound physiological principles, this method has inherent assumptions that require consideration. These assumptions are that:

1. HRmax equals 220 - age
2. Using 70-85% of estimated HRmax will result in the same intensity of exercise for each person
3. Submaximal heart rates are not affected by internal or external factors

This method assumes that the formula for age predicted HRmax gives an accurate prediction of HRmax for each individual. The estimation of HRmax has a standard deviation of ~11bpm (Londeree & Moeschberger, 1984). Therefore, a subject with an actual HRmax that was significantly lower than that predicted by the formula would have their VO_2max greatly overestimated. The intensity of the exercise at 70-85% of HRmax would also be considerably higher for this subject than an individual who's actual HRmax existed at 220–age. Despite its inherent assumptions, the age prediction formula (220-age) is a widely used and accepted method for the estimation of HRmax (Barker, Hurley, Hanlon, & Vaccaro, 1989; King & Senn, 1996; Lear *et al.*, 1999; McArdle, Katch, & Katch, 2000).

Although there are limitations with the extrapolation method for the estimation of VO_2max, it is generally accepted for the assessment of cardiorespiratory fitness when maximal protocols are deemed inappropriate (Von Dobeln, Astrand, & Bergstrom, 1967; Astrand, Astrand, Hallback, & Kilbom, 1973; Pollock *et al.*, 1980; Hartung, Blancq, Lally, & Krock, 1995; Lear *et al.*, 1999; Skinner *et al.*, 2000).

1.2.2.3 Factors that affect the HR/VO_2 relationship

There are a number of factors that can influence the HR/VO_2 relationship. These include: the ingestion of food prior to testing, dehydration, elevated body temperature, environmental temperature and humidity, emotional state, some medications, previous physical activity, body position, muscle groups used, exercise mode, whether the exercise was of a continuous or discontinuous nature, and whether the muscles act statically or more dynamically (see: Shephard, 1984; Astrand & Rodahl, 1986; Rayson, Davies, Bell, & Rhodes-James, 1995; Gilman, 1996; Swain, Leutholtz, King, Haas, & Branch, 1998; McArdle *et al.*, 2000, for review). The effects of some of these variables can be lessened by controlling the environmental conditions and by implementing strict pretest and test procedures.

Gilman (1996) stated that, under some conditions, HR does not accurately reflect the metabolic stress an individual is experiencing. He proposed that the phenomenon of 'cardiac drift', where heart rate slowly rises when exercise duration exceeds 20 minutes, would produce higher heart rates than that normally seen for an individual at a given VO_2. The increase in heart rate as a result of 'cardiac drift' could be as high as 20bpm (Gilman, 1996).

Research has shown that the relationship between heart rate and oxygen consumption is significantly different when performing static compared to dynamic exercise (Sanchez, Monod, & Chabaud, 1979; Maas *et al.*, 1989). Maas *et al.*, (1989) investigated the accuracy of using the HR/VO_2 relationship determined in running to predict VO_2 from HR in tasks involving static and combined static/dynamic exercise. They found that static work resulted in higher heart rates, at the same oxygen uptake, compared to dynamic work. The difference was more marked as workload increased. They concluded that when only static workloads were involved, the use of running task HR/VO_2 relationships always overestimated the VO_2 at a given HR.

The effect of arm exercise and leg exercise on the HR/VO_2 relationship has been investigated (Bevegard, Freyschuss, & Strandell, 1966; Stenberg, Astrand, Ekblom, Royce, & Saltin, 1967; Vokac *et al.*, 1975). Higher heart rates and ventilation than those seen with leg exercise, have been observed at given levels of oxygen consumption with arm exercise (Bevegard *et al.*, 1966; Stenberg *et al.*, 1967; Tulppo, Makikallio, Laukkanen, & Huikuri, 1999; Vokac *et al.*, 1975). This elevation in heart rate was attributed to higher peripheral resistance and arterial blood pressures (Bevegard *et al.*, 1966; Stenberg *et al.*, 1967; Vokac *et al.*, 1975) and increased sympathetic tone during arm work (Bevegard *et al.*, 1966; Parker *et al.*, 1989; Tulppo *et al.*, 1999). Also, Vokac *et al.*, (1975) found that there was a tendency to synchronise respiratory frequency with the frequency of the rotatory movements at submaximal workloads during arm cranking and cycling. This was more apparent in arm cranking than in cycling.

Bernard *et al.*, (1997) demonstrated that the HR/VO_2 relationship alters according to whether it is determined under transitory, steady state or recovery phases of exercise. Further, under non steady state conditions, VO_2 measured at the mouth, as is required for gas analysis, underestimates true oxygen requirements during exercise (Whipp & Wasserman, 1972).

1.2.2.4 Effect of mode of exercise on the HR/VO_2 relationship

The HR/VO_2 relationship has been investigated for exercise performed on various exercise machines including ski simulators, shuffle skiers, steppers, rowers, arm cranking ergometers, treadmills, and cycle ergometers (Vokac *et al.*, 1975; Londeree *et al.*, 1995; Hiilloskorpi *et al.*, 1999; Tulppo *et al.*, 1999). It has also been examined for aerobic dance, jogging, circuit weight training, Body Pump aerobics and weight lifting (Parker *et al.*, 1989; Collins, Cureton, Hill, & Ray, 1991; Stanforth *et al.*, 2000).

Londeree *et al.*, (1995) compared the %HRmax/%VO_2max relationships obtained from the same subjects during exercise on a treadmill, cycle, ski simulator (skier), shuffle skier (shuffler), stepper, and rower. They reported that exercise modes that were weight bearing and upright (treadmill, skier, shuffle and stepper) produced similar relationships between heart rate and oxygen uptake. Interestingly, the regression equations for the skier and shuffler, which both included loaded arm work, were not significantly different compared to the treadmill equation. This was not consistent with other findings (Bevegard *et al.*, 1966; Stenberg *et al.*, 1967; Vokac *et al.*, 1975; Tulppo *et al.*, 1999). Weight supported modes (cycle and rower) produced significantly different HR/VO_2 slopes to that obtained for treadmill exercise. Londeree *et al.*, (1995) recommended that mode specific equations should be used for exercise of this type.

Parker *et al.*, (1989) detected higher heart rates during aerobic dance exercise than treadmill exercise for the same VO_2. Similar findings have been observed with circuit weight training (Hurley *et al.*, 1984), Body Pump aerobics (Stanforth *et al.*, 2000) and weight lifting (Collins *et al.*, 1991). Stanforth *et al.*, (2000) showed that, as a result, oxygen consumption at a given heart rate was over predicted for 'Pump It' aerobics when estimated from a relationship obtained during treadmill walking. Similarly, treadmill or cycle data has been shown to over predict oxygen consumption during weight lifting at a given heart rate (Collins *et al.*, 1991). As in previous studies, the studies by Hurley *et al.*, (1984), Parker *et al.*, (1989) and Stanforth *et al.*,

(2000) attributed the higher HR relative to VO_2 for this type of exercise to increased sympathetic tone during arm work.

In summary, The HR/VO_2 relationship obtained during treadmill walking has been validated for the prediction of oxygen consumption and intensity of training for exercise that is upright, dynamic and weight bearing (Londeree *et al.*, 1995). However, research suggests that training intensities and oxygen consumption are over predicted during exercise similar to 'Pump It' aerobics when the HR/VO_2 relationship is obtained for the individual during treadmill walking (Parker *et al.*, 1989; Collins *et al.*, 1991; Stanforth *et al.*, 2000).

1.3 Obesity and its Implications on Health

Many studies have identified an increase in the occurrence of health related risk factors associated with obesity (see: Stefanick, 1993; Blair & Brodney, 1999; Grundy, Blackburn, Higgins, Lauer, Perri, & Ryan, 1999, for reviews). Two surveys, NHANES I and II (National Health and Nutrition Examination Surveys conducted in the USA during 1971-74 and 1976-80 respectively), gave evidence linking the adverse effects of obesity to certain cancers and several of the major risk factors for coronary heart disease (CHD) (Stefanick, 1993). The risk factors for CHD included hypertension, hypercholesterolemia, NIDDM (non-insulin-dependent diabetes mellitus), and hyperlipidaemia (Depres & Lamarche, 1993; Stefanick, 1993). Central obesity or excessive deposition of fat in the abdominal region, especially, has been identified as a precursor of hyperinsulinemia, increased plasma triglycerides, decreased high density lipoprotein (HDL) levels and elevated blood pressure (Kissebah, Krakower, & Sonnenberg, 1998).

There is significant evidence supporting a role for exercise in the prevention and treatment of obesity and its associated risk factors (Bouchard *et al.*, 1993;

Hunter *et al.*, 1998; Fagard, 1999; Grundy *et al.*, 1999; Terenzi, 2000). Reductions in CHD risk factors with physical activity have been attributed to a slight reduction in resting systolic and diastolic pressures in both hypertensives and normotensives, an increase in serum HDL cholesterol and decreased serum triglycerides, a reduction in body fat, a decreased requirement of the body for insulin and an associated improvement in glucose tolerance (Bouchard *et al.*, 1993; Depres & Lamarche, 1993; Hinkleman & Nieman, 1993; Mahler *et al.*, 1995). However, the exact mechanism by which exercise acts to prevent disease states often associated with obesity and its comorbidities are not known.

It is important to consider whether it is obesity itself or the often associated decrease in physical activity that is responsible for the increase in the occurrence of CHD and its risk factors. Blair & Brodney, (1999) stated that active and fit individuals had lower risk rates of morbidity and increased longevity when compared with sedentary and unfit individuals for all body profiles. Also, the morbidity and mortality rates for overweight and obese individuals who exercised regularly were at least as low, if not lower, than normal weight individuals who were sedentary (Blair & Brodney, 1999). Fagard (1999) stated that the incidence of hypertension is less in physically fit or active people than in unfit or sedentary subjects and this was independent of baseline BMI or body fat.

1.3.1 Incidence and Causes of Obesity

While the importance of cardiovascular fitness is recognised, the primary goal for many who are undertaking an exercise regimen is to reduce body fat levels while increasing or maintaining lean body mass (Marks *et al.*, 1995; Gornall & Villani, 1996). This is especially true in more recent times where a widespread increase in the occurrence of obesity has been reported (Hunter *et al.*, 1998; Grundy *et al.*, 1999; Wilson, Wilson, & Russell, 2001). Since the

1960's a 10% increase in the incidence of obesity, defined as a BMI $\geq$ 25.0 kg.m^{-2} (BMI refers to *weight*.kg $\div$ *height*^{2}.m^2), has been documented in all ages, genders and racial/ethnic groups (Grundy *et al.*, 1999). The NHANES III (National Health and Nutrition Examination Surveys, 1988-1994) revealed 54.9% of American adults to be overweight (BMI $\geq$25 kg.m^{-2}) or obese (BMI $\geq$30 kg.m^{-2}) (Grundy *et al.*, 1999). Similarly, New Zealand has seen an increase in the occurrence of individuals that are overweight or obese. Over one half of New Zealanders were either overweight (BMI $\geq$ 25 kg.m^{-2}) or obese (BMI $\geq$30 kg.m^{-2}) in a 1997 survey, compared to less than a third in 1989 (Wilson et al., 2001). Also, New Zealand Maori have approximately double the incidence of obesity compared to New Zealand Europeans (Males 27% vs 12.6%, Females 28% vs 16.7%) (Ministry of Health, NZ, 1999). This is reflected in an increased incidence of diabetes, ischaemic heart disease and stroke in New Zealand Maori (Ministry of Health, NZ, 1999).

Grundy *et al.*, (1999) stated that the development of obesity requires that energy intake exceeds energy expenditure and that societal trends, which are moving towards increasing energy intake and decreasing energy expenditure, may be causative of the problem. The increased energy intake has been attributed to an increased consumption of highly palatable foods that are high in fat and sugar but low in fibre and bulk (Hammer, Barrier, Roundy, Bradford, & Fisher, 1989). In contrast, a US trends survey has identified a diverging trend in energy flow, with intake falling and obesity prevalence rising in the population since the 1970s (Hunter *et al.*, 1998). The results of this survey suggest that the increases in obesity were a result of decreased total energy expenditure rather than from dietary influences. Similar findings have been made in the UK (Hunter *et al.*, 1998). In New Zealand, the widespread increase in body mass has been attributed to an increase in total energy intake (Simmons, Jackson, Swinburn, & Lay Yee, 1996) and an imbalance in food energy consumed and energy output in physical activity

(Wilson *et al.*, 2001). This decrease in total energy expenditure has been attributed to progressively lesser amounts of activity required at work and leisure (Bouchard *et al.*, 1993; Simmons *et al.*, 1996; Grundy *et al.*, 1999). This lack of demand for activity may be a result of improvements in technology which reduce or remove the need for physical labour in the home and workplace.

Societal and cultural issues may also impact on daily activity levels and hence daily energy expenditure. In Western society, it could be considered that exercising regularly and projecting a healthy active lifestyle is more socio-politically correct or accepted than a more sedentary lifestyle. While this may encourage an individual to spend more time taking part in planned exercise activity, such as attending the gym, subconsciously, they may actually be decreasing the amount of energy they would normally expend performing incidental activity. Therefore, if people are intending to implement planned exercise activities into their daily lifestyles, they should make a conscious effort to maintain their 'normal' daily activity levels.

1.4 Exercise and Weight loss

It is widely accepted that exercise plays a role in the promotion of fat loss and weight maintenance (Bouchard *et al.*, 1993; Depres & Lamarche, 1993; Stefanick, 1993; McCarty, 1995; Zelasko, 1995; King & Senn, 1996; Zachwieja, 1996; Bryner *et al.*, 1997; Cullinen & Caldwell, 1998; Hunter *et al.*, 1998; Pollock *et al.*, 1998; Utter *et al.*, 1998; Glass, Santos, & Armstrong, 1999; Van Baak, 1999). The proposed mechanisms by which exercise is thought to promote the loss of body fat and aid in weight management include: increasing lean muscle mass, increasing post exercise oxygen consumption, increased caloric expenditure, a shift of substrate oxidation toward a greater reliance on fat oxidation and a reduction in appetite (see: King & Senn, 1996; Pinto & Szymanski, 1997; Poehlman &

Melby, 1998). However, the extent to which exercise assists in weight loss and weight control is not clear.

1.4.1 Recommendations for promoting weight loss through exercise

The exercise prescription that is recommended for weight loss varies greatly depending upon the source. The ASCM recommends that an individual should expend a minimum of 300kcal per exercise session, three days per week (Pollock *et al.*, 1998). Some researchers stand by the opinion that exercise should be moderate in intensity (~50-65%HRmax) to maximise fat oxidation during the exercise session (Bouchard *et al.*, 1993; Stefanick, 1993; McCarty, 1995). Others, however, who are more in line with the recommendations of the ACSM, propose that exercise should be of high volume, that is high frequency, duration and intensity, to maximise net daily energy expenditures (Depres & Lamarche, 1993; Zachwieja, 1996; Bryner *et al.*, 1997; Hunter *et al.*, 1998; Van Baak, 1999). McCarty (1995) stated that fat loss is optimised when exercise is performed post-absorptively, preferably during morning fasting metabolism, following ingestion of caffeine and hydroxycitrate/carnitine. The exercise was to be of moderate intensity and of prolonged duration. It was also recommended that no calories be ingested for several hours following exercise. While drastic recommendations, such as these, may provide the individual with information that may successfully promote fat loss they may actually increase the prevalence of obesity. The recommendations by McCarty (1995) fail to address the problems of long term weight maintenance that are sure to arise once the individual has achieved weight loss and reverts to their normal daily activity and dietary practices. Long term weight maintenance is thought to be more achievable with programmes that include regular physical activity, modest energy intakes and reduced calories from fat (Zachwieja, 1996).

Studies have shown the effects of exercise on body composition to be significantly enhanced when combined with low fat or low calorie diets (Hill, Sparling, Shields, & Heller, *1987;* Leutholtz, Keyser, Heusner, Wendt, & Rosen, 1995; see Depres & Lamarche, 1993, for review). Others have shown no such added benefits (Donnelly *et al.*, 1993; Gornall & Villani, 1996; Utter *et al.*, 1998).

1.4.2 Effects of Resistance Training on Body Composition

Muscle mass often increases as a result of most types of training, especially in previously sedentary individuals (King & Senn, 1996). This increase in muscle mass, known as muscular hypertrophy, is more marked with resistance training (Goldberg, Etlinger, & Goldspink, 1975). Resistance exercise is thought to play a beneficial role in promoting and maintaining fat loss through increases in lean body mass rather than through the direct energy costs of the resistance exercise itself (Poehlman & Melby, 1998).

Increases in lean body mass and decreases in fat mass have been observed with CWT (Gettman, Ayers, Pollock, & Jackson, 1978; Gettman, Ward, & Hagan, 1982; Wilmore, Parr, Girandola, Ward, Vodak, Barstow, Pipes, Romero, & Leslie, 1978). In females, increases in lean body mass of between 2.9 and 3.9% have been produced with CWT (Gettman *et al.*, 1982; Wilmore *et al.*, 1978). Decreases in fat mass in the same studies ranged between 1.8 and 2.8%. The studies by Wilmore *et al.*, (1978) and Gettman *et al.*, (1982) were completed within 10 and 12 weeks of training, respectively. Scott (1995) did not observe any significant changes in body composition in previously sedentary females who took part in a CWT programme. This study was conducted over six weeks in the absence of dietary adjustment. In general however, the findings of these studies suggest that resistance type exercise may be effective in altering fat mass and increasing lean body mass.

1.4.3 Effects of Walking on Body Composition

In the absence of dietary manipulation, studies have demonstrated positive effects on body composition as a result of walking training (Franklin *et al*., 1979; Hardman & Hudson, 1994; Sale *et al*., 1995; Kukkonen-Harjula *et al*., 1998) while others have produced no effect (Santiago *et al*., 1987). In studies where walking training was combined with dietary restriction the results were also inconsistent, with positive benefits (Hill *et al*., 1987) and no added benefits seen for body composition (Leutholtz *et al*., 1995). Changes in body composition with walking training are summarised in Table 4 (pg. 25-26).

Hardman & Hudson, (1994) produced significant decreases in the sum of four skinfolds with previously sedentary, normal weight females in a 12 week brisk walking programme. Body mass did not change over the 12 weeks in the Walking programme, suggesting that lean mass had increased. In contrast, in another study, 20 weeks of walking training failed to produce any changes in body composition in previously sedentary females (Santiago *et al*., 1987). Kukkonen-Harjula *et al*., (1998) produced modest decreases in body mass (1.5kg) following 15 weeks of walking training. Although these decreases were found to be significant ($p<0.001$), the researchers concluded that such a minor decrease in weight over this time frame was clinically insignificant. Therefore, although improvements in body composition have been seen with walking training, the results are inconsistent and the benefits often minor.

Table 4. Changes in Body Composition with Walking Training

Year	Author	Sex	n	Frequency (x week)	Duration (mins)	Intensity	Length of Training (weeks)	Dietary Changes	Initial Body Composition	Change in Body Composition
1979	Franklin *et al*	F	13	4	35-45	75% VO_2max	12	-	<30 %BF	- 17.7 mm ΣSKF(10)
1979	Franklin *et al*	F	23	4	35-45	75% VO_2max	12	-	>30 %BF	- 37.8 mm ΣSKF(10)
1995	Grediagin *et al*	F	6	4	-	80% VO_2max	12	-	31.3 %BF	- 3.4 %BF
1995	Grediagin *et al*	F	6	4	-	50% VO_2max	12	-	31.0 %BF	-2.9 %BF
1994	Hardman *et al*	F	10	3	> 60	Brisk	12	-	76.5mm ΣSKF(4)	- 5.1mm ΣSKF(4)
1987	Hill *et al*	F	5	7	≤ 60	Brisk	5	800 kcal/day	37-50%BF	- 2.7 %BF
1998	Kukkonen-Harjula *et al*	M	55	4	50	65-75% VO_2max	15	-	19.4%BF	-1.4%BF
1998	Kukkonen-Harjula *et al*	F	62	4	50	65-75% VO_2max	15	-	27.1%BF	-0.6%BF

Continued next page. Note: %BF is percentage Body Fat, ΣSKF (4), (8) and (10) refers to the Sum of four, eight and ten skinfolds, respectively.

Table 4. Continued

Year	Author	Sex	n	Frequency (x week)	Duration (mins)	Intensity	Length of Training (weeks)	Dietary Changes	Initial Body Composition	Change in Body Composition
1995	Leutholtz *et al*	M	5	3	-	60%HRR	12	420kcal /day	≥ 25%BF	-9.6%BF
1995	Leutholtz *et al*	M	2	3	-	40%HRR	12	420kcal /day	≥ 25%BF	-8.3%BF
1995	Leutholtz *et al*	F	15	3	-	60%HRR	12	420kcal /day	≥ 30%BF	-9.6%BF
1995	Leutholtz *et al*	F	18	3	-	40%HRR	12	420kcal /day	≥ 30%BF	-8.3%BF
1995	Sale *et al*	F	26	3	40-70	60-80% VO_2max	12	-	283.0mm ΣSKF(8)	- 48.8mmΣSKF(8)
1987	Santiago *et al*	F	9	4	55	52%VO_2max	20	-	27.22%BF	-

Note: %BF is percentage Body Fat, ΣSKF (4), (8) and (10) refers to the Sum of four, eight and ten skinfolds, respectively.

1.5 Body Composition Assessment

'Men tend to belly, women tend to bum' (Garn, Sullivan, & Hawthorne, 1987)

"The Human body may be analyzed and measured in many ways, the 'best' way will depend on the end sought and the practical possibilities for measurement" (Keys & Brozek, 1953). Studies have shown that assessing body composition changes in humans allows us to quantify the effectiveness of specific training methods in promoting fat loss, maintaining body fat levels, or improving lean body mass (Hill *et al.*, 1987; Santiago *et al.*, 1987; Hammer *et al.*, 1989; Donnelly *et al.*, 1993; Whatley, Gillespie, Honig, Walsh, & Blackburn, 1994; Grediagin *et al.*, 1995; Leutholz *et al.*, 1995; Sale *et al.*, 1995; Gornall & Villani, 1996; Bryner *et al.*, 1997; Shimamoto *et al.*, 1998; Utter *et al.*, 1998).

The accuracy and validity of the assessment of body composition greatly depends upon the method used. The methods available include Hydrostatic Weighing (HW), Dual-Energy X-ray Absorptiometry (DEXA), Bioelectric Impedance Analysis (BIA), Skinfolds, Anthropometry and a new method using gas displacement and Boyles law (the Bod Pod). For practical reasons, only HW, Skinfolds and the Anthropometric method, Circumferences, were considered for the current study.

1.5.1 Hydrostatic Weighing

Hydrostatic Weighing (HW) or hydrodensitometry is considered the 'Gold Standard' for the indirect assessment of body composition and changes in body composition (Pollock & Jackson, 1984; Sanborn, 1991; Eaton, Israel, O'Brien, & Hortobagyi, 1992; Grediagin *et al.*, 1995; Heyward, 1996). HW is a two-component model separating fat mass and fat-free mass. There are a number of problems with HW that make it an undesirable method to use on the general population. One of these is the need for the subject to empty their lungs during total submersion in water for the estimation of residual lung volume and underwater weight. Also, HW must be repeated 8-12 times to achieve a suitable level of accuracy and repeatability (Sanborn, 1991).

1.5.2 Skinfolds

Another two-component model often used for assessing changes in body composition is the skinfolds method. This method is based on the fact that skinfold contains the thickness of a double layer of skin and the underlying subcutaneous fat (Sanborn, 1991). Within limits, the thickness of the skin will be constant and the measurement will reflect subcutaneous fat.

The major sources of error involved in this method are the type of caliper used, subject factors and the skill level of the sampler. The most reliable calipers exert a constant pressure throughout the range of measurement. Harpenden and Lange calipers are considered to be the best skinfold caliper (Heyward, 1998) as they exert a constant pressure (9.36 g/mm^2 and 9.3 g/mm^2) throughout the range of measurement (0mm to 60mm) with excellent scale precision (0.2mm and 1.0mm). Harpenden calipers have been shown to produce significantly smaller values compared to Lange calipers (Lohman, Pollock, Slaughter, Brandon, & Boileau, 1984; Gruber, Pollock, Graves, Colvin, & Braith, 1990. Heyward (1998) recommends that the same caliper be used when monitoring changes in an individuals skinfold thickness.

Subject factors which can alter the reliability of skinfold measures include skin thickness, compressibility of adipose tissue, handedness and hydration levels of the individual (Heyward, 1998). Errors caused by skin thickness and adipose compressibility can be reduced by determining changes in an individuals body fat level rather than using skinfolds to compare body fat levels in different populations or between subjects. Hydration states may alter readings due to accumulation of water (oedema) in subcutaneous tissue as a result of peripheral vasodilation or disease. In order to remove or minimise the effects of hydration on skinfold measurement it is recommended that measures are not taken immediately after exercise, especially in hot environments (Heyward, 1998).

Errors arising from different handedness can be removed by measuring skinfolds on the same side of the body each time. The reliability of results when measuring body composition using the skinfold method is also dependent on the experience of the user. These errors arise from unfamiliarity with the skinfold protocol, anatomical landmark identification, and incorrect placement of the calipers and errors when reading the caliper scale. A number of recommendations have been made to minimise the error resulting from inexperience (Lohman *et al.*, 1984; Pollock & Jackson, 1984; Jackson & Pollock, 1985). These recommendations for measuring skinfolds using Harpenden calipers are as follows:

1. Be meticulous when locating anatomical landmarks used to identify skinfold sites. When measuring distances, mark site with a surgical pen
2. Read dial of caliper to the nearest 0.1mm (gives accuracy of ± 0.1mm)
3. Take a minimum of 2 measurements at each site
4. Take measurements in a rotational order
5. Keep the subjects skin dry and lotion free
6. Do not measure immediately after exercise
7. Practice on 50-100 subjects
8. Train with a skilled anthropometrist and compare results

It is also advised that technicians follow a standardised testing procedure (Pollock & Jackson, 1984; Klipstein-Grobusch, Georg & Boeing, 1997; Ulijaszek & Kerr, 1999).

Skinfold measurements are a non-invasive, inexpensive method for identifying changes in body fat, when the possible sources of measurement error are minimised (Sanborn, 1991; Heyward, 1998). The estimation of body fat by skinfolds agrees to within ± 3-5% of body fat estimates by the 'gold standard' of hydrostatic weighing (McArdle *et al.*, 1996).

1.5.2.1 Predicting Percentage Body Fat using Skinfold Measurements

Many investigators express body fat levels as a percentage body fat calculated from prediction equations using skinfold measurements (Legg *et al.*, 1988; Hammer *et al.*, 1989; Heyward, Cook, Hicks, Jenkins, Quatrochi, & Wilson, 1992; Hinkleman & Nieman, 1993; Sale *et al.*, 1995; Cullinen & Caldwell, 1998; Glass *et al.*, 1999; Branch *et al.*, 2000). Examples of these prediction equations include those developed by Jackson Pollock & Ward (1980) using the sum of three, four and seven skinfold sites. Prediction equations are based on a number of assumptions. Heyward (1996) lists these assumptions as:

1. compressibility of the skinfold is constant
2. fraction of the skin thickness is minimal or negligible
3. adipose tissue patterning is fixed
4. the fraction of fat in adipose tissue is constant
5. the proportion of internal to subcutaneous fat is fixed

The validity of prediction equations is questionable as they were developed for relatively homogeneous populations. The equations can only be considered valid when the individuals are of the same age, gender, ethnicity and the same level of physical activity as the population for which the equation was developed (Heyward, 1996).

Heyward (1996) concluded that skinfold thickness transformed to a %BF was appropriate for group parameters, but not for individual predictions. It is also recommended that the actual raw data be used for assessing changes in body composition rather than comparing %BF (Sanborn, 1991).

1.5.2.2 Comparison of Skinfold Protocols

The number of skinfold sites used varies greatly between studies. Shimamoto *et al.*, (1998) used only two skinfolds; triceps and subscapular, while Franklin *et al.,* (1979) used the sum of ten skinfolds; cheek, chin, upper arm, chest, side, waist, abdomen, back, knee and calf. It is important when selecting a skinfold protocol to identify one that will accurately represent body fat levels while not having an excessive number of skinfold sites as this would prove impractical for use on large populations. Including skinfold measurements from the lower body is thought to improve the estimation of body fat (Sanborn, 1991).

Jackson *et al.*, (1980) developed and then compared three prediction equations for predicting body density using skinfold measurements. They recommend that researchers use their prediction equation which used the sum of three skinfolds (triceps, suprailiac, and thigh) and the subjects age as it produced values similar to their other equations (with more skinfold sites) and was the most feasible for mass testing. This protocol has been extensively used in research (Legg *et al.*, 1988; Hammer *et al.*, 1989; Heyward *et al.*, 1992; Hinkleman & Nieman, 1993; Sale *et al.*, 1995; .

Santiago *et al.,* (1987) used a protocol developed by Pollock *et al.,* (1980) to assess changes in body fat levels for previously sedentary females taking part in a 20-week conditioning programme of walking or jogging. Three methods (body mass, body density by HW and the sum of four skinfolds: triceps, anterior thigh, abdomen and suprailiac) were used to assess body composition before and after the training period. There were no changes in body mass, %BF as estimated by HW and the Sum of Skinfolds. As there were no changes in body composition detected by any of the methods employed for this study the use of the sum of four skinfolds could not be validated.

Women are generally characterised by relatively high levels of subcutaneous fat in the upper arm (Stefanick, 1993) and gluteal-femoral (gynoid) regions (Bouchard *et al.*, 1993). Some, however, demonstrate a more 'male' or android type fat patterning of increased abdominal visceral fat (Stefanick, 1993). This type of fat patterning increases the risk of obesity related diseases for both males and females (Stefanick, 1993). The abdominal skinfold used in the study by Santiago *et al.*, (1987) strengthens the assessment of body composition, especially for those women with android fat patterning.

Broeder *et al.*, (1992) assessed changes in body composition of 47 males performing 12 weeks of either high-intensity endurance or resistance training. They used six skinfold sites (subscapular, triceps, chest, suprailiac, abdomen, and thigh) to estimate relative body fat (%BF) and also to verify the estimation of %BF, fat free weight (FFW) and fat weight (FW) as determined by HW. They observed strong correlation's between relative body fat determinations obtained by HW and skinfold measurements for both pre- ($r = 0.92$, $p<0.0001$) and post treatment periods ($r = 0.92$, $p<0.0001$). Although the sample population were male, it was concluded that the six skinfold sites used were representative of total body fat.

1.5.3 Circumferences

Sanborn (1991) stated that 'assessments should not rely on one method or one measure but incorporate various techniques that estimate different components of the body, i.e. muscle, bone, water and fat'. One alternative to skinfold measurement is the circumference method. Body girths or circumferences are affected by skin, muscle, fat and bone (Sanborn, 1991) and represent both fat mass and lean body mass (Heyward, 1996).

The importance of this can be seen in the study by Grediagin *et al.,* (1995) which investigated the effect of exercise intensity on body composition. Body composition was analysed using body mass, body fat (measured by HW), seven skinfold sites, and seven circumference sites. The results showed no changes in skinfold measurements while significant decreases in circumferences were observed in one of the exercise groups (low intensity) compared to the other (high intensity). They concluded that the high intensity group had gained a greater amount of fat free mass than the low intensity group. This study illustrates that circumferences used in conjunction with skinfold measurements give a more accurate representation of body composition.

Some factors that influence the significance of data obtained by the circumference method include the identification of anatomical landmarks and the tension applied to the anthropometric tape (Heyward, 1998). It is recommended that the anthropometric tape used for measuring circumferences be flexible but not elastic (Sanborn, 1991; Heyward, 1998) and a minimum of 0.7 cm wide (Sanborn, 1991). The use of anthropometric tapes with a spring-loaded handle allows a constant tension to be applied during measurement (Heyward, 1996).

It has been argued that, when standardised procedures are used, skill was not thought to be a major source of error with circumference measurements (Heyward, 1996). Heyward, (1996) recommended that circumferences be measured in the following way:

1. Take all measures on the right side of the body

2. Carefully identify and measure the site. Be meticulous about locating anatomical landmarks used to identify the measurement site
3. Take a minimum of three measurements at each site in a rotational order
4. Use anthropometric tape – zero end of tape held in the left hand, positioned below the other part of the tape held in the right hand
5. Tension should be applied to the tape so that it fits snugly around the body part but not so much as to indent the skin or compress the subcutaneous tissue

1.5.3.1 Comparison of Circumference Protocols

Circumference measures have often been used to estimate body composition (Himes, Roche, & Webb, 1980; Mueller & Malina, 1987; Fanelli, Kuczmarski, & Hirsch, 1988; Hammer *et al.*, 1989; Whatley *et al.*, 1994; Grediagin *et al.*, 1995; Klipstein-Grobusch *et al.*, 1997; Kukkonen-Harjula *et al.*, 1998; Madsen, Adams, & Van Loan, 1998; Shimamoto *et al.*, 1998; Kumar, Cantor, Allen, & Cox, 2000). One protocol widely used in studies involving women, measures waist and hip circumferences to assess body composition (Hardman & Hudson, 1994; Whatley *et al.*, 1994; Bonoro, Micciolo, Ghiatas, Lancaster, Alyassin, Muggei, & DeFronzo, 1995; Klipstein-Grobusch *et al.*, 1997; Kumar *et al.*, 2000; Wilson *et al.*, 2001). Hip circumference gives a reliable estimation of subcutaneous adipose tissue in the gluteofemoral region (ie. peripheral fat) while waist circumference is an indicator of both subcutaneous and visceral adipose tissue (Bonoro *et al.*, 1995). The ratio between the two is thought to be a reliable indicator of body fat patterning (Ferland, Depres, Tremblay, Pinault, Nadeau, Moorjani, Lupien, Theriault, & Bouchard, 1989; Bonoro *et al.*, 1995; Wilson *et al.*, 2001). While the ratio of waist and hip circumferences method is extensively used, it is only considered to be an indicator of adiposity not lean muscle mass.

Studies by Mueller *et al.*, (1987), Fanelli *et al.*, (1988), Ellison, Christian, Johnson, Warren, & Collins, (1992) and Grediagin *et al.*, (1995) used circumference measurement protocols with multiple measurement sites that included limb, torso and upper and lower body areas. Fanelli *et al.*, (1988) investigated the effectiveness of ten circumference sites at estimating body density in women, as measured by hydrostatic weighing. The sites were; wrist, forearm, mid-upper arm, waist-1 (at level of natural waistline, midway between costal border and the iliac crest), waist-2 (at the level of bi-iliac crest and anteriorly; at the umbilicus), hip, upper thigh, mid-thigh, calf and ankle. The best estimators of body density were: mid-upper arm ($r = -0.703$; $P<0.001$), waist 2 ($r = -0.660$; $P<0.001$), hip ($r = -0.700$; $P<0.001$), upper thigh ($r = -0.668$; $P<0.001$) and mid-thigh ($r = 0.626$; $P<0.001$).

Grediagin *et al.*, (1995) assessed changes in body composition in previously untrained women over a twelve week training intervention study using hydrostatic weighing, skinfold and circumference measurements. The circumference sites chosen were wrist, chest, waist, abdomen, gluteals, mid-thigh and calf. As was discussed previously, these circumference measurements were successful in identifying changes in the ratio between fat mass and lean body mass when compared to hydrostatic weighing.

The relative reliability of circumferences and skinfolds in estimating body fat distribution was investigated using repeated measures by Mueller *et al.*, (1987). They showed the circumference sites: chest, waist, hip, mid-upper arm, forearm, and calf, to be more reliable estimators than skinfold measurements ($r = 0.96$ and $r = 0.91$ respectively, $P<0.01$). Unfortunately, neither method was compared to hydrostatic weighing.

Ellison *et al.*, (1992) used five circumference sites to assess musculoskeletal development in females. These sites (waist, forearm, upper arm, calf and gluteal) are the same as those described by McArdle *et al.*, (1996) who also include hip circumference.

In summary, it is generally accepted that an accurate representation of body composition for an individual can be produced with skinfold and circumference measurements. Assessments that use both methods are considered to provide more accurate estimations of body composition with respect to fat mass and lean muscle mass.

1.6 The Current Study

The primary aim of the research was to investigate the effectiveness of two popular modes of training, walking and 'Pump It' aerobics, at producing changes in body composition and cardiorespiratory fitness in previously sedentary females. Sedentary females were used for Experiment 2 as it was estimated that they were more likely to show improvements within six weeks of training than currently trained subjects. For this experiment, a suitable method was required for estimating/measuring the intensity of training during the exercise sessions for both walking and 'Pump It'. The method in which oxygen consumption is measured directly was considered impractical for the current study due to the nature of the 'Pump It' exercise class and the size of the gas analysis equipment.

A preliminary investigation (Experiment 1) was performed to establish whether the relationship between heart rate and oxygen consumption (HR/VO_2) altered with different types of exercise, namely, treadmill walking, cycling and 'Pump It' aerobics. Experiment 1 also investigated the validity of using HR for the prediction of VO_2 during 'Pump It' aerobics using the HR/VO_2 relationship of each individual obtained with treadmill walking or cycling. Any discrepancies between the HR/VO_2 relationships obtained during 'Pump It' aerobics and treadmill walking that were observed were taken into consideration for Experiment 2.

There have been no studies to date on the fitness benefits of 'Pump It' aerobics at the Massey University Recreation Centre. 'Pump It' is essentially a resistance training class that aims to improve or maintain current levels of body composition or body image. It is generally not regarded as a class aimed at improving cardiorespiratory fitness. 'Pump It' classes are attended by a large number of students and staff at Massey University. Studies in other labs suggest that improvements in cardiorespiratory fitness were unlikely with this type of training due to insufficient exercise intensity. No studies to date have examined the effects of this type of training on body composition. However, studies have shown increases in lean body mass and decreases in fat mass with CWT. As the Massey University 'Pump It' class contains unique features, it was considered important to establish the training effects of 'Pump It' on cardiorespiratory fitness and body composition rather than rely on findings from other studies.

Walking is another popular exercise option for women, especially when starting a training programme. In the absence of dietary manipulation, walking is primarily performed to improve current levels of cardiorespiratory fitness. The current study examined the short-term (six weeks) effects of walking training. Although walking has been shown to improve cardiorespiratory fitness and body composition (Franklin *et al.*, 1979; Santiago *et al.*, 1987), it has not been established whether benefits can be observed within six weeks of training for previously sedentary females. It was decided that the current study would attempt to establish whether cardiorespiratory fitness and body composition are improved in previously sedentary females with six weeks of walking training.

The preliminary experiment 'Predicting Oxygen Consumption using the HR/VO_2 relationship', is referred to in the text as Experiment 1. The main study, 'The Effects of Different Forms of Exercise on Body Composition and Cardiorespiratory Fitness in Previously Sedentary Females', is referred to as Experiment 2.

Chapter 2

Predicting Oxygen Consumption using the HR/VO_2 Relationship

2.1 Introduction

The relationship between HR and VO_2 has been used to predict training intensity and oxygen consumption during various modes of exercise (Wilmore & Haskell, 1971; Franklin, 1980; Parker *et al.*, 1989; Londeree *et al.*, 1995; Gilman, 1996; Bernard *et al.*, 1997).

Adaptations to training are specific to the type of training being performed (Barnett *et al.*, 1973; Williams & Jackson, 1977; Perez, 1981; Sale, 1988). As a result, it is reasonable to state that any improvements in fitness resulting from 'Pump It' aerobics would be specific in terms of the movements performed, speed of the movement, body position and the intensity of work. It could also be assumed, when trying to detect adaptations to a specific type of training, that the testing method selected needs to be sensitive to that mode of exercise. The use of the HR/VO_2 relationship determined during treadmill walking for the estimation of VO_2max may not be a suitable method for illustrating any changes in cardiorespiratory fitness resulting from 'Pump It' aerobics.

The use of the HR/VO_2 relationship during treadmill walking for the prediction of training intensity and oxygen consumption was deemed appropriate for the Control and Walking groups in Experiment 2. Studies have shown that oxygen consumption and training intensity were over predicted for exercise similar to 'Pump It' when based on data obtained during treadmill walking (Parker *et al.*, 1989; Collins *et al.*, 1991; Stanforth *et al.*, 2000). Therefore, the validity of using the HR/VO_2 relationship during treadmill walking for predicting training intensity and oxygen consumption for 'Pump It' aerobics was questioned.

In this experiment, individual HR/VO_2 relationships were established and compared during three different modes of exercise (treadmill walking, cycling and 'Pump It' aerobics). The establishment of these individual, mode specific, relationships allowed the evaluation of the appropriateness of assessing changes in cardiorespiratory fitness for 'Pump It' aerobics, based on physiological responses obtained during treadmill walking. Also, comparisons of the mode specific HR/VO_2 relationships would determine whether the relationships were affected by mode of exercise. Experiment 1 also assessed the validity of using heart rate measurements during 'Pump It' aerobics and Walking for the estimation of intensity of work using the HR/VO_2 relationship established during treadmill walking.

2.2 Methods

The pre-test instructions and testing environments for both Experiment 1 and 2 were standardised according to ASCM Guidelines (Mahler et al., 1995). All of the subjects in Experiment 1 and 2 completed a PAR-Q questionnaire (Physical Activity Readiness Questionnaire) see Appendix A.1. The PAR-Q was used to identify any contraindications to exercise for participants. PAR-Q is a widely accepted method for pre-exercise screening (Firor & Faulkner, 1988; Shephard, 1988; Thomas, Reading, & Shephard, 1992; Mahler *et al.*, 1995) due to its sensitivity and specificity relative to such criteria as medical examination, hypertension and exercise induced ECG abnormalities (Shephard, 1988).

Prior to the first exercise session in Experiment 1, and before the initial fitness test in Experiment 2 subjects signed a consent form. This consent form acknowledged that the subjects had agreed to take part in the study and were fully aware of the details of the study. The study design involved using technologically advanced equipment including the Pulmolab Ergospirometry System (ex-670, Morgan Medical, UK) and the Excalibur Sport Lode cycle ergometer (Lode BV, Groningen, The Netherlands). The Massey University Human Ethics Committee had given prior approval for both Experiment 1 and 2 and the wording of the consent form (see Appendix A.2).

2.2.1 Experimental Design

2.2.1.1 Respiratory Gas Analysis

The ex-670 Pulmolab Ergospirometry System allowed breath by breath analysis of both inspired and expired gases. The ex-670 system provided results on oxygen uptake (VO_2), carbon dioxide production (VCO_2), ventilation (V_E), and respiratory exchange ratio (Q) in real time. Inspired and expired gases were sampled continuously through a capillary tube during each of the testing sessions. A capillary tube was attached to a bi-directional turbine volume transducer which measured the rate of flow through the volume transducer for each breath. A mouthpiece was connected to the volume transducer. Subjects breathed through this mouthpiece just prior to beginning the exercise test, for the entire exercise period and during the recovery phase. A nose clip was worn to prevent nasal breathing.

The ex-670 was calibrated for flow and gas analysis before each exercise test. Flow calibration was achieved using a 3L syringe which was connected to the bi-directional turbine volume transducer. The syringe was completely emptied and then filled at set times of 0.5, 1 and 2 seconds. The calibration was accepted if a verification stroke produced a volume of 3.0 ± 0.01 L. Gas was calibrated using air and a calibration gas containing approximately

16.1% O_2 and 5.1% CO_2 (alpha standard gas, BOC Analytical Gases, Wellington).

2.2.1.2 Treadmill Calibration

A calibration of treadmill speed, gradient and calculated Work was performed before commencement of the experiment. The calibration of treadmill speed involved measuring the length of the treadmill belt using a tape measure. A mark was then made on the treadmill belt to allow belt revolutions to be counted. The treadmill was run at known speeds for periods of thirty seconds and the number of belt revolutions recorded. This allowed the distance travelled on the treadmill to be measured and hence speed to be calculated.

The minimum increment for the increase in gradient on the treadmill was 1%. An increase in treadmill gradient of 1% was defined as being a vertical increase of 1cm for every 100cm along the treadmill belt on the horizontal. Therefore an increase in treadmill gradient of 3% resulted in an increase of 3cm every 100cm along the treadmill belt. A calibration was performed to match every percentage change to its respective angle.

The treadmill computer automatically calculated the work performed by each subject based on the subjects' weight, the speed of the treadmill and the treadmill gradient. This estimation of work was tested for accuracy by calculating work for some of the subjects using the formula: Work = Mass x Vertical Height. The calculations confirmed that the treadmill gave accurate and reliable estimations of Work performed on the treadmill. As a result, the estimate of Work given by the treadmill computer was used for both Experiments 1 and 2.

2.2.2 Subjects

Subjects were chosen from a group of volunteers that responded to an advertisement displayed on notice boards at the Palmerston North Campus of

Massey University. The subjects were required to fit the following criteria; female, between the ages of 18-45 years, did not smoke tobacco, healthy, of a stable weight and who were active but not taking part in competitive sports. Of the 14 individuals that responded, 12 agreed to take part. Nine subjects completed the study. Subjects were randomly assigned to one of six groups labelled; A, B, C, D, E, and F. These groups determined which order each subject performed the activities involved in the study. For example Group A performed the tests in the following order; treadmill, cycle, 'Pump It'. While the order for Group B was; 'Pump It', cycle, treadmill. All of the groups took part in every activity.

2.2.3 Testing Procedures

At the beginning of each testing session blood pressure was measured using an electronic sphygmomanometer (Kenz-45m, Medical Teletronics Ltd., Auckland). Each subject was weighed at the start of the first testing session using electronic scales (Jadever Scale JPS-2030, Jadever Scaleco Ltd, Taiwan) to the nearest 0.001 kg. Subjects were asked to remove their shoes and to wear light clothing (T-shirt and shorts) in an attempt to standardise this procedure. The subject then took part in one of the three testing sessions.

2.2.3.1 Exercise Sessions

The subjects selected for this study agreed to take part in three separate testing sessions. These testing sessions included two submaximal exercise tests, one on a treadmill, the other on a cycle ergometer. The third test involved resistance exercises, modelled on exercises taken from the 'Pump It' aerobics class investigated in Experiment 2. The testing schedule was designed to allow each subject at least 48 hours between tests (see Table 5).

Table 5. Testing Schedule for Experiment 1

Time	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9
AM	A+B (pump)	E+F (cycle)	Break	Break	B+E (walk)	Break	Break	A+F (walk)	C+E (pump)
PM	C+D (walk)	Break	Break	A+C (cycle)	D+F (pump)	Break	Break	B+D (cycle)	Break

Note: pump = 'Pump It' test, walk = treadmill test, cycle = cycle ergometer test

Subjects wore a body-borne heart rate monitor (polar sport tester, Polar Electro, Finland) for each of the exercise sessions. Heart rates were obtained before commencing the exercise trial, during the exercise test and during the recovery period. Pre-exercise heart rate was monitored while the subject relaxed until a stable rate was observed for thirty seconds at which stage the exercise test would begin. The heart rate monitors enabled heart rates to be obtained every five seconds.

2.2.3.2 Treadmill Test

The treadmill test involved taking part in a submaximal walking test similar to the one that was to be used in Experiment 2 (see section 3.2.3.7.2). Each subject completed a warm up prior to the exercise test that involved walking on the treadmill for three minutes at a speed of 4.0km/hour and an incline of 1%. Differences existed in the warm up protocols for the two experiments because workloads on the treadmill and cycle had to be identical in Experiment 1. At an incline of 0% subjects are effectively not performing any work. Therefore, increasing the incline to 1% allowed work to be equated for exercise performed on both the treadmill and cycle ergometer. Speed of the treadmill was decreased from 5km/hr (speed for Experiment 2) to 4km/hr in an attempt to compensate for the increase in intensity resulting from the increase in gradient.

The exercise test began upon completion of this warm up stage, at which time treadmill speed and gradient was increased to 5km/hour and 3% respectively. The gradient was increased by 3% every three minutes thereafter until the test was terminated. The criteria for terminating the test depended on which order the subjects performed the tests. The termination criteria for the treadmill test were as follows:

1. Subjects who had already performed a test on the cycle ergometer terminated their treadmill test following three minutes at the highest workload that the subject had achieved on the cycle ergometer.

2. Subjects who were scheduled to perform the treadmill test before the cycle test terminated at the end of the stage where the subjects' heart rate reached 75-85% of their age predicted maximum heart rate.

2.2.3.3 Cycle Ergometer Test

The cycle ergometer used for the testing was a Lode Excalibur Sport cycle ergometer (Lode BV, Groningen, The Netherlands). The Excalibur Sport cycle ergometer system consists of an electrically braked cycle ergometer with a work load programmer computer (WLP) that controls the testing protocols. The cycle ergometer test was designed to mimic the treadmill test in terms of duration, intensity and workload. Workload was calculated prior to testing by calculating the workload that each subject would perform for each stage of the treadmill test. For example a 60kg subject walking on the treadmill at 4km/hr at an incline of 1% (as in the warm up) would be working at 51Watts. This workload would then be used as the warm up workload for that subject on the cycle ergometer. Subjects scheduled to exercise on the treadmill first, as in groups B, C and D, had their cycle test terminated at the end of the workload equivalent to the final workload that they had completed on the treadmill. Subjects in groups A, E and F, who exercised on the cycle ergometer first, continued exercising until the end of the stage at which their heart rate reached 70-85% of their age predicted maximum heart rate. Subjects were warmed down on the cycle for three minutes at a previously determined workload equal to that, which would be performed, on the treadmill.

2.2.3.4 'Pump It' exercise test

The exercises used in this testing session were taken from an aerobics class, 'Pump It', that is run at the Massey University Recreation Centre. Each subject performed three exercises: squats, upright rows and bench press. These three exercises were chosen as they are performed in every 'Pump It' class and they also recruit the major muscle groups in the body. For example, Squats recruit the quadriceps, hamstrings, gluteals and calf muscles as well as the core body muscles (abdominals and lower back). Upright Rows use the muscles of the shoulder, back and upper arms, while bench press involves the chest and upper arm muscles. These exercises also differ in terms of body position where squats and upright rows are upright and weight bearing while bench press is supine and weight supported.

The subjects used a 'Pump' bar with weights of 2, 4, or 5kg in total. The subjects selected their own weights according to current levels of strength. Each of the subjects warmed up on the treadmill for two minutes at a speed of 4km/hour and 1% incline. Resting heart rate was determined prior to the warm up as in the treadmill test.

The speed and duration that the exercises were performed were designed to mimic that of a 'Pump It' aerobics session while allowing a steady state to be reached for heart rate and oxygen consumption. Movements, in a typical 'Pump It' session, are performed on average, at a speed of 15.5 repetitions per minute. Therefore, subjects executed the moves at this speed for three minutes at a time, for steady state gas analysis. A metronome was used to keep the subjects exercising at this rate.

Multiple regression equations described the relationships between VO_2 and W (Appendix D.1.) and HR and W (Appendix D.2.) for exercise on both the cycle and treadmill. Equations were generated for the subjects as a group and individually.

Experiment 1 was analysed in two steps. Firstly, the relationships between Oxygen Uptake (VO_2) and Workload (W), then Heart Rate (HR) and W were established (Appendix D.1. and D.2.). These relationships were then compared for the two modes of exercise; cycle (Cy) and treadmill (Tr). The second step used heart rates obtained during the 'Pump It' exercise tests and derived equations from the two modes of exercise to predict VO_2. The predicted VO_2 values were then correlated to see which, if any, of the derived equations (Cy or Tr) were better at predicting VO_2 during 'Pump It' aerobics (Appendix D.4.). All of the analyses for Experiment 1 were done using Statistical Programme for Social Scientists (SPSS, version 10.0; SPSS inc, Chicago).

2.3 Results

The VO_2/W relationships were different for the cycle and treadmill tests for all of the subjects, except subjects 1, 3 and 7. The multiple regression equation derived for subject 5 produced VO_2 values 0.3 L/min higher on the cycle compared to the treadmill at any given workload. In contrast, the equation for subject 9 gave higher VO_2 values for the treadmill ($VO_{2\ (Cy)} = 7.33E^{-02} + 1.01\ E^{-02}W$, $VO_{2\ (Tr)} = 0.15 + 1.01\ E^{-02}W$). When subjects were grouped together, however, mode of exercise did not alter the VO_2/W relationship.

The multiple regression equations describing the HR/W relationships showed that the HR response to exercise was influenced by the type of exercise equipment being used for some of the subjects (2,4,5,7 and 8). The equation describing the relationship for Subject 2 illustrates this effect, with the HR produced being ~22 bpm higher for any given workload on the cycle ($HR_{(Cy)} = 99.1 + 0.60W$, $HR_{(Tr)} = 76.8 + 0.60W$). However, as was observed with the VO_2/W relationship, the HR/W relationship was not altered by the mode of exercise at any given workload when the subjects were grouped ($HR_{(Cy/Tr)} = 77.8 + 0.50W$).

Equations describing the relationship between HR and VO_2 were derived using the multiple regression equations produced for the VO_2/W and HR/W relationships discussed above. The derived equations for the subjects as individuals and as a group are given in Appendix D.3. The average of the steady state heart rate (during the last minute of the three minute test) obtained for squats, upright rows and bench press were then imputed into the derived equations to calculate a predicted VO_2 for each subject. Mode of exercise was a factor in the derived equations for every subject except subjects 1 and 3.

Correlations between predicted $VO_{2\ (Cy)}$ and actual $VO_{2\ (\text{'Pump It'})}$ and then predicted $VO_{2\ (Tr)}$ and actual $VO_{2\ (\text{'Pump It'})}$ differed for the three 'Pump It' exercises; squats, upright rows and bench press. Weak correlations were observed when predicting VO_2 for squats and upright rows using equations for both the cycle and treadmill. Squats produced the strongest correlation (Cy = - 0.561, sig = 0.116, Tr = - 0.557, sig = 0.120) but these were still only weak. The correlations for each group for both Cy and Tr were negative in every case. This negative correlation illustrates that the derived equations over predicts VO_2 for low values of actual $VO_{2\,(\text{'Pump It'})}$ and under predicts when the actual $VO_{2\,(\text{'Pump It'})}$ is high.

Overall, predicted VO_2 during 'Pump It' was overestimated in 75% of the cases. Predicted oxygen consumption for 'Pump It' using the relationship for treadmill walking was on average 0.38 L/min higher (SD ± 0.20 L/min) than the actual measured oxygen consumption. Values were under predicted for 12.5% of the cases. Predicted values that were the same as the measured VO_2 for 'Pump It' also represented 12.5% of the cases.

2.4 Discussion

In the current study, individual HR/VO_2 relationships were different for exercise on the treadmill and cycle ergometer for 7 of the 9 subjects. This is consistent with other findings (Londeree *et al.*, 1995). However, VO_2 during 'Pump It' when predicted from the HR/VO_2 relationships obtained during treadmill or cycle training, produced similar correlations. This suggested that mode of exercise in the current study did not affect the accuracy of the prediction of VO_2 during 'Pump It' exercise. This finding is consistent with the study by Bernard *et al.*, (1997) who found no difference between treadmill and cycle exercise.

Oxygen consumption during 'Pump It' aerobics, in the current study, was not accurately predicted by the HR/VO_2 relationships obtained during either treadmill or cycle exercise. This finding was in agreement with other studies (Parker *et al.*, 1989; Collins *et al.*, 1991; Stanforth *et al.*, 2000). It was not surprising to observe that the weakest correlations occurred when predicting oxygen consumption during the 'Pump It' exercises; upright rows and bench press. Both movements involve primarily muscles of the upper body. However, in upright rows there is thought to be some involvement of the trunk muscles due to postural stabilisation (Stenberg *et al.*, 1967). Heart rate is elevated disproportionately to VO_2 with this type of exercise (Bevegard *et al.*, 1966; Stenberg *et al.*, 1967; Vokac *et al.*, 1975; Tulppo *et al.*, 1999). The findings in the current study provide further evidence that mode specific HR/VO_2 relationships should be obtained for exercise of this type.

While oxygen consumption during 'Pump It' aerobics was not predicted accurately using treadmill data, it was consistently over predicted (75% of the cases). As it was not practical to obtain HR/VO_2 relationships during 'Pump It' it was decided that data obtained during treadmill walking would be used to predict oxygen consumption for 'Pump It' aerobics in Experiment 2. When analysing the values obtained for exercise intensities or oxygen consumption for the 'Pump It' group in Experiment 2 it would be taken into account that values would be overestimated. For oxygen consumption, this overestimation would be approximately 0.38L/min.

Chapter 3

The Effects of Different Forms of Exercise
on Body Composition and Cardiorespiratory Fitness
in Previously Sedentary Females

3.1 Introduction

Many young women begin exercising because of the well known benefits for health through improved cardiorespiratory fitness (Franklin *et al.*, 1979; Sale *et al.*, 1995; Kukkonen-Harjula *et al.*, 1998) and loss of weight (Bouchard *et al.*, 1993; Hunter *et al.*, 1998; Fagard *et al.*, 1999; Grundy *et al.*, 1999; Terenzi, 2000). Different types of exercise which are popular are walking, aerobic fitness classes and resistance training aerobics classes, such as 'Body Pump'. Body Pump involves mainly static exercise and is not designed to improve cardiorespiratory fitness (Stanforth *et al.*, 2000), but to improve the participants' muscular strength and endurance while inducing favourable changes in body composition and appearance.

The 'Pump It' aerobics class developed at the Massey University Recreation Centre is similar in concept and design to 'Body Pump' in that it is a resistance training class using a barbell and weights to perform a range of conventional weight training exercises to music. Exercises that use the participants body weight as the resistance, such as press-ups and triceps dips, have also been incorporated into the class. Pre-mixed aerobics music with a steady base beat is used throughout, allowing the instructor to control the speed at which the participants perform the movements. Progressive overload is achieved by altering the exercise stimulus by means of the exercise chosen, weight load, range of motion, speed of movement, hand grip, foot placement and body position. A typical 'Pump It' session lasts 60 minutes and includes a general body warm up, approximately 50 minutes of resistance training, followed by a cool down and stretch. The warm up phase facilitates the transition from rest to exercise by stretching the postural muscles, augmenting blood flow, and increasing metabolic rate from resting levels (Baldy *et al.*, 2000). Warm ups are also thought to reduce susceptibility to musculoskeletal injury by increasing connective tissue extensibility, improving joint range of motion and function, and enhancing muscular performance (Pollock *et al.*, 1998). The cool down, which is simply a gradual decrease in the imposed workload, avoids blood pooling and limits any muscle discomfort that may occur (Lear *et al.*, 1999).

The effectiveness of 'Pump It' aerobics at producing improvements in cardiorespiratory fitness, muscular endurance and body composition have not been investigated. It is also difficult to identify the potential improvements in cardiorespiratory fitness and body composition that may occur in response to a programme involving 'Pump It' aerobics, as it is quite unlike any other form of resistance training. Stanforth *et al.*, (2000) thought that CWT was most similar to 'Body Pump' (their version of 'Pump It'). They identified the major differences between CWT and Body Pump as being the length of the exercise period, the number of repetitions performed and the resistance used. These differences would also be applicable when comparing CWT to 'Pump It'.

Walking is commonly prescribed for sedentary individuals when they begin a training regimen, with the aims of improving general health and well being (Davison & Grant, 1993; Hardman & Hudson, 1994). Walking has been shown to produce positive effects on cardiorespiratory fitness and body composition (Franklin *et al.*, 1979; Santiago *et al.*, 1987; Hardman & Hudson, 1994; Grediagin *et al.*, 1995; Kukkonen-Harjula *et al.*, 1998), however, few studies have attempted to investigate the minimum training duration required to produce improvements (Liang *et al.*, 1982). The findings of Liang *et al.*, (1982) suggest that improvements may be observed within six weeks.

The present experiment was designed to assess whether 'Pump It' aerobics, undertaken for only six weeks, would improve cardiorespiratory fitness and change body composition. For comparison, a group of subjects undertook walking at a similar level of exercise intensity. Improvements in cardiorespiratory fitness have been observed with running and cycling following six weeks of training (Carter *et al.*, 1999; Branch *et al.*, 2000). Carter *et al.*, (1999) and Branch *et al.*, (2000) suggest that if training volume were sufficient, improvements in VO_2max may be observed after only six weeks of walking. For the current study, exercise duration was based on a typical 'Pump It' session, which lasts approximately sixty minutes. Therefore, the training intensity chosen for the walking group needed to be maintainable by the sedentary subjects for sixty minutes while being sufficiently high to promote improvements in VO_2max. It was decided that subjects would be advised to maintain a 'brisk' walking pace for the duration of the walking sessions. This would not limit the individual to a set %HRmax or $\%VO_2max$ and would possibly enable the participants to exercise for the entire session duration.

For the assessment of cardiorespiratory fitness, a protocol suitable for healthy but sedentary females between the age of 18-45 years was required. The protocol needed to be continuous and progressive in nature while allowing a 'steady state' to be reached at each work level for gas for gas analysis using the Douglas Bag method. Steady State exercise is usually accepted to be in the third minute of exercise at any given submaximal workload below the anaerobic threshold (Whipp & Wasserman, 1972; Bezucha, Lenser, Hanson, & Nagle, 1982; Sietsema, Daly, & Wasserman, 1989; Jones & Carter, 2000). The protocol chosen for the current study was shown to be suitable for estimating VO_2max using individual HR/VO_2 relationships, determined during exercise at submaximal workloads (Chapter 2). This method is accepted for the assessment of cardiorespiratory fitness when maximal protocols are deemed inappropriate

(Von Dobeln, Astrand, & Bergstrom, 1967; Astrand, Astrand, Hallback, & Kilbom, 1973; Pollock *et al.*, 1980; Hartung, Blancq, Lally, & Krock, 1995; Lear *et al.*, 1999; Skinner *et al.*, 2000). The protocol was based on the Balke (section 1.2.1) and modified Balke (section 1.2.1) tests and continued to 70-85%HRmax.

Body composition was assessed using standardised procedures to measure body mass, height, skinfold thickness and circumference measurements. When selecting an appropriate circumference protocol for the assessment of body composition for the current study, it was important to identify one that would accurately reflect any changes that may result from performing 'Pump It' and Walking. Walking involves predominantly the muscles of the lower body, while 'Pump It' is intended to target the body's major muscle groups (Stanforth *et al.*, 2000). As a result, the chosen protocol needed to include measurements on the upper body, lower body, limb and torso regions and to include sites that reflected both muscle and adipose tissue. The sites chosen, biceps (mid-upper arm), forearm, waist, hips, thigh and calf, were a combination of the sites used by Mueller *et al.*, (1987), Fanelli *et al.*, (1988), Ellison *et al.*, (1992) and Grediagin *et al.*, (1995).

In order to determine the effects of 'Pump It' and Walking, it was important that the only alteration to the daily activity of all subjects would be that imposed by the study. Previous studies have identified problems where activity levels have not been recorded and subjects have performed extra activity unbeknown to the researcher (Scott, 1995). In the current study, subjects were asked to maintain their normal current daily activity levels, with the exception of the activity required in the 'Pump It' and Walking sessions and to any other activity was to be recorded in an activity diary.

Dietary intake is often monitored during exercise intervention studies to ensure that any changes in body composition are not a result of alterations in the participants' diet (Sale *et al.*, 1995; Cullinen & Caldwell, 1998; Kukkonen-Harjula *et al.*, 1998). Dietary intake was estimated in a similar manner to Sale *et al.*, (1995), Cullinen *et al.*, (1998) and Kukkonen-Harjula *et al.*, (1998), whose subjects recorded everything that they ate or drank on any two weekdays and one weekend day in the first and last weeks of their respective studies. Analysis of food and drink consumed in the current study was based on food composition data obtained from The Concise New Zealand Food Composition Tables (Burlingame, Milligan, Apimerika, & Arthur, 1993).

3.2 Methods

3.2.1 Experimental Overview

All subjects who took part in this trial were female, 18–45 years old, non-smokers, healthy, of stable weight and who were previously sedentary (no strenuous or regular exercise in previous two months). Subjects volunteered in response to an advertisement placed in the Massey University Newsletter. Therefore, the sample population generated was a self-selected group and could not be classified as a true random sample of the general population. Each subject was randomly assigned to one of three groups (Control, 'Pump It' and walking) and then assessed for their current fitness levels and anthropometric measurements were made for an evaluation of their body composition. The order of testing was arranged according to recommendations given in the ASCM Guidelines (1995), i.e. Blood Pressure was measured first followed by (in order) body composition and cardiorespiratory fitness. See section 3.2.3.7 for complete list and order of tests. After determining these baseline measures of fitness, the subjects took part in an exercise intervention programme, which continued for six weeks. At the end of this six-week period, subjects were again assessed for cardiovascular fitness and body composition. The same person made all of the measurements in the first and second fitness testing sessions. This person had considerable experience in fitness testing and had practised each aspect of the assessment protocol on over 100 subjects prior to the current study.

3.2.2 Subjects

The advertisement that subjects responded to, specified that subjects were female, between the ages of 18-45 years, did not smoke tobacco, were healthy, were of a stable weight and had not performed strenuous or regular exercise in the previous two months. Of the 42 that initially replied, 35 agreed to participate in the study. As in Experiment 1, all subjects read an information sheet and filled out PAR-Q and consent forms (see section 2.2).

3.2.3 Experimental Design

Eleven subjects started in the walking programme. Initially there were twelve subjects in both the 'Pump It' and control groups. Seven walkers, twelve controls and ten of the 'Pump It' group completed the study. All subjects were asked to maintain their normal eating habits and recreational activity levels during the study.

3.2.3.1 Non-experimental Exercise

Activity levels were recorded by all of the subjects in the first and last weeks of the experimental period according to an activity guide (Appendix A.4.) adapted from the Green Prescription (1999) and used with the permission of Sport Manawatu, Palmerston North, New Zealand (Appendix A.5.). The activity guide specified activities which were of significant intensity or duration to alter the subject's metabolic rate. The subjects were instructed on how to record their activity prior to commencing the study. Subjects were also asked to document any significant activity that they may have performed outside the times when activity was being recorded (none did).

3.2.3.2 Dietary Intake

Subjects recorded their dietary intake during the first and last weeks of the training period. This dietary record entailed measuring or weighing the food and drink that was consumed on any two week days and any one weekend day for the weeks mentioned on recording sheets provided in a subject diary (an example of a completed dietary recording sheet is given in Appendix A.6.). Subjects used their own scales or measuring equipment. The recording period could begin at any time on their chosen days but had to continue for twenty-four hours. The subjects were instructed in the method for recording their intake before beginning the study. Short cut methods were offered for foods eaten often and also for takeaways. These short cuts gave standardised compositions and portion sizes of common takeaway foods. Foods that were eaten regularly were assumed to be of the same size and composition as a previous portion that had been measured and recorded.

Following completion of the study, the dietary records were assessed using The Concise New Zealand Food Composition Tables (Burlingame *et al.*, 1993). Diets were assessed in terms of energy, protein, fat and carbohydrate content. Calculations were made for each day and the total energy (energy intake for two weekdays and one weekend day) were compared between the first and last weeks of the study. The dietary components of protein, fat and carbohydrate were also compared for the first and last weeks to identify changes in the consumption levels for each respective food group.

3.2.3.3 Control Group

The members of the Control group were asked to remain inactive during the experimental period. Each subject wore a heart rate monitor for one hour each week. During this hour, the subject was to continue with her 'normal' daily activities such as employed work, watching television or household chores.

3.2.3.4 'Pump It'

The 'Pump It' group was required to attend three classes per week, each of which lasted for approximately sixty minutes. 'Pump It' aerobics involves performing high repetitions (>25) of resistance exercises (Table 6) to music at varying tempos which altered the speed of the movement. The class was run by a trained 'Pump It' instructor who was responsible for subject safety and teaching the correct technique for the exercises involved. All of the classes started with a five-minute general body warm up.

Subjects were instructed to start with light weights consisting of a barbell with additional weight plates. The selection of weight plates available were 1kg, 2.5kg and 5kg. Therefore, the minimum weight that the subjects could add to the bar was 2kg but 1kg increases in weight could be achieved by selecting the right combination of weights. It was recommended that the weight on the bar be altered to suit the exercises being performed. For example, a subject could use 5kg for a bench press and then decrease the weight to 4kg for biceps curls. Subjects were encouraged to increase their weights (2kg increments) as the study progressed in order to challenge the subject during the session without compromising technique.

Stretching followed the strength component of the class; this involved static stretches of the muscle groups used. The stretching component of the class was adapted from the ACC stretching guidelines to allow them to be performed in a class environment. The ACC guidelines are utilised by most commercial gyms and sporting teams.

Table 6. Example of a typical 'Pump It' aerobics class

Exercise	*Approximate time spent on activity (min)*	*Major muscles used*
warm up	5-6	all major muscles
squats	4-5	Quadriceps femoris, Hamstrings, Gluteus maximus and minimus
lunges	3-4	Quadriceps femoris, Gluteus maximus and minimus, hip flexors
calf raises	3-4	Soleus, Gastrocnemius
inner/outer thigh	3-4	Pectineus, Adductor brevis, Adductor longus, Adductor magnus, Gracilis, Tensor fasciae latae, Gluteus medius.
upright rows	3-4	Trapezius, Deltoids
chest press	3-4	Pectorals, Latissimus dorsi
shoulder press	3-4	Trapezius, Deltoids
biceps curls	3-4	Biceps brachii
triceps extensions	3-4	Triceps brachii
press ups	3-4	Pectorals, Latissimus dorsi, Triceps, Rectus Abdominus, Obliques, Erector Spinae
abdominals (crunches/prone)	2-3	Rectus, Transverse and Obliques abdominus

Appendix A.8. diagrammatically identifies the major and minor muscle that would be used in a 'Pump It' class.

3.2.3.5 Walking

Subjects in the Walking group were required to walk under supervision three times per week for between fifty-five to sixty minutes. The subjects walked briskly as a group. The group was encouraged to push themselves appropriately by a staff member of the Massey University Recreation Centre who supervised each session.

3.2.3.6 Training Intensity

Exercise intensities for the Control, 'Pump It' and Walking groups over the six weeks of training were estimated using heart rate monitors during the exercise sessions ('Pump It' and Walking groups) and for 'normal' daily activity for the Control group. These heart rates were averaged and expressed as a percentage of predicted maximal heart rate (%HRmax). Oxygen consumption was estimated using the average heart rates obtained during the exercise sessions and the individual HR/VO_2 relationships determined on the treadmill in the first fitness assessment. Oxygen consumption was expressed as a percentage of maximum oxygen consumption (%VO_2max). Equipment failure in the third week meant that heart rates only could be obtained for the Control group during that week. In Experiment 1, oxygen consumption was found to be overestimated by ~0.38L/min during 'Pump It' when the HR/VO_2 relationship was determined during treadmill walking. As a result, all values given for training intensity, expressed as estimated VO_2, for the 'Pump It' group have been adjusted by - 0.38L/min before being converted to estimated %VO_2max.

3.2.3.7 Fitness testing

Each subject had a separate appointment at the fitness-testing laboratory prior to the first fitness testing session. At this time they were exposed to all of the fitness testing equipment and experimental procedures. All of the subjects were familiarised with the treadmill by walking on it for 2-3 minutes at a speed of 5km/hour. The speed of the treadmill was altered for some subjects where their height or walking gait meant that their heart rate would be affected by increased or decreased stride frequency. For example, one subject walked at a speed of 4.0km/hour as her shorter stature made walking at a speed of 5.0km/hour uncomfortably fast and her heart rate rose too quickly as a result. Three other subjects walked at 4.5km/hour while four walked at 5.5km/hour. This speed was kept the same for each subject for both testing sessions. The warm up speed was adjusted according to the final speed chosen for these subjects. Again, this speed was kept the same for both testing sessions.

Measurements of body composition and cardiorespiratory fitness were obtained for each subject at week zero and week seven of the trial. These variables were measured in the following order: blood pressure, height, weight, circumferences, skinfolds, pre-exercise heart rate, estimated maximum oxygen uptake, and rate of heart rate recovery following exercise. See Appendix B.1. for a summary of the variables obtained in the initial fitness test (week 0).

3.2.3.7.1 Body Composition

3.2.3.7.1.1 Height and Body Mass

Height was measured to the nearest 0.1cm using a stadiometer fixed to the wall of the laboratory. Weight was obtained using balance scales (Avery, 120kg capacity, Type 3306 ABV, Birmingham) to the nearest 0.025kg. It was requested that subjects wore light clothing (shorts and T-shirt) and removed their shoes for these measurements to standardise the procedure.

3.2.3.7.1.2 Circumferences

Girth measurements were taken using a fixed tension tape measure (Figure Finder Tape Measurer, Novel Products, Rockton, IL, USA) to the nearest millimetre. The sites used were described in the *ASCM's Resource Manual for Guidelines for Exercise Testing and Prescription, 3rd Edition (1998)* and were:

- *Abdomen* – at the level of the umbilicus.
- *Hips* – at the maximal girth of the hips and buttocks region, above the gluteal fold.

- *Right thigh* – at the maximal girth of the thigh (below the gluteal fold) with the legs slightly apart.
- *Right upper arm* – midway between the acromium and olecranon processes with the arm in anatomical position.
- *Right forearm* – at maximum forearm girth with the arms hanging downward and slightly away from the trunk, palms facing forward.
- *Right calf* – at maximum girth between the knee and ankle joint.

(See Appendix A.9. for detailed illustration of the sites)

3.2.3.7.1.3 Skinfolds

Skinfolds thickness measurements were taken using Harpenden Skinfold Calipers (Baty International, England) at the following sites as described in *ASCM's Resource Manual for Guidelines for Exercise Testing and Prescription, 3^rd^ Edition (1998)*. The sites were: (1) triceps - vertical fold on the posterior midline of the upper arm, halfway between the acromium and olecranon processes, with the arm held firmly at the side, (2) subscapular – diagonal fold (45°) 1 to 2cm below the inferior angle of the scapula, (3) suprailiac – diagonal fold in line with the natural angle of the iliac crest taken in the anterior axillary line immediately superior to the iliac crest, (4) abdomen - vertical fold 2 cm to the right of the umbilicus, and (5) anterior thigh- vertical fold on the anterior midline of the thigh, midway between the proximal border of the patella and the inguinal fold. These sites are shown in Appendix A.8.

The relative amount of body fat for each subject was estimated by summing the five skinfold sites obtained. Comparisons were made of the sum of five skinfolds. Changes in individual skinfolds were also compared to allow any localised changes in body fat levels to be identified.

3.2.3.7.2 Cardiorespiratory Fitness

Blood Pressure was obtained using a portable sphygmomanometer (Kamiya Tsunan Kaisha Ltd., Tokyo, Japan). Heart rate was monitored prior to, during, and for three minutes following the submaximal treadmill test using a body-borne heart rate monitor (polar sport tester, Polar Electro, Finland). A heart rate reading was obtained every five seconds. Prior to the test, the subjects stood on the treadmill breathing through the mouthpiece used to collect gas for analysis while heart rate and breathing stabilised. When heart rate had remained stable for thirty seconds, the pre-exercise heart rate was recorded and subjects were warmed up by walking at 4km/hour and 0% incline for three minutes. No expired gas was collected during this time. Following this preparatory stage, the treadmill was increased to a speed of 5km/hour while the incline was maintained at 0%. After three minutes and every three minutes thereafter, the incline was increased by 3%. Some subjects walked at a different speed from that given, the details of which are discussed in section 3.2.3.7.

Subject weight was entered into the treadmill computer upon commencement of each test and work performed at each stage of the test was calculated by the treadmill computer. The details of the calibrations performed in Experiment 1 and 2 for treadmill speed, gradient and calculation of work are given in section 2.2.1.2.

The test was terminated at the end of the three-minute workload during which the subjects heart rate reached approximately 70-85% of their age-predicted maximum heart rate based on the formula 220-age. The subject continued walking on the treadmill for a further three minutes after completion of the last workload, at a speed of 4km/hour and 0% incline to allow their heart rate to recover to within 30-40 beats of the pre-exercise HR.

The subjects breathed continuously through a one-way respiratory valve with mouthpiece attached while wearing a nose clip that prevented nasal breathing. Elephant tubing (diameter 45mm) connected the one-way respiratory valve to the Douglas Bags allowing expired gases to be collected. Expired gas was collected in the last minute of each three-minute stage. Analysis of the expired gas involved drawing a continuous sample of the gas through a 300mm high column of Drierite (Hammond Drierite Co., Xenia, Ohio) to dry the gas. The gas was then passed through a Servomex OA 137 oxygen analyser (Servomex Controls, Crowborough, England) and a Datex Normocap carbon dioxide analyser (Datex Medical, Helsinki, Finland). Both analysers had been modified to give a digital output accurate to ±0.01%. The gas analysers were calibrated using air and standard gas containing approximately 16%O_2 and 5%CO_2 (beta standard gas (±0.1%), BOC Analytical Gases, Wellington). The gas composition of each Douglas Bag was sampled for two minutes. Before measuring the volume of gas in each of the bags, the expired gas was cooled by passing it though vanes that ran through a bath of water of known temperature. The bags were evacuated through a standard 'dry' gas volume meter (Harvard Apparatus, Massachusetts) to obtain the volume of the expired gas to the nearest 0.1L. Room temperature, bath temperature, relative humidity and atmospheric pressure were measured prior to gas analysis. Cooling the expired gas before measuring volume allows the exact temperature of the gas to be known and ensures that the gas is completely saturated with water. This method removes the assumptions that expired gas does not cool in the Douglas Bag, which it undoubtedly does, and that the gas at this temperature is completely saturated. Oxygen uptake was calculated from the fractional concentration of oxygen and carbon dioxide in the expired air using the formulae given in Figure 1. The Harvard Dry Gas Meter was calibrated by filling Douglas Bags with a known amount of air (20 or 25L) using a Benedict Bell Jar Spirometer

(Scientific Research Instruments Limited, Croydon, Surrey, UK). Repeated measures agreed to within 0.1L.

A. Calculation of VE at standard temperature, pressure and dry (STPD)

$$V_E\,(STPD) = V_E\,(BTPS^*) \times \frac{(273)}{(273 + 37)} \times \frac{(P_B - 47.08)}{760}$$

* Water bath temperature, ambient pressure, and saturated with water vapour

B. Estimation of V_I

$$V_I = V_E \times \frac{1 - (F_{E_{O2}} + F_{E_{CO2}})}{1 - (F_{I_{O2}} + F_{I_{CO2}})}$$

C. CO_2 concentration in air was calibrated at 0 % therefore FI_{CO2} could be removed from the equation in figure 1(B) giving the equation in figure 1(C).

$$V_I = V_E \times \frac{1 - (F_{E_{O2}} + F_{E_{CO2}})}{(1 - F_{I_{O2}})}$$

D. Calculation of Oxygen Uptake

$$V_{O2} = (V_I \times F_{I_{O2}}) - (V_E \times F_{E_{O2}})$$

Figure 1. Formulae used in gas analysis calculations

3.2.3.8 Statistical Analysis:

The statistical analysis for Experiment 1 used 'SPSS' statistical software on a PC computer. The means, standard deviations and standard errors were calculated for the Control, "Pump It" and Walking groups for all variables measured in fitness test One and Two (week 0 and week 7, respectively). The means and standard deviations for body composition, blood pressure, pre-exercise HR, estimated VO_2max and dietary intakes are given in Appendix C.

A one-factor analysis of variance (ANOVA) was used to compare the groups. A post hoc test was performed for ANOVAs that were significant at the $\infty = 0.05$ level. Post hoc tests were also done for the variables: pre-exercise HR ($\infty = 0.084$), biceps circumference ($\infty = 0.106$) and hip circumference ($\infty = 0.089$) as they were close to the desired $\infty = 0.05$ level. The Post hoc tests were ANOVA comparing the Control group to the exercising groups ('Pump It' and Walking combined). The two exercising groups were also compared. Summary tables of post hoc tests are given in Appendix B.5.

3.3 Results

There were no significant differences between the groups for the variables: age, height, pre-exercise heart rate, systolic and diastolic blood pressures (SBP and DBP) and predicted VO_2max. However, a comparison of the group means for body mass, sum of six circumferences (SC-6; biceps, forearm, abdomen, hip, thigh and calf) and the sum of five skinfolds (SSK-5; triceps, subscapular, suprailiac, abdomen and thigh) revealed a significant difference between the groups prior to the study. The mean body mass for the 'Pump It' group was ~12kg lower ($\alpha < 0.05$) than both the Control and Walking groups. SC-6 was ~31mm lower ($\alpha < 0.05$), while SSK-5 was 48 and 78mm less than the Control and Walking groups respectively (Figure 2). Therefore, although the groups were randomly assigned, the subjects in the 'Pump It' group tended to have a smaller body mass, fat mass and circumferences compared to the members of the Control and Walking groups. A summary of the results obtained for the Control, 'Pump It' and Walking groups for the first fitness test (week 0) is given in Appendix B.1. An analysis of these results (1-way ANOVA) are given in Appendix B.2.

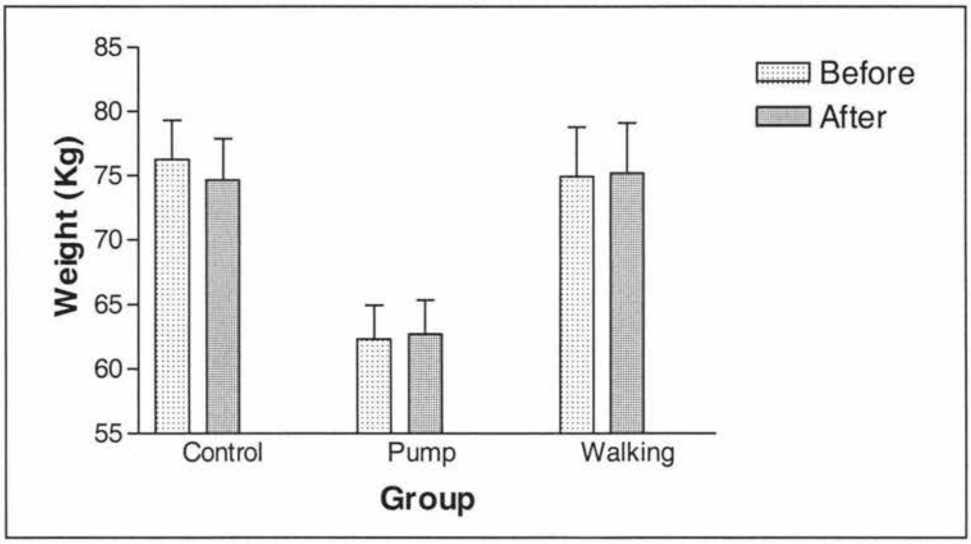

Figure 2. Body Mass of Control, 'Pump It' and Walking group before (week 0) and after the training period (week 7), Experiment 2.

3.3.1 Dietary Intake

Dietary composition and energy intake for the first and last weeks (week 1 and week 6) were assessed by measuring energy, protein, carbohydrate and fat intake for each of the three groups. The means and standard deviations of the combined 3-day intakes for each food group for both recording weeks (1 and 6) are given in Table 7. There was no significant change in dietary intake for any group.

Table 7. Total Dietary Intakes for week one (W1) and six (W6).

	Energy (g/3days)	**Protein** (g/3days)	**Carbohydrate** (g/3days)	**Fat** (g/3days)
Control W1	5268 ± 1354	251 ± 172	662 ± 363	206 ± 46
Control W6	5180 ± 970	199 ± 69	677 ± 155	191 ± 25
'Pump It' W1	5425 ± 1773	214 ± 87	742 ± 195	215 ± 116
'Pump It' W6	5214 ± 1138	196 ± 68	700 ± 182	216 ± 52
Walking W1	5173 ± 2213	170 ± 45	654 ± 156	167 ± 66
Walking W6	4826 ± 992	193 ± 58	606 ± 127	186 ± 52

Values are mean ± SD

3.3.2 Body Composition

Alterations in body composition between the first and second fitness testing sessions (week 0 and week 7) were assessed by measuring body mass, the sum of six circumferences (SC-6) and the sum of five skinfolds (SSK-5). Localised changes in body composition were monitored using individual circumferences and skinfold measurements. The means and standard deviations for these variables are given for the three groups in Appendix C. The results are depicted as bar graphs in Appendix B.4.

A difference in biceps circumference was detected with a post hoc test comparing the two exercise groups. The 'Pump It' group had a smaller biceps circumference than the Walking group (27.43 and 32.31cm respectively) see Figure 3. This difference was significant at the $p = 0.011$ level. There was no change over time for any of the groups for SC-6.

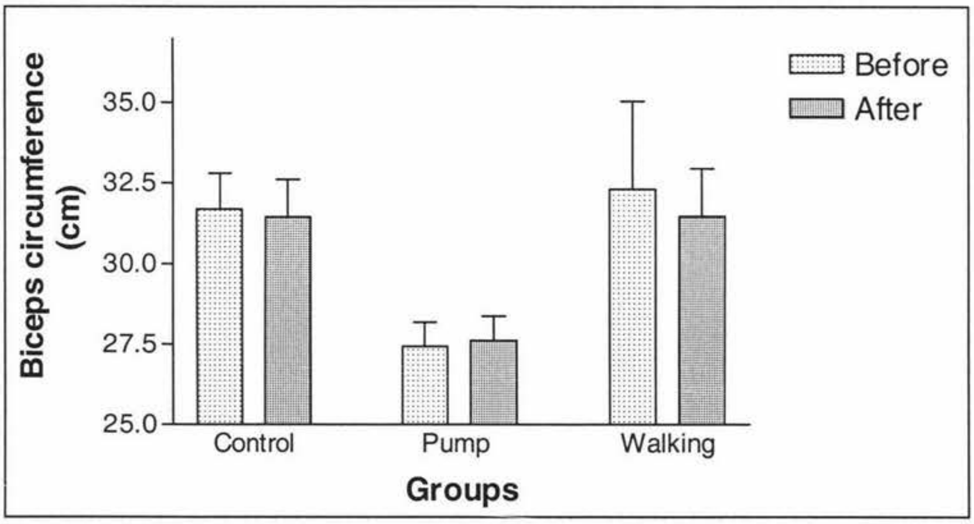

Figure 3. Biceps Circumference at week 0 and week 7 for the Control, 'Pump It' and Walking groups, Experiment 2.

Measurements taken at individual skinfold sites produced different results in all of the groups over the six-week training period. All three groups demonstrated a significant increase in triceps skinfold (p = 0.011). This increase in skinfold thickness over time was not significantly different between the groups. However, a post hoc test confirmed observations that the 'Pump It' group had very significantly lower measurements of triceps skinfold thickness than the Control and Walking groups (p = 0.001). Similar results were observed at the suprailiac site, where all groups showed an increase in skinfold thickness. Post hoc analysis showed that the increase was greater for the Control and Walking group compared to the 'Pump It' group. Skinfold measures taken at the abdominal site showed a significant decrease over the six weeks for all three groups (see Figure 4). This decrease was not significantly different between the groups. An analysis of SSK-5 showed no significant changes for any of the groups.

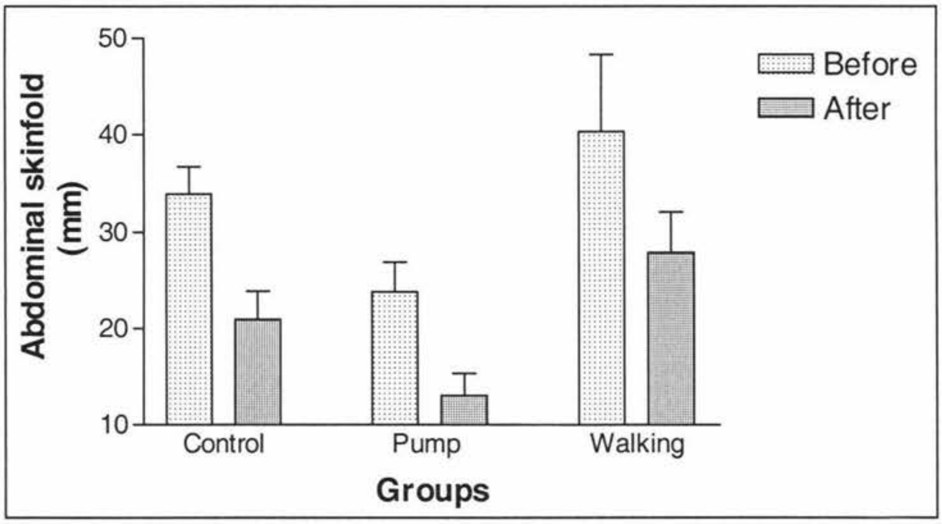

Figure 4. Abdominal Skinfold for Control, 'Pump It' and Walking groups over 6 weeks, Experiment 2.

3.3.3 Pre-exercise Heart Rate and Blood Pressure

Both Systolic and Diastolic blood pressure did not significantly change for any of the three groups over the experimental period. No significant differences were observed for pre-exercise HR for any of the groups. Pre-exercise heart rate for fitness tests one and two for all three groups is given in Figure 5.

The means and standard deviations for Systolic and Diastolic Blood Pressure and pre-exercise Heart Rate are given in Appendix C. The results are presented as bar graphs in Appendix B.4. Summary tables of ANOVA for these variables are shown in Appendix B.3.

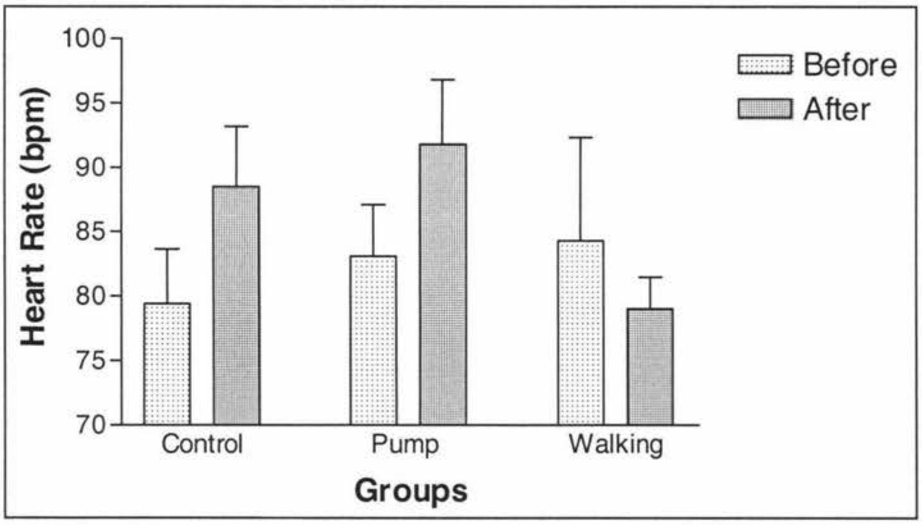

Figure 5. Pre-exercise Heart Rate at weeks 0 and 7 for the Control, 'Pump It' and Walking groups, Experiment 2.

3.3.4 Cardiorespiratory Fitness

Predicted VO_2max increased significantly for the Control, 'Pump It' and Walking groups (2.05 to 2.61 L/min; p=0.001, 1.71 to 2.42 L/min; p=0.001 and 2.01 to 2.75 L/min; p=0.001, respectively). These increases were not significantly different between the groups. An increase in predicted VO_2max was also observed for each of the groups when individual body weights were taken into account. The Control group increased by 7.69 ml/kg/min (p=0.001) while the 'Pump it' and Walking groups showed increases of 10.0 and 9.84 ml/kg/min respectively (p=0.001). Again, these increases were not significantly different between the groups (see Figure 6).

Apparent decreases in the slope relating heart rate to workload were demonstrated for the Control and 'Pump It' groups over the experimental period while the Walking group did not appear to show a change. None of these differences were significant.

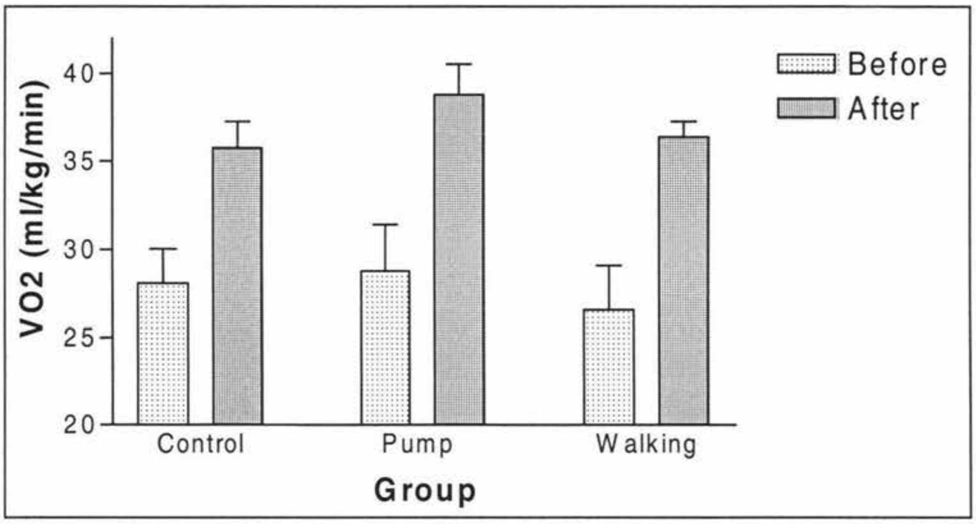

Figure 6. Estimated VO_2max for the Control, 'Pump It' and Walking groups at weeks 0 and 7, Experiment 2.

3.3.5 Training Intensity

The Control groups produced values between 39.4 - 44.9 %HRmax while the 'Pump It' and Walking groups were 60.5 – 64.0 %HRmax and 66.9 – 69.9 %HRmax respectively. The average %HRmax values for each group over the six-week training period are presented in Figure 7. The results showed that the Walking group worked at a higher aerobic intensity, based on %HRmax, than the 'Pump It' group while both groups produced significantly higher values of

%HRmax than the Control group. Further analyses of training intensity for the 'Pump It' group separated the heart rates obtained into heart rates during leg exercise and arm exercise. There was no significant difference between arm and leg exercise.

Intensity, as estimated by $\%VO_2max$, differed significantly for the three groups over the six weeks. The Walking group exercised at a considerably higher mean oxygen consumption than the 'Pump It' and Control groups (58 $\%VO_2max$ compared with 30 and 29 $\%VO_2max$, respectively, $p = 0.001$). No significant difference was found between the 'Pump It' and Control groups. Therefore, although exercise intensity when expressed as %HRmax were similar for the 'Pump It' and Walking groups it was found that training intensity, when expressed as $\%VO_2max$, was considerably higher for the Walking group.

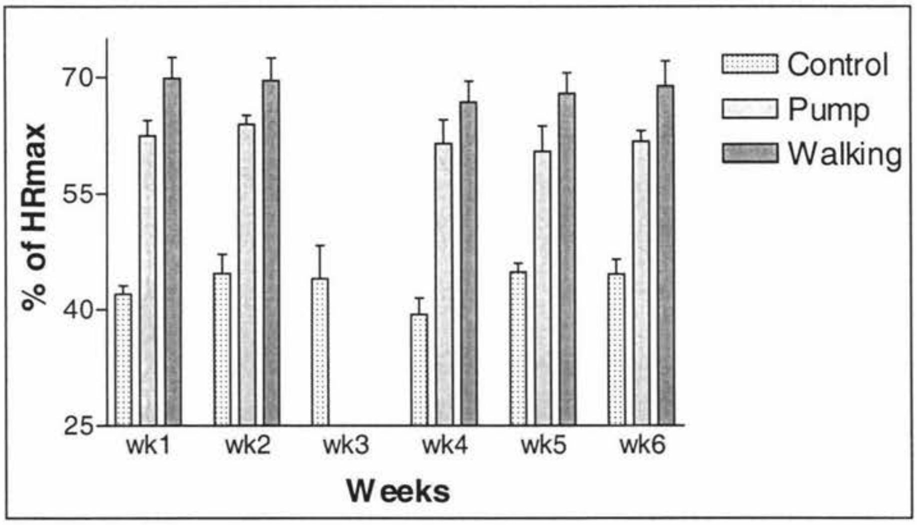

Figure 7. Exercise Intensity (%HRmax) for weeks 1-6 for the Control, 'Pump It' and Walking groups, Experiment 2.

3.4 Discussion

'There is no Truth. There is only Perception' - MILOS STANKOVIC

The key findings of this study were that six weeks of 'Pump It' or Walking training failed to produce statistically significant greater changes in either cardiorespiratory fitness or body composition than in a control group who undertook no additional exercise beyond their normal daily activities.

3.4.1 Individual Subjects

A confounding effect in the study may have been the individual differences between subjects at the beginning of the experimental period, as well as individual responses to the training regimen and in their diet and daily activities. Despite the subjects being randomly assigned to the three groups, it was found that body mass, SC-6 and SSK-5 were lower for the 'Pump It' group compared with the Walking and Control groups. This also occurred in an earlier study (Scott, 1995), when subjects were randomly allocated. Differences in body weight and skinfold thickness may have had significant implications for any changes in both body composition and cardiorespiratory fitness for this study. Positive effects of an exercise regimen may be more readily detectable when subjects in each group are matched for physical status i.e. cardiorespiratory fitness level, body composition and age.

Lower initial body fat levels for the 'Pump It' group may have reduced the potential for any improvement in body composition. While this group did not demonstrate any significant decreases in body mass, SC-6 and SSK-5, some changes in individual skinfolds (such as the abdominal skinfold) were observed and may have reached significance had the initial body fat levels of the 'Pump It' group been higher.

Predicted VO_2max values at Week=0 when recorded in L/min would not be suitable for comparison due to the initial difference in the amount of metabolically active tissue (i.e. fat free mass) between the groups. Therefore, it was important to take body mass into account when investigating any changes in cardiorespiratory fitness. As a result, when discussing changes in predicted VO_2max, values were presented as the oxygen consumption per kilogram of body weight (ml/kg/min).

The subjects in the current study may have performed additional strenuous activity, although none was reported. Some of the results suggest that the Control group may have increased their daily activity levels as some improvements in estimated VO_2max and body composition were observed in this group. In the absence of any data provided by any of the subjects it can not be taken into account when evaluating the different programmes.

3.4.2 Cardiorespiratory Fitness

3.4.2.1 Improvements in predicted VO_2max

The physiological adaptations that might be expected with improvements in cardiorespiratory fitness would be increases in predicted VO_2max and a decrease in the slope relating heart rate to oxygen consumption (HR/VO_2) (Swaine *et al.*, 1992). All three groups showed an increase in predicted VO_2max, probably as a result of familiarisation with the testing protocol and equipment. This is also a feature of other studies (Scott, 1995). The increments in predicted VO_2max observed in the 'Pump It' and Walking groups were not significantly greater than in the Control group, although the group means in both cases were more than 2ml/kg/min higher (+10.0, +9.84 and +7.69 ml/kg/min for 'Pump It', Walking and Control groups respectively). There was considerable individual variation within each group, so that even with group sizes of seven, ten and twelve these differences did not reach statistical significance. This may also mean that previous training, body type, diet and other factors make an important contribution to fitness.

3.4.2.2 Methodology

The failure to produce improvements in mean estimated VO_2max is not likely to be a result of technological error. The 'dry' gas volume meter had been calibrated prior to testing and was found to give a maximum error of approximately 0.1L. The gas analyser was calibrated prior to every test using both air and standard gas containing known concentrations of carbon dioxide and oxygen. Repeated sampling of expired gas in a Douglas Bag was found to result in a maximum error of approximately 0.1% of Oxygen. However, some error is likely to occur when measuring gas volume in the Douglas Bags. Gas was collected for periods of one minute. Opening and closing of the respiratory valves may have occurred during different phases of the respiratory cycle. This could lead to variation in the volume of air collected. It is not likely that this would have affected the estimation of VO_2max in this study as this error would not be different between the groups.

Pre-exercise HR was observed to be high for all of the groups compared with those reported in other studies (Scott, 1995). However, in the current study, pre-exercise HR was obtained while the subjects were standing on the treadmill not in a resting state and would therefore, be expected to be higher. As pre-exercise HRs were not used in the calculation of estimated VO_2max, any elevation in pre-exercise HR was unlikely to have affected the estimation of VO_2max during the testing procedure.

3.4.2.3 Initial Fitness Levels of the Subjects

Generally, the lower the initial VO_2max the greater percentage improvement in VO_2max (Ekblom, Astrand, Saltin, & Stenberg, 1968; Rowell, 1974). Initial values for predicted VO_2max (ml/kg/min) were not significantly different between the groups and when age was taken into account the participants were not considered to be of above average fitness according to the norms for cardiorespiratory fitness given in Table 1 (pg. 8). In fact, the 'Pump It' and Control groups initial fitness levels were the absolute minimum for the 'Average' fitness classification, while the values for the Walking group lay in the upper regions of the 'Fair' fitness classification. Therefore, it can be stated that, on average, all of the groups were of below average to average fitness. It is unlikely that the initial fitness levels would have affected the improvements in VO_2max in the current study.

3.4.2.4 Exercise Intervention Programmes

Failure of the 'Pump It' and Walking groups to show improved cardiorespiratory fitness cannot be attributed to low attendance, as both showed a very high attendance rate (92.2% and 94.4%, respectively). Kukkonen-Harjula *et al*, (1998) produced improvements in VO_2max with similar attendance rates (92%) for their walking programme. Also, 15% improvements in VO_2max have been seen with attendance rates lower (87%) than the current study (Franklin *et al.*, 1979).

It is unlikely that the lack of improvement in predicted VO_2max was a consequence of the frequency or duration of the exercise sessions as studies have produced improvements in VO_2max with same protocols (Carter *et al.*, 1999; Liang *et al.*, 1982; Sale *et al.*, 1995). The frequency and duration of the exercise sessions were also based on the recommendations for improving cardiorespiratory fitness given by the ACSM (Pollock *et al.*, (1998).

Training intensity may have been a factor in the lack of improvement seen for estimated VO_2max, especially in the Walking group, where the walking pace was self-selected. However, training intensity was found to be 68%HRmax and 58%VO_2max during the walking sessions. These values were within the recommended intensity for improving VO_2max (65%-90%HRmax and 50%-85%VO_2max) given by Pollock *et al.,* (1998) and were in fact higher than that recommended for unfit individuals (55%HRmax and 40%VO_2max). Also, 17% increases in VO_2max have been observed with exercise intensities of 40% VO_2max (Branch *et al.*, 2000). The 'Pump It' group exercised at an exercise intensity of 30%VO_2max which was not significantly different to the oxygen consumption produced for the control groups when performing 'normal' daily activity. This intensity was below that recommended for improving cardiorespiratory fitness. Predicted oxygen consumption in the current study was very close to that reported for Body Pump aerobics (29.1%VO_2peak) by Stanforth *et al.*, (2000) who measured oxygen consumption directly, using breath by breath gas analysis. This suggests that when adjustments were made for predicted oxygen consumption, accurate estimates of oxygen consumption were obtained for 'Pump It' in the current study. Both studies also produced similar values for %HRmax (~63%HRmax). The higher heart rates observed for a given VO_2 in 'Pump It' are consistent with other studies in similar types of exercise (Wilmore *et al.*, 1978; Maas *et al.*, 1989; Tulppo, Makikallio, Laukkanen, & Huikuri, 1999; Stanforth *et al.*, 2000).

The length of the exercise programme is likely to have been a contributing factor for the lack of increased predicted VO_2max. While studies have shown improvements in VO_2max over six weeks of training (Liang *et al.*, 1982; Carter *et al.*, 1999), most studies take a minimum of 12 weeks (Franklin *et al.*, 1979; Santiago, 1987; Sale *et al.*, 1995; Kukkonen-Harjula *et al.*, 1998; Utter *et al.*, 1998). Linear improvements in VO_2max have been shown to occur up 10 to 11 weeks of training regardless of the initial fitness level, intensity, duration and frequency of training (Wenger & Bell, 1986). Therefore, extending the length of the current study may have increased the improvements in predicted VO_2max observed for the exercising groups, particularly for the Walking group, in comparison to the Control group.

3.4.3 Body Composition

There was no change in body composition over the six weeks of the training programme in any of the groups. Differences between groups may have been difficult to detect as the groups were not uniform at the beginning of the experiment. Despite the subjects being randomly assigned to the three groups, it was found that body mass, SC-6 and SSK-5 were lower for the 'Pump It' group compared to the Walking and Control groups. Lower initial body fat levels for the 'Pump It' group may have reduced the potential for any improvement in body composition. While this group did not demonstrate any significant decreases in body mass, SC-6 and SSK-5, some changes in individual skinfolds (such as the abdominal skinfold) were observed and may have been more significant had the initial body fat levels of the 'Pump It' group been higher.

3.4.3.1 Methodology

A failure to show improvements in body composition in the current study may have been a result of measurement error. The observation that some measurements differed significantly for all of the groups following the six weeks suggests that measurement error may have affected the results. However, standardised procedures were followed for all measurements and the measurer had considerably experience with the protocols. Also, the measurer knew subject groupings, which may have affected the results. However, it was impossible for the measurer not to be aware to which group each subject belonged in the current study. Also, if the results had been influenced, it would have been expected that the results would show improvements for subjects in the exercising groups.

The assessment of dietary intake through dietary records, while extensively used, has a number of limitations (Poppit, Swann, Black, & Prentice, 1998). In the current study, two main factors are thought to have been possible sources of error in the assessment of dietary intake. These factors are the occurrence of under-reporting and accuracy in the measurement of portion size. Researchers have identified under-reporting in studies where dietary intake has been monitored (Poppit *et al.*, 1998). They identified the major cause of under-reporting to be a failure to record between meal snacks. In fact only 64.2% of energy from snacks were reported. If under-reporting had occurred in the current study, there was significant potential for dietary intake to be underestimated, depending on the type of food that was omitted from the dietary records. An attempt was made to minimise the occurrence of under-reporting in the current study by stressing the importance of recording everything that was consumed (both food and drink) during the recording periods. Subjects were also assured that they would not be judged on their levels of dietary intake or for their dietary choices.

Subjects measured their own dietary intake using personal scales and measuring equipment. While attempts were made to minimise measurement error by instructing the subjects on how to measure and record their diet prior to the study, it is unlikely that their personal measuring devices possessed the accuracy required for a reliable measurement of dietary intake. Unfortunately, due to a lack of availability of suitably accurate scales and measuring equipment, this source of error could not be reduced. However, as the equipment used was the same for each measuring period and it was the change in dietary intake that was required for each subject, not an absolute measure, it was felt that this method was appropriate for the current study.

3.4.3.2 Exercise Intervention Programmes

Body Composition did not appear to change for either of the Walking or 'Pump It' groups compared with the Control group over the six weeks of the study. Fat loss, in the absence of dietary adjustments, should be promoted when total energy expenditure exceeds 900 kcal per week (Pollock *et al.*, 1998). At speeds of 5km/hr, walking has been found to expend ~4.5 kcal/min in female adolescents (Wergel-Kolmert & Wohlfart, 1999). Therefore, after sixty minutes of walking exercise at this speed, the energy expenditure would be ~270kcal. Resting metabolic rate (RMR) and energy expenditure are higher in subjects with greater amounts of lean muscle mass (DeNubile, 1991). The weight of the subjects in the Walking group for the current study was significantly higher (+15kg) than the females in the study by Wergel-Kolmert & Wohlfart, (1999). As the subjects were not considered to be overweight in the current study, it could be assumed that lean muscle mass would be higher compared to the subjects in that study. Therefore, energy expenditure may have been higher in the current study.

It was unlikely that lean muscle mass was increased for the 'Pump It' group in the current study as there were no changes in the sum of skinfolds or the sum of six circumferences. Measurements of caloric expenditure were obtained for

Body Pump in the study by Stanforth *et al.*, (2000). They reported that the total energy expenditure for a Body Pump session lasting ~50 minutes were 315 and 214 kcal for males and females, respectively. The lower energy expenditure observed in the female participants was attributed to the smaller fat free mass of these subjects. The weights of the females in this study were comparable to the weights of the subjects in the 'Pump It' group (60 and 62kg, respectively). Therefore, it is likely that the energy expenditures of the subjects in the 'Pump It' group were similar to those in the study by Stanforth *et al.*, (2000) and were below that necessary to cause a reduction in body fat. Improvement in body composition with 'Pump It' may have been significant had the initial body fat levels been higher for the subjects in this group

3.4.4 Summary

Six weeks of 'Pump It' or Walking training failed to produce significant changes in cardiorespiratory fitness and body composition compared with non exercising Controls. Improvements in estimated VO_2max for the Walking group may have become significant had the length of the study been longer, as significantly higher training intensities were observed in the Walking group. Estimated oxygen consumption during 'Pump It' was considered low and therefore, unlikely to promote increases in VO_2max. The lack of improvement in body composition for the Walking and 'Pump It' groups was attributed to insufficient energy expenditures during training.

Chapter 4

General Discussion

Increasing interest in fitness, exercise and weight control has resulted in an increased participation in various types of exercise. This is especially true in females, where body image is becoming increasingly important. Whether these programmes produce the desired changes does not appear to have been assessed in the same rigorous manner as in elite training. Rigorous evaluation requires that all activity and diet be controlled throughout a study. This might be acceptable for elite athletes but it is unlikely to be acceptable to people involved in casual fitness programmes.

When assessing the training effects for serious athletes it is appropriate to perform laboratory-based studies. However, in the case of 'normal' people it may be more valid for the participants to continue with their usual activity and dietary practices while using the best assessment methods to detect any benefits. Unlike athletes, average individuals do not generally control their daily activity or dietary intake. Therefore, the question 'Should a study be controlled when investigating real life training effects?' needs to be addressed.

The purpose of this study was to investigate the training effects of six weeks of Walking or 'Pump It' training on cardiorespiratory fitness and body composition in previously sedentary females compared with sedentary controls. 'Normal' people with the aim of improving their current fitness levels practice both of these training methods. While the study was in part controlled (activity and diet), it is unlikely and unrealistic to assume that the participants did not alter their daily activity or dietary intakes over the course of the study.

When selecting assessment methods in real life situations, as in the current study, would it be better to use controlled laboratory measures or should attempts be made to improve the methods used for the prediction of the physiological response being assessed. Although impractical, measurements of oxygen consumption could have been obtained during 'Pump It' aerobics to enhance the assessment of training intensity. However, predicted oxygen consumption in the current study agreed with findings in a study where oxygen consumption was measured directly. Despite the fact that realistic estimations of VO_2 were obtained for 'Pump It' in the current study, alterations may have improved the accuracy of the estimation of VO_2. Correlating the HR/VO_2 relationship obtained during treadmill walking to the HR/VO_2 relationship obtained for a range of intensities of 'Pump It' rather than for only one intensity of exercise, may have improved the prediction of VO_2. The range of intensities could be achieved by varying the speed of the movement, the weight load used or both.

The current study and that by Scott (1995) have shown that intermittent six-week training programmes may not be effective in producing improvements in cardiorespiratory fitness and body composition. Although some individuals may benefit in this time a commitment to longer training programmes of at least twelve weeks may be necessary to produce significant effects (Franklin *et al.*, 1979; Santiago *et al.*, 1987; Sale *et al.*, 1995; Kukkonen-Harjula *et al.*, 1998; Utter *et al.*, 1998).

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Appendix A:

1. Physical Activity Readiness Questionnaire (PAR-Q)
2. Consent Form
3. Information Sheet
4. Daily Activity Diary: recommendations and recording sheet
5. The 'Green Prescription'
6. Dietary Intake: instructions and recording sheet
7. Anatomical Pictures: Muscles of the Human Body
8. Anatomical Sites of Skinfold Measurements
9. Anatomical Sites of Circumference Measurements

Appendix A.

1. Physical Activity Readiness Questionnaire (PAR-Q)

Physical Activity Readiness Questionnaire - PAR-Q (revised 1994)

PAR - Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
☐	☐	1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
☐	☐	2. Do you feel pain in your chest when you do physical activity?
☐	☐	3. In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?
☐	☐	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
☐	☐	7. Do you know of any other reason why you should not do physical activity?

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want—as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active—begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal—this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever—wait until you feel better; or
- if you are or may be pregnant—talk to your doctor before you start becoming more active.

Please note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

You are encouraged to copy the PAR-Q but only if you use the entire form

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

NAME ____________________

SIGNATURE ____________________ DATE ____________________

SIGNATURE OF PARENT ____________________ WITNESS ____________________
or GUARDIAN (for participants under the age of majority)

Supported by: Health Canada Santé Canada

Appendix A.

2. Consent Form

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I understand I have the right to withdraw from the study at any time and to decline to answer any particular questions.

I agree to provide information to the researcher on the understanding that my name will not be used without my permission. *(The information will be used for this research and publications arising from this research project).*

I agree to participate in this study under conditions set out in the Information Sheet.

Signed: ....

Name: ....

Date: ....

Appendix A.

3. Information Sheet

My name is Amy Barr and I am studying for an MSc in Exercise Physiology. I can be contacted at the Massey University Recreation Centre ph. 3505080 or please leave a message. My supervisor, Dr Rodger Pack, can be contacted at Massey University ph.350 4476.

This research project is being conducted for my MSc thesis. I am investigating the effects of 'Pump It' aerobics at the Massey Recreation Centre and conventional aerobic exercise on body composition and cardiovascular fitness in females who have not performed exercise for at least 2 months.

There will be three groups of subjects. Subjects will be allocated to each group randomly.

- Group 1 will perform 'Pump It' aerobics 3 times a week for 6 weeks.
- Group 2 will walk briskly 3 times a week for 6 weeks to simulate similar energy expenditures to the 'Pump It' group.
- Group 3 will be asked to remain sedentary for the 6 week period. If subjects in this group significantly alter their exercise regimen, it is important that this is reported to me. This group will have the opportunity to participate in supervised exercise sessions at the end of the experiment.

Both the 'Pump It' and walking sessions will last up to one hour each time. Each subject will also wear a heart rate monitor during one of the exercise sessions each week. Subjects in the sedentary control group will also be asked to wear a heart rate monitor for one hour each week.

'Pump it' is a non impact aerobics class which is part of the aerobics programme running at the Massey University Recreation Centre. The class consists of resistance exercises involving high repetitions of low-medium weights at varying speeds. 'Pump It' classes will take place on Monday's, Wednesday's and Friday's. You will be required to attend all classes for the 6 week period.

All groups will undergo two testing sessions. The first will be performed prior to the training period and the second will take place upon completion of the training protocol. Each testing session will last a maximum time of 1 hour and will consist of a submaximal treadmill or cycle ergometer test and the measurements of height, weight, girth circumferences and skinfold measurements.

Appendix A.

3. Continued

Testing Sessions

For each testing session you will need to wear loose fitting shorts, a singlet or t-shirt and sports shoes.

Before each testing session
- do not exercise for the 24 hours prior to testing,
-please allow enough time to get to each testing session which will enable you to have around five minutes of relaxation time prior to testing,
-do not drink alcohol for at least 6 hours prior to testing,
-do not smoke, eat food, drink tea or coffee for at least 2 hours prior to testing.

Before the first testing session you will be required to sign a consent form and fill in a pre-exercise screening questionnaire to ensure that the tests and exercise programme will be safe for you to do.

During the testing session the following tests will be done.

1. Weight and height will be recorded

2. Blood Pressure will be recorded using a standard sphygmomanometer

3. Girth measurements will be taken at the following sites; biceps (front of arm), forearm, abdomen, hips, thigh and calf.

4. Skin fold measures will be taken at the following sites; triceps (back of the arm), subscapular (shoulder blade), suprailiac (above the hip bone), abdomen, thigh and calf.

5. A submaximal treadmill or cycle ergometer test. During this test you will be required to wear a chest strap which will record your resting heart rate prior to exercise and your heart rate during the test. You will also be asked to breathe through a mouth piece so that the air that you breathe out can be collected and analysed.

Dietary Record

All subjects are required to fill out a dietary record for two weekdays and one weekend day during the first and last weeks of the experimental period. During this time you should not alter your diet in any way and it is necessary to record everything that you consume on those days.

Appendix A.

3. Continued

Daily Activity Diary Information

During the experimental period you will be encouraged to not alter the amount of activity that you perform except for the 'Pump It' or walking groups who will be exercising three times per week for 1 hour each session. It is not always possible to maintain your daily activity with the occurrence of field trips etc so it is necessary to record this extra activity.

The daily activity diary requires that you record certain activities, specified in the **Physical Activity Guide** (attached), if performed for more than the minimum time which is also stated in the **Physical Activity Guide** eg. Walking-moderate pace, no hills, 25 mins.

General

You have the right to ask questions at any time relating to the testing procedure or the research project. You may refuse to answer any questions in the fitness questionnaires. You may also withdraw your consent and discontinue participation at any stage during the programme at any time for any reason. All information obtained from you is completely confidential. All questionnaires and result sheets will be recorded with subject numbers only. Consent forms, and the master list with names and addresses and subject numbers will be filed separately from the questionnaires and results sheets. Individuals will therefore be unable to be identified from either the questionnaires or results sheets. No names will be used on the final report, just subject numbers.

All results and procedures will be explained on completion of each testing session. A copy of your results and a written explanation of the results will be available after each testing session. A summary of the findings from this study may be obtained on request upon completion of the study.

Individuals who were in the control group will be given an individualised programme following the study and have further fitness tests performed if they so desire.

Accident and Injury:

ACC has been contacted in reference to this project with respect to accident or injuries which may occur during the experiment. It has been confirmed that any subjects who take part in this experiment have the same rights for cover/compensation as in any normal non-experimental exercise situation.

Appendix A.

4. Daily Activity Diary: instructions and recording sheet

This daily activity diary will allow me to monitor your general activity to see if you change your levels of activity during the experimental period. This activity diary needs to be filled out every day of the experiment.The activities that need to be recorded are described in the Physical Activity Guide.

Physical Activity Guide

Category	Around the Home Activity for Comparison	Physical Activity and Exercise Options	Minimum duration of activity which requires recording
Light (Level 1)	Cleaning windows Raking leaves Gardening-weeding Washing the floor Vacuuming	Gentle exercise to music-mainly on the spot, no armwork Walking-mod pace, no hills Stationary bike-no resistance Swimming-gentle movements, within pool Dancing-social/line, low intensity Tai Chi	30 mins
Moderate (Level 2)	Easy digging in garden Lawn mowing-level ground Carrying Objects Climbing stairs-slowly	Gentle Exercise to music-minimal armwork Walking-mod pace with some hills Bike-mod pace with some resistance/hills Swimming-recreational pace, strokes Dancing-social/line mod intensity Tennis and Badminton	20 mins
Intense (Level 3)	Heavy digging Sawing wood Chopping wood Climbing stairs-moderate pace	Exercise to music-including overhead armwork Walking-up and down hills, brisk, power Bike-mod to brisk pace with some resistance Swimming-continuous lengths, aqua-jogging Dancing-assorted, mod intensity to vigourous Squash, Jogging	10 mins

Appendix A.

5. The 'Green Prescription'.

Hillary Commission, (2001). Push Play: Green Prescriptions: *http://www.hillarysport.org.nz/aboutpushplay/greenp.shtml.* Retrieved from the World Wide Web 31/10/2001.

PHYSICAL ACTIVITY GUIDE

Green Prescription
the active way to health

CATEGORY	Around the Home Activity for Comparison	Physical Activity and Exercise Options	Possible Time Per Session
VERY LIGHT (Level 1)	Washing Dressing Washing dishes Driving car	Gentle exercise to music - seated, min resistance Walking - strolling, no hills Stationary Bike - no resistance Swimming - basic movements in pool ie kicking Dancing - social, v. low intensity	5 minutes to begin with - up to 15 minutes
LIGHT (Level 2)	Cleaning windows Raking leaves Gardening - weeding Washing the floor Vacuuming	Gentle exercise to music - mainly on the spot, no overhead armwork Walking - mod pace, no hills Stationary Bike - min resistance, no hills Swimming - gentle movements, within pool Dancing - social/line, low intensity Tai Chi	10 to 15 minutes - up to 30 minutes or see how you feel - depending on intensity
MODERATE (Level 3)	Easy digging in garden Lawn mowing - level ground Carrying objects Climbing stairs - slowly	Gentle Exercise to music - minimal armwork Walking - mod pace with some hills Bike - mod pace with some resistance/hills Swimming - recreational pace, strokes Dancing - social/line, mod intensity Tennis and Badminton	15 to 30 minutes to begin - depends on starting fitness level
INTENSE (Level 4)	Heavy digging Sawing wood Chopping wood Climbing Stairs - moderate pace	Exercise to music - including overhead armwork Walking - up & down hills, brisk, power Bike - mod to brisk pace with some resistance Swimming - Continuous lengths, aqua-jogging Dancing - assorted, mod intensity to vigorous Squash, Jogging,	20 to 40 minutes - progress as appropriate (Acknowledgement to Sport Waikato for this Form.)

Appendix A

6. Dietary Intake: instructions and recording sheet

<u>Procedure</u>

Record your actual diet **as it is eaten** for:

a) any two weekdays
b) any one weekend day.

These records may start at any time, but must continue for 24 hours. Use the sheets provided to list all foods and drink consumed, and its weight or serving size in teaspoons, tablespoons or cups. Record the method of cooking eg. roast. boiled, fried etc and the type of food eg. white bread, frozen peas boiled, iced chocolate cake, tinned peaches in heavy syrup etc.

If you have scales it would be best if you could weigh all your food as you eat it, especially servings of meat, fish and vegetable.

NOTE:
Please state whether you are weighing your food in grams or ounces.

Weighing method for different food types

a) Bread or toast with spreads
Weigh the bread or toast and record its weight.
Spread the usual amount of butter or margarine. Record the weight of the buttered toast. Spread with usual amount of listed spread. Record the total weight of bread and spreads. Refer to short cut method for next time.

b) Bowl Foods
Weigh the bowl.
Put the usual amount of food in the bowl. Record the weight of the bowl with food in it. Pour the usual amount of milk (if used) into the bowl. Record the new total weight. Sprinkle with the usual amount of sugar (or other additive) if used. Record the final weight. Refer to short cut methods for next time.

6. Continued.

c) Plate Meals eg. main meals or lunches with a variety of foods.
Proceed as for bowl foods as in (ii). Weigh the plate then add one food item at a time, weighing after each addition, until the plate meal is complete.

d) Beverages eg. instant coffee, milo, cocoa etc.
Weigh the cup.
Add the usual amount of drink powder. Record weight of cup and powder.
Add water to the usual level. Record new weight.
Add milk to the usual level. Record new weight.
Add usual amount of sugar. Record total weight. Refer to short cut methods for next time.

Short Cuts

a) Weights of repetitive food items already recorded may be used again without reweighing eg. pre-sliced bread, butter/margarine on bread, spreads on bread, instant coffee/milo, milk in beverages (if same cup size), sugar added to beverages, cereals etc.

b) The weights of some bought luncheon foods eg. rolls, individual meat pies, sausage rolls, buns, and scones are supplied in the appendix.

c) The weights of some snack foods eg. sweets and individual lollies, potato chips, and bought biscuits are supplied in the appendix.

d) The weights of many bought foods eg. yoghurt, are given on the container as are the volumes of many bought drinks.

Appendix A.

6. Continued.

Example of completed Diet Record Sheet

Subject Number: 45
Date: 3/10/2000

Time	Description of food or drink consumed and method of cooking	Weight of Plate/ Bowl (g or ounces)	Total Weight or serving size (g, cups, etc)
9 am	Toast (wholemeal)		20g
	Butter		21.5g
10:30 am		130g (bowl)	130
	Cornflakes		175g
	Milk		187g
	Sugar		190g
12 pm		200g (plate)	200g
	Ham (cold sliced)		243g
	Potatoes (roasted)		263g
	Broccoli (steamed)		272g
	Carrots (steamed)		290g
3 pm	Apple (uncooked)		65g
		150g (mug)	150g
	Milo		154g
	Water		280g
	Milk		305g

Appendix A.

7. Major Muscles of the Human Body

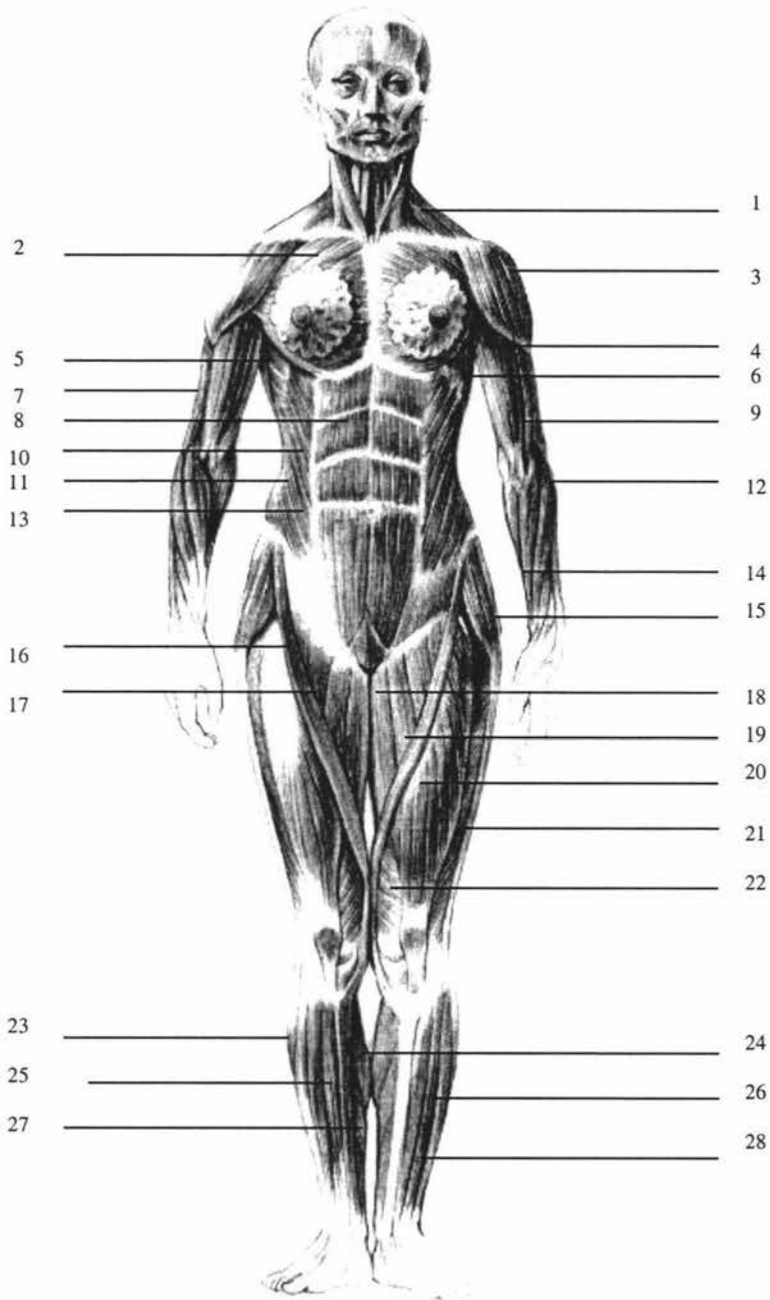


Figure 1: Muscles of the Human Body (anterior view)

1. Stenocleidomastoideus
2. Pectoralis major
3. Deltoideus
4. Biceps brachialis
5. Serratus anterior
6. Latissimus dorsi
7. Triceps brachii
8. Rectus abdominis
9. Brachialis
10. Obliquus externus abdominis
11. Obliquus internus abdominis
12. Brachioradialis
13. Transversus abdominis
14. Flexor carpi ulnaris
15. Tensor fasciae latae
16. Sartorius
17. Pectineus
18. Gracilis
19. Adductor longus
20. Rectus femoris
21. Vastus lateralis
22. Vastus medialis
23. Soleus
24. Medial head of Gastrocnemius
25. Tibialis anterior
26. Peroneus longus
27. Soleus
28. Extensor digitorum longus

Appendix A.

7. Continued.

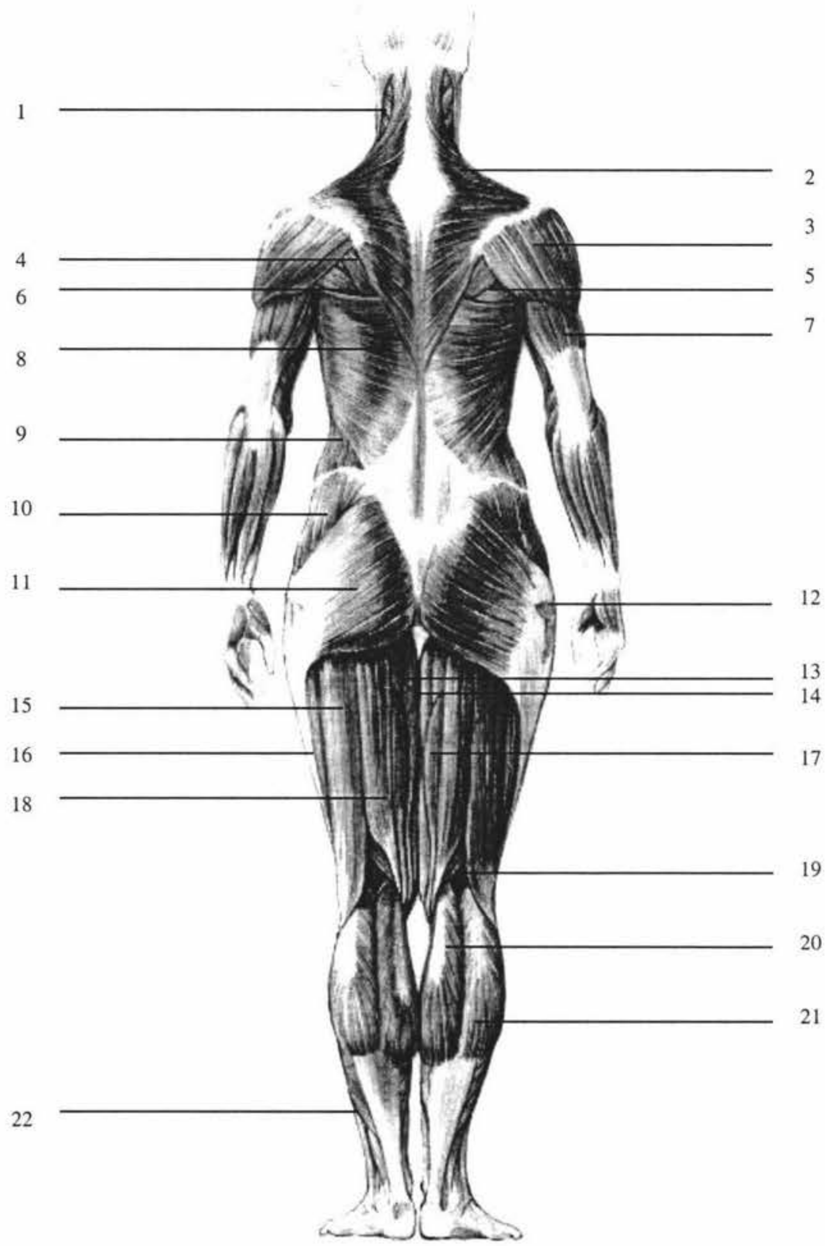


Figure 2: Muscles of the Human Body (posterior view)

15. Sternocleidomastoideu s
16. Trapezius
17. Deltoideus
18. Infraspinatus
19. Teres minor
20. Teres major
21. Triceps brachii
22. Latissimus dorsi

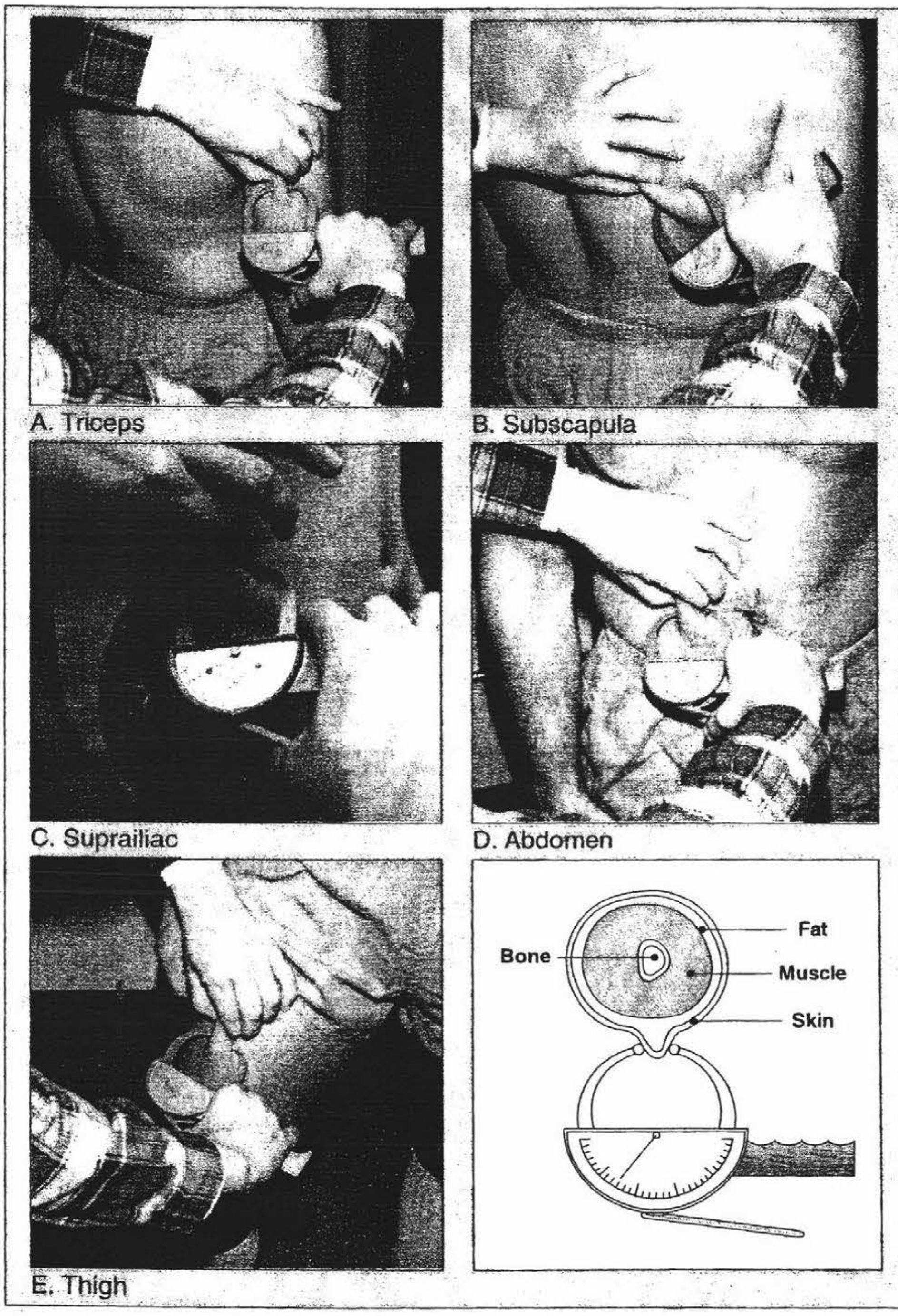
8. Obliquus externus abdominus
9. Gluteus medius
10. Gluteus maximus
11. Tensor fasciae latae
12. Adductor magnus
13. Gracilis
14. Biceps femoris

1. Vastus lateralis
2. Semimembranosus
3. Semitendinosus
4. Plantaris
5. Medial head of Gastrocnemius
6. Lateral head of Gastrocnemius
7. Soleus

Appendix A.

8. Anatomical Sites of Skinfold Measurements

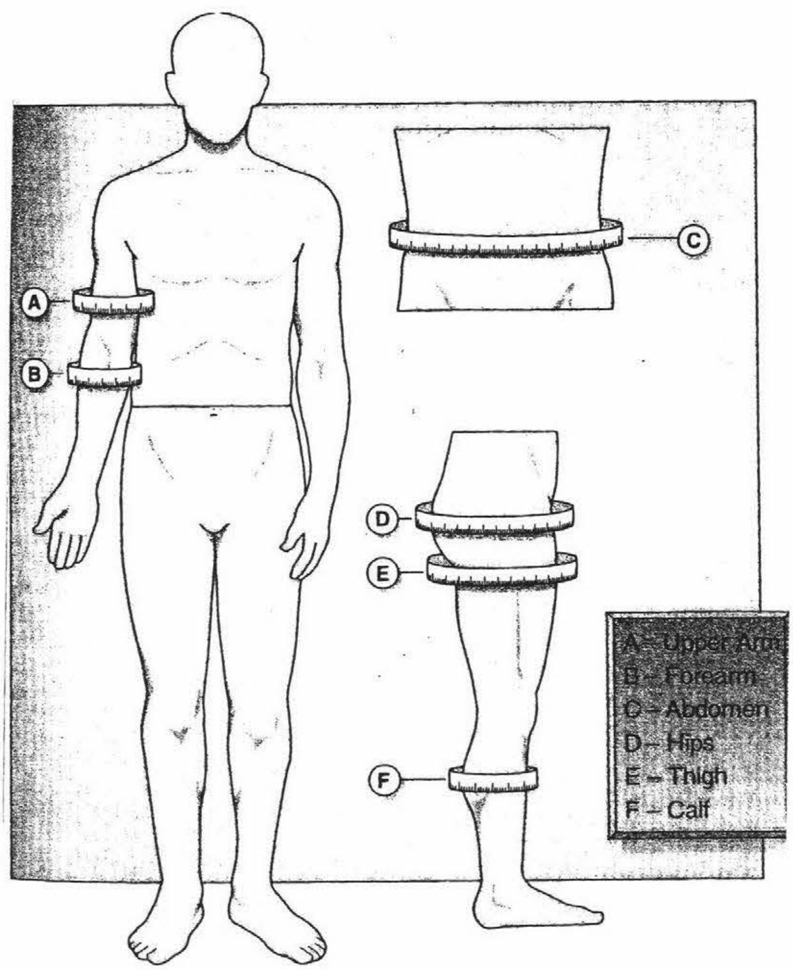
Illustrations of skinfold sites used for assessment of body composition in Experiment 2. Picture from McArdle, Katch & Katch (2000).



Appendix A.

9. Anatomical sites for Circumference Measurements

Illustrations of the Circumference sites used for the assessment of body composition in Experiment 2. Picture from McArdle, Katch & Katch (2000).



Appendix B.

1. Group Comparisons of Age, Body Mass, Height, Blood Pressure, Pre-Exercise Heart Rate, Circumferences, Skinfold Measurements and Estimated VO_2max at Week =0, Experiment 2

Variable	Control Group		'Pump It' Group		Walking Group		Statistical Comparison	Sig.
	Mean	SD	Mean	SD	Mean	SD	F	
Age	32.5	3.0	27.4	2.72	34.9	2.48	1.61	.220
Body Mass	74.48	3.05	62.33	2.63	74.94	3.85	5.476	.010*
Height	163.6	5.0	166.1	8.7	165.5	5.7	.398	.676
Systolic BP	119.75	2.95	114.8	4.12	113.29	6.20	.943	.402
Diastolic BP	73.2	2.35	69.4	2.66	75.1	3.64	1.277	.296
Pre-exercise HR	79.4	4.22	83.1	4.03	84.3	8.05	.255	.780
Sum of Five Skinfolds	159.69	15.01	111.29	10.66	189.18	18.27	6.466	.005**
VO_2 (L/min)	2.05	0.49	1.71	0.42	2.01	0.67	1.00	0.383
VO_2 (ml/kg/min)	28.07	6.22	28.78	7.48	26.55	6.69	0.210	0.812

n=12 for the Control group, n=10 for the 'Pump It' group and n=7 for the Walking group for all of the variables.

Appendix B.

2. Summary Tables for ANOVA, Fitness Test I, Experiment 2

A summary of the calculations to determine F of characteristics of the Control, 'Pump It' and Walking groups at Week = 0.

2.1. Age

	Df	Sums Squares	Mean Squares	F	sig.
Between Groups	2	257.95	128.975	1.614	0.218
Within Groups	26	2078.257	79.933		
Total	28	2336.207			

2.2. Body Mass (1-way ANOVA)

	Df	Sums Squares	Mean Squares	F	sig.
Between Groups	2	976.509	488.255	5.376	0.011*
Within Groups	26	2270.635	90.825		
Total	28	3247.144			

2.3. Height (1-way ANOVA)

	Df	Sums Squares	Mean Squares	F	sig.
Between Groups	2	35.532	17.766	.398	.676
Within Groups	26	1161.149	44.660		
Total	28	1196.681			

2.4. Systolic Blood Pressure (1-way ANOVA)

	Df	Sums Squares	Mean Squares	F	sig.
Between Groups	2	227.963	113.981	0.943	0.402
Within Groups	26	3141.279	120.818		
Total	28	3369.241			

2.5. Diastolic Blood Pressure (1-way ANOVA)

	Df	Sums Squares	Mean Squares	F	sig.
Between Groups	2	149.628	74.814	1.277	0.296
Within Groups	26	1522.924	58.574		
Total	28	1672.552			

2.6. Pre-exercise Heart Rate (1-way ANOVA)

	Df	Sums Squares	Mean Squares	F	sig.
Between Groups	2	128.203	64.102	0.255	0.777
Within Groups	26	6539.245	251.509		
Total	28	6667.448			

2.7. Sum of Six Circumferences (1-way ANOVA)

	Df	Sums Squares	Mean Squares	F	sig.
Between Groups	2	6446.603	3223.302	5.227	.012*
Within Groups	26	16032.527	616.636		
Total	28	22479.13			

2.8. Sum of Five Skinfolds (1-way ANOVA)

	Df	Sums Squares	Mean Squares	F	sig.
Between Groups	2	26858.637	13429.319	6.466	.005**
Within Groups	26	53996.014	2076.77		
Total	28	80854.651			

2.9. VO2 (L/min) (1-way ANOVA)

	Df	Sums Squares	Mean Squares	F	sig.
Between Groups	2	.534	.267	1.000	.383
Within Groups	23	6.143	.267		
Total	25	6.677			

2.10. VO_2 (ml/kg/min) (1-way ANOVA)

	Df	Sums Squares	Mean Squares	F	sig.
Between Groups	2	18.465	9.233	.210	.812
Within Groups	23	1009.504	43.891		
Total	25	1027.969			

Appendix B.

3. Summary tables for ANOVA, Fitness Test I & II, Experiment 2

A summary of the calculations to determine F for the characteristics of the Control, 'Pump It' and Walking before and after the training programme, Weeks = 0 & 7.

3.1. Body Mass

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	1924.513	962.256	5.154	0.013*
Error 1	25	4667.774	186.711		
Subjects	27				
Times	1	1.118	1.118	1.634	0.213
Times x group	2	0.131	0.0654	0.096	0.909
Error 2	25	17.099	0.684		
Total	55				

3.2. Systolic Blood Pressure

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	341.416	170.708	0.877	0.428
Error 1	26	5062.515	194.712		
Subjects	28	5403.931	365.42		
Times	1	3.118	3.118	0.06	0.808
Times x group	2	113.796	56.898	1.095	0.349
Error 2	26	1350.687	51.949		
Total	57				

3.3. Diastolic Blood Pressure

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	253.131	126.565	1.476	0.247
Error 1	26	2229.973	85.768		
Subjects	28	2483.104	212.333		
Times	1	43.874	43.874	1.469	0.236
Times x group	2	31.675	15.838	0.53	0.595
Error 2	26	776.325	29.859		
Total	57				

3.4. Pre-exercise Heart Rate

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	183.427	91.713	0.274	0.763
Error 1	26	8715.298	335.204		
Subjects	28	8898.725	426.917		
Times	1	279.953	279.953	3.219	0.084
Times x group	2	137.46	68.73	0.79	0.464
Error 2	26	2261.264	86.972		
Total	57				

3.5. Sum of Six Circumferences

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	12337.603	6168.801	4.862	0.016*
Error 1	26	32991.24	1268.889		
Subjects	28	45328.843	7437.69		
Times	1	27.892	27.892	1.518	0.229
Times x group	2	23.015	11.508	0.626	0.542
Error 2	26	477.71	18.373		
Total	57				

3.6. Biceps Circumference

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	228.714	14.357	4.819	0.017*
Error 1	26	616.941	23.728		
Subjects	28	845.655	38.085		
Times	1	1.254	1.254	2.808	0.106
Times x group	2	2.154	1.077	2.412	0.109
Error 2	26	11.611	0.447		
Total	57				

3.7. Forearm Circumference

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	54.508	27.254	4.59	0.020*
Error 1	26	154.371	5.937		
Subjects	28	208.879	33.191		
Times	1	0.167	0.167	2.558	0.122
Times x group	2	1.34E-02	6.71E-03	0.103	0.903
Error 2	26	1.701	6.54E-02		
Total	57				

3.8. Abdominal Circumference

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	1522.887	761.443	7.4	0.003**
Error 1	26	2675.258	102.895		
Subjects	28	4198.145	864.338		
Times	1	0.14	0.14	0.041	0.841
Times x group	2	0.105	5.24E-02	0.015	0.985
Error 2	26	88.46	3.402		
Total	57				

3.9. Hip Circumference

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	751.235	375.618	3.725	0.038*
Error 1	26	2622.072	100.849		
Subjects	28	3373.307	476.467		
Times	1	8.782	8.782	3.124	0.089
Times x group	2	2.552	1.276	0.454	0.640
Error 2	26	73.083	2.811		
Total	57				

3.10. Thigh Circumference

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	249.94	124.97	2.335	0.117
Error 1	26	1391.541	53.521		
Subjects	28	1641.481	178.491		
Times	1	0.537	0.537	0.429	0.518
Times x group	2	3.853	1.926	1.539	0.233
Error 2	26	32.535	1.251		
Total	57				

3.11. Calf Circumference

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	91.34	45.67	2.647	0.09*
Error 1	26	448.61	17.254		
Subjects	28	539.95	62.924		
Times	1	0.185	0.185	1.042	0.317
Times x group	2	0.142	7.11E-02	0.4	0.674
Error 2	26	4.617	0.178		
Total	57				

3.12. Sum of Five Skinfolds

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	46448.726	23224.363	5.902	0.008**
Error 1	26	102303.694	3934.757		
Subjects	28	148752.42	27159.12		
Times	1	111.693	111.693	1.715	0.202
Times x group	2	452.458	226.229	3.473	0.046*
Error 2	26	1693.766	65.145		
Total	57				

3.13. Triceps Skinfold

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	1844.365	922.183	5.673	0.009**
Error 1	26	4226.158	162.545		
Subjects	28	6070.523	1084.728		
Times	1	173.696	173.696	7.395	0.011*
Times x group	2	23.528	11.764	0.501	0.612
Error 2	26	610.681	23.488		
Total	57				

3.14.Subscapular Skinfold

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	2320.5	1160.25	5.589	0.010**
Error 1	26	5397.114	207.581		
Subjects	28	7717.614	1367.831		
Times	1	183.952	183.952	5.031	0.034*
Times x group	2	419.356	209.678	5.734	0.009**
Error 2	26	950.719	36.566		
Total	57				

3.15. Suprailiac Skinfold

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	3102.312	1551.156	7.506	0.003**
Error 1	26	5373.107	206.658		
Subjects	28	8475.419	1757.814		
Times	1	351.055	351.055	19.742	0.000***
Times x group	2	111.276	55.638	3.129	0.061*
Error 2	26	462.337	17.782		
Total	57				

3.16. Abdominal Skinfold

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	2115.03	1057.515	6.132	0.007**
Error 1	26	4483.684	172.449		
Subjects	28	6598.714	1229.964		
Times	1	2007.343	2007.343	96.995	0.000***
Times x group	2	13.725	3.863	0.332	0.721
Error 2	26	538.076	20.695		
Total	57				

3.17. Thigh Skinfold

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	603	301.5	1.782	0.188
Error 1	26	4399.317	169.205		
Subjects	28	5002.317	470.705		
Times	1	97.875	97.875	3.694	0.066*
Times x group	2	89.7	44.85	1.693	0.204
Error 2	26	688.899	26.496		
Total	57				

3.18. Energy Intake

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	830506.207	415253.104	0.119	0.888
Error 1	23	80128424	6483844.52		
Subjects	25	80958930.21	6899097.624		
Times	1	5.93E+05	5.93E+05	0.871	0.360
Times x group	2	139417.723	69708.862	0.102	0.903
Error 2	23	15649153.2	680397.967		
Total	51				

3.19. Fat Intake

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	6160.602	3080.301	0.428	0.657
Error 1	23	165443.378	7193.19		
Subjects	25	171603.98	10273.491		
Times	1	158.608	158.608	0.115	0.737
Times x group	2	6730.459	3365.229	2.449	0.109
Error 2	23	31606.69	1374.204		
Total	51				

3.20. Carbohydrate Intake

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	85796.699	42898.35	0.612	0.551
Error 1	23	1611782.33	70077.493		
Subjects	25	1697579.029	112975.843		
Times	1	3773.152	3773.152	0.147	0.705
Times x group	2	10119.129	5059.565	0.197	0.822
Error 2	23	590101.13	25656.571		
Total	51				

3.21. Protein Intake

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	9998.527	4999.264	0.304	0.741
Error 1	23	378809.229	16469.966		
Subjects	25	388807.756	21469.23		
Times	1	4154.468	4154.468	1.249	0.275
Times x group	2	1899.037	949.519	0.285	0.754
Error 2	23	76517.067	3326.829		
Total	51				

3.22. Predicted VO_2max

	Df	Sums Squares	Mean Squares	F	sig.
Groups	2	0.918	0.459	1.135	0.339
Error 1	23	9.298	0.404		
Subjects	25	10.216	0.863		
Times	1	5.558	5.558	85.608	0.000
Times x group	2	0.07157	0.03579	0.551	0.584
Error 2	23	1.493	0.06492		
Total	51				

* ∞ < .05 some evidence of significance for General Linear Model (GLM) with repeated measures

** ∞ < .01 strong evidence of significance for General Linear Model (GLM) with repeated measures

*** ∞ < .001 very strong evidence of significance for General Linear Model (GLM) with repeated measures

Appendix B.

4. Graphs Experiment 2. All graphs are Mean ± SD

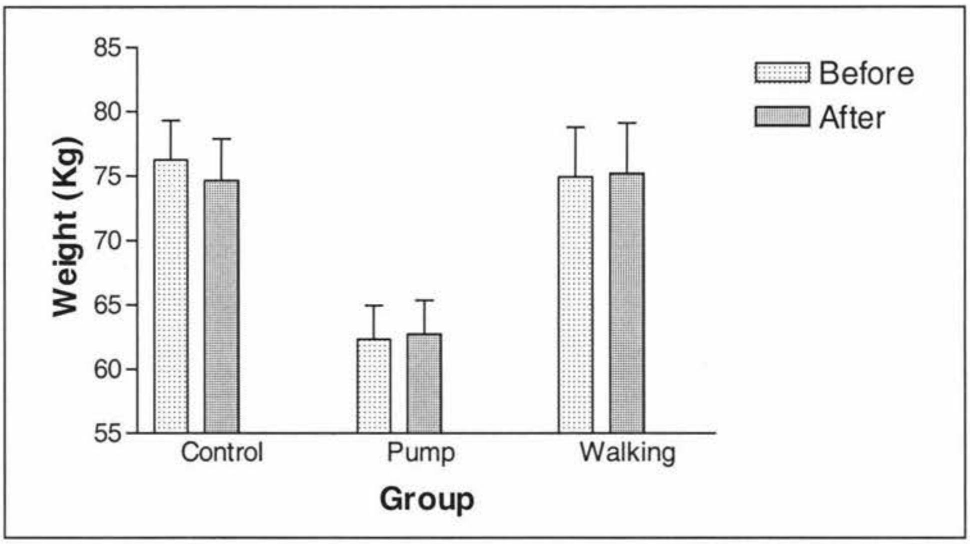


Figure 4.1. Body Mass
Body mass before (week=0) and after (week=7) for the Control, 'Pump It' and Walking groups.

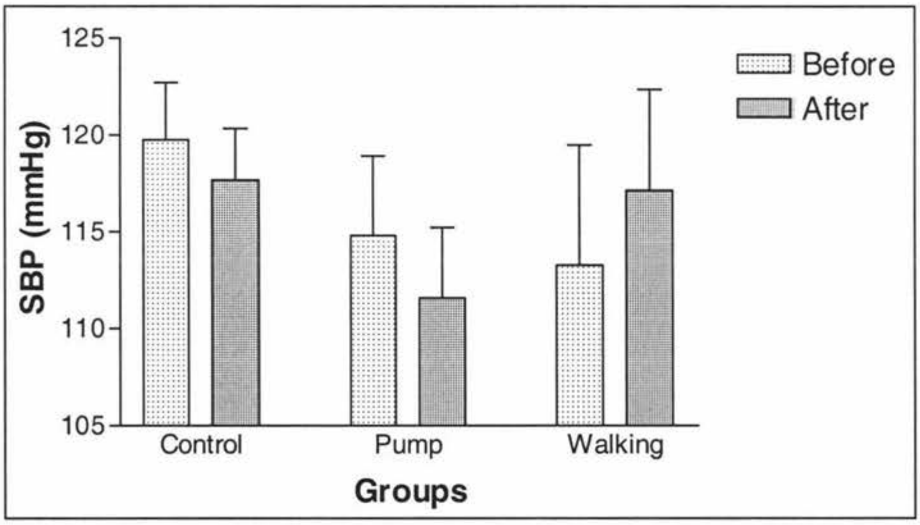


Figure 4.2. Systolic Blood Pressure
Systolic Blood Pressure at week=0 and week=7 for the Control, 'Pump It' and Walking groups.

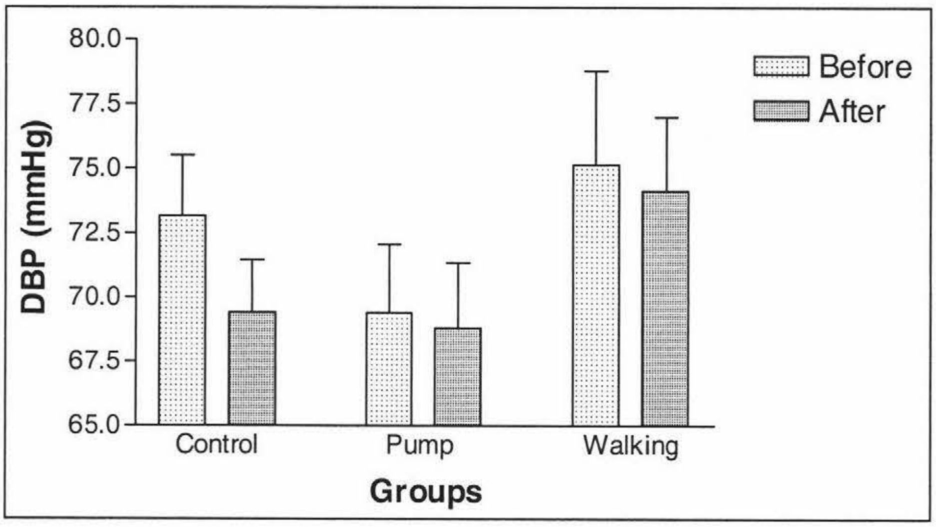


Figure 4.3. Diastolic Blood Pressure
Diastolic blood pressure at week=0 and week=7 for the Control, 'Pump It' and Walking groups.

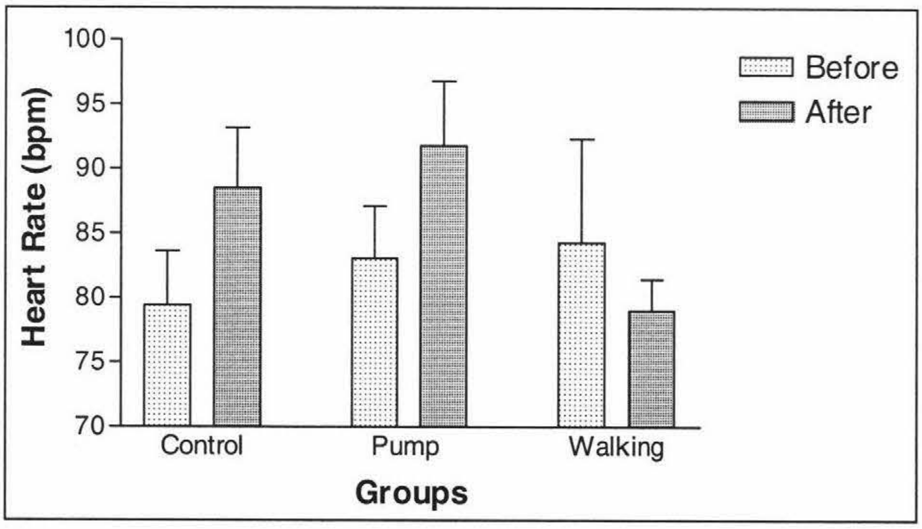


Figure 4.4. Pre-exercise Heart rate
Changes in pre-exercise heart over 6 weeks for the Control, 'Pump It' and Walking groups.

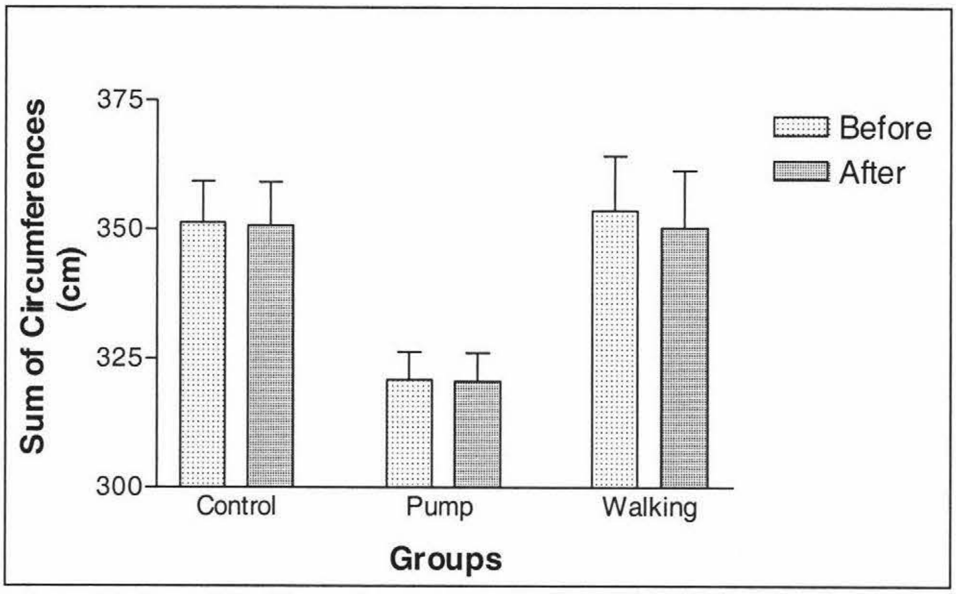


Figure 4.5. Sum of Six Circumferences
Changes in the sum of circumferences (biceps, forearm, abdominal, hip, thigh and calf) for the Control, 'Pump It' and Walking groups (week=0 and week=7).

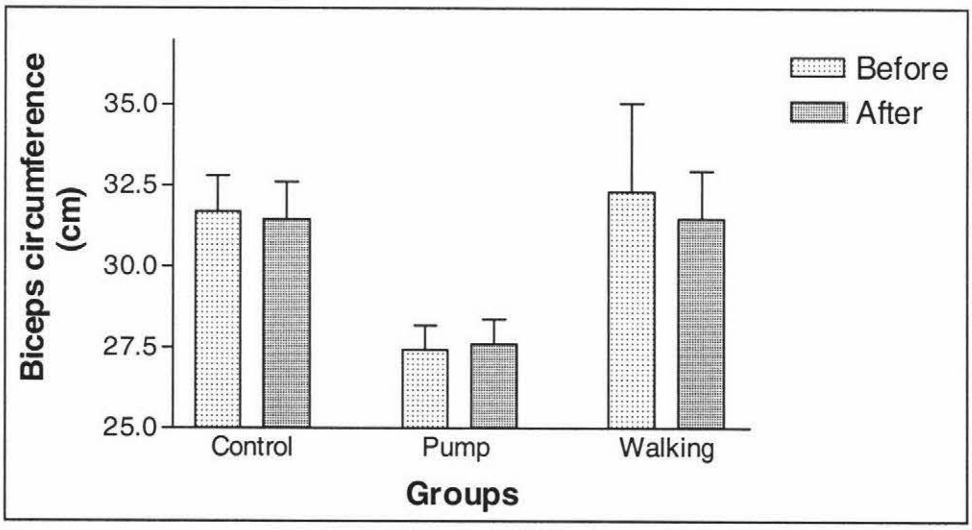


Figure 4.6. Biceps Circumference
Biceps circumference at week=0 (before) and week=7(after) for the Control, 'Pump It' and Walking groups.

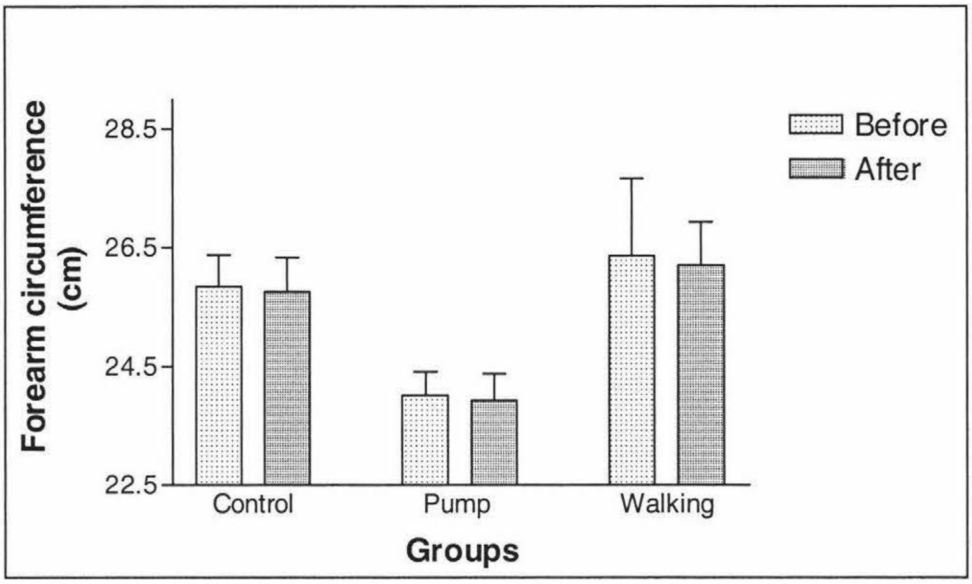


Figure 4.7. Forearm Circumference
Forearm circumference at week=0 and week=7 for the Control, 'Pump It' and Walking groups.

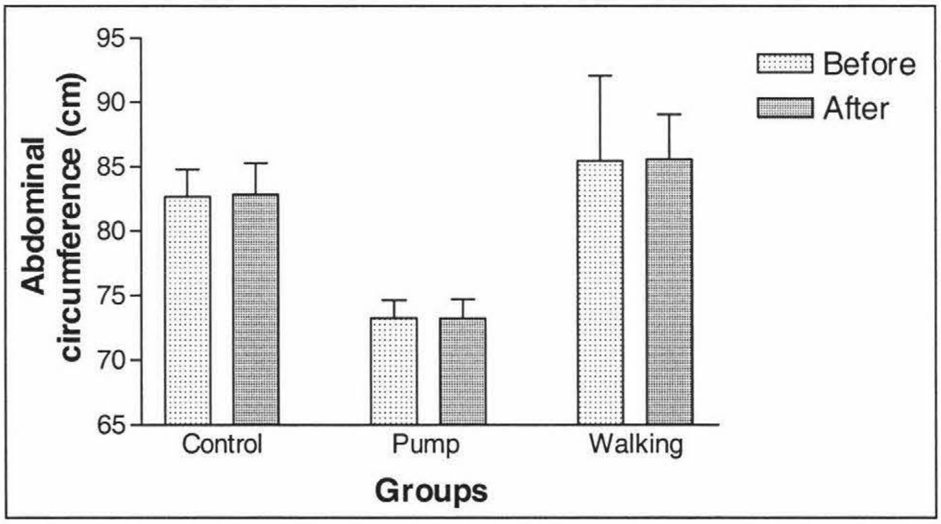


Figure 4.8. Abdominal Circumference
Abdominal circumference over 6 weeks (week=0 and week=7) for the Control, 'Pump It' and Walking groups.

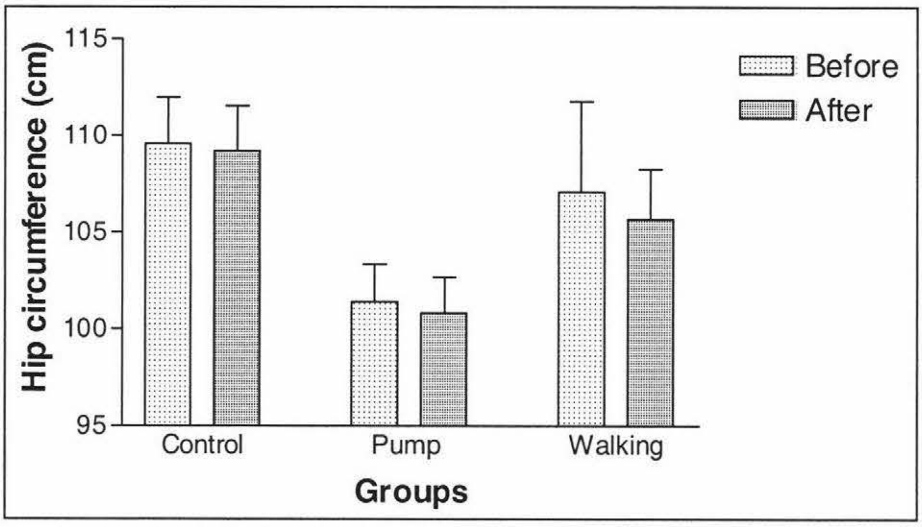


Figure 4.9. Hip Circumference
Hip circumference at week=0 and week=7 for the Control, 'Pump It' and Walking groups.

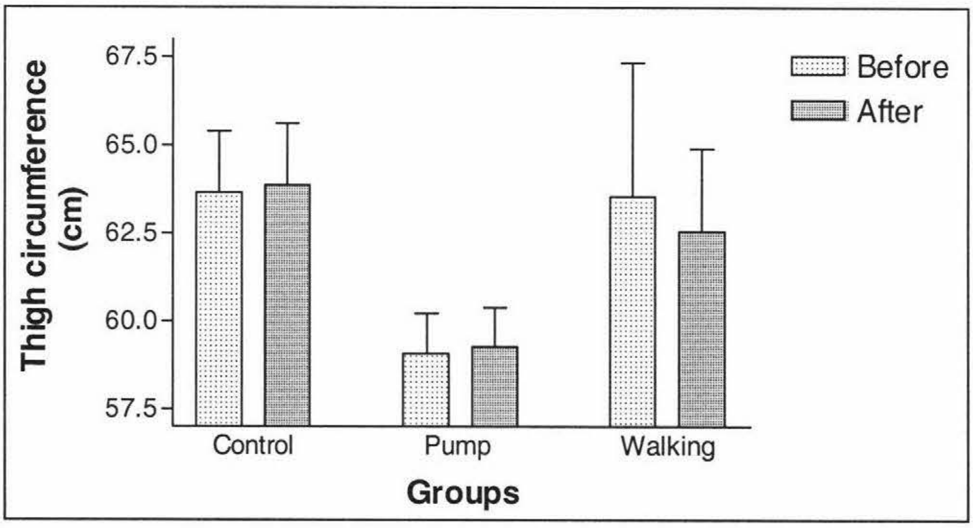


Figure 4.10. Thigh Circumference
Thigh circumference for the Control, 'Pump It' and Walking groups before and after the six week training period (week=0 and week=7 respectively)

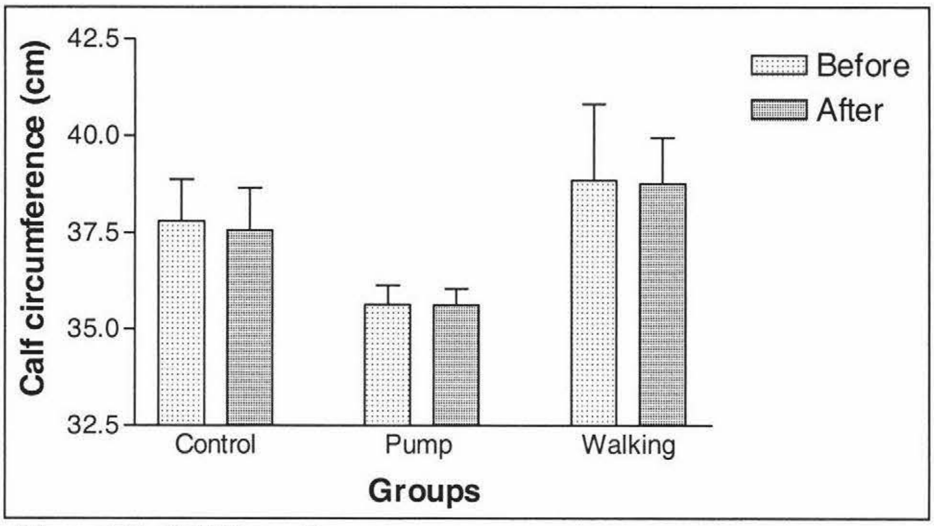


Figure 4.11. Calf Circumference
Calf circumference at week=0 and week=7 for the Control, 'Pump It' and Walking groups.

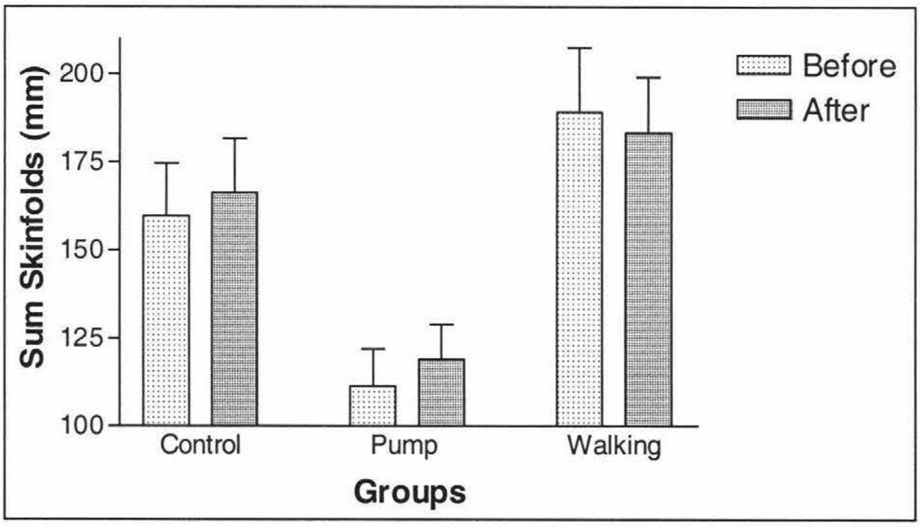


Figure 4.12. Sum of Five Skinfolds
Changes in the sum of the triceps, subscapular, suprailiac, abdomen and thigh skinfolds over 6 weeks for the Control, 'Pump It' and Walking groups.

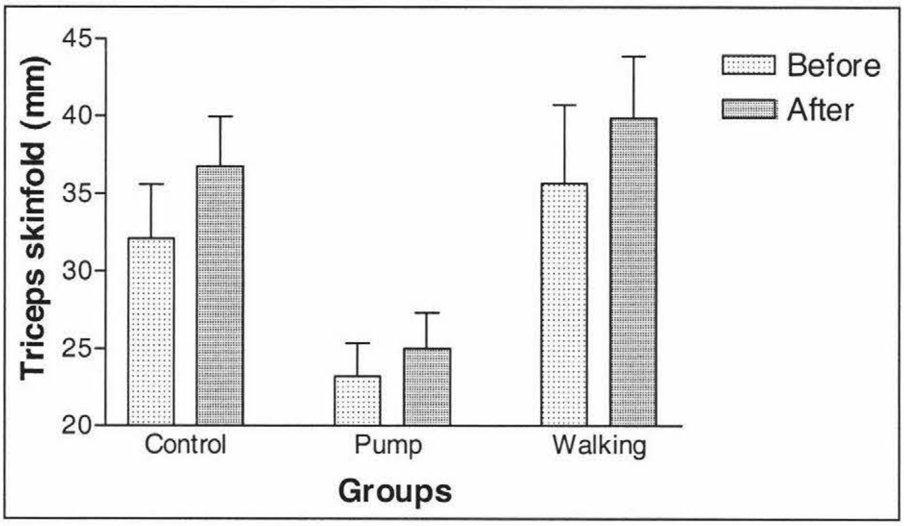


Figure 4.13. Triceps Skinfold
Changes in triceps skinfolds over 6 weeks for the Control, 'Pump It' and Walking groups.

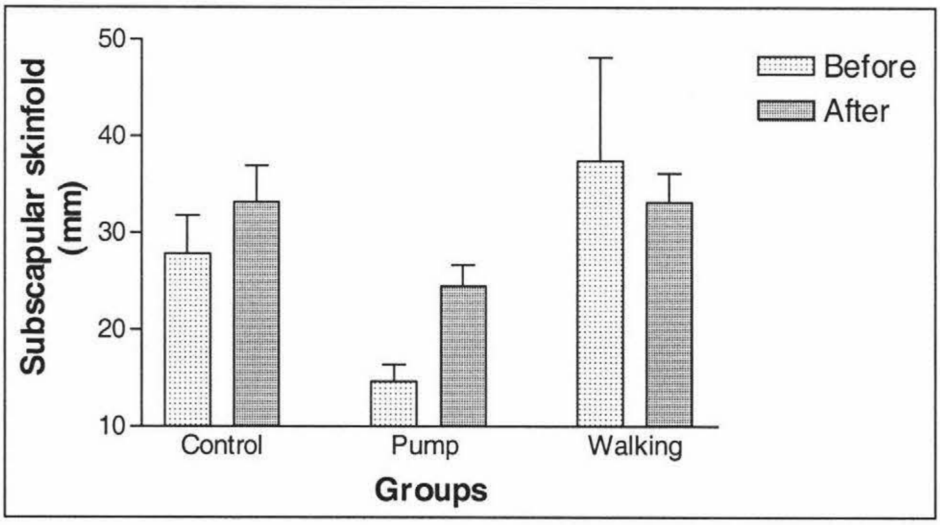


Figure 4.14. Subscapular Skinfold
Changes in subscapular skinfolds over 6 weeks for the Control, 'Pump It' and Walking groups.

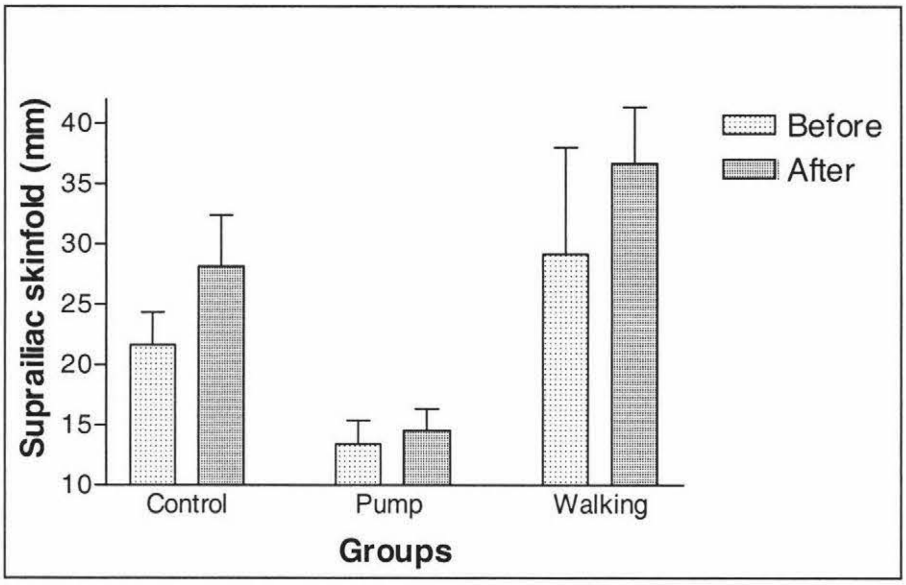


Figure 4.15. Suprailiac Skinfold
Changes in suprailiac skinfolds over 6 weeks for the Control, 'Pump it' and Walking groups.

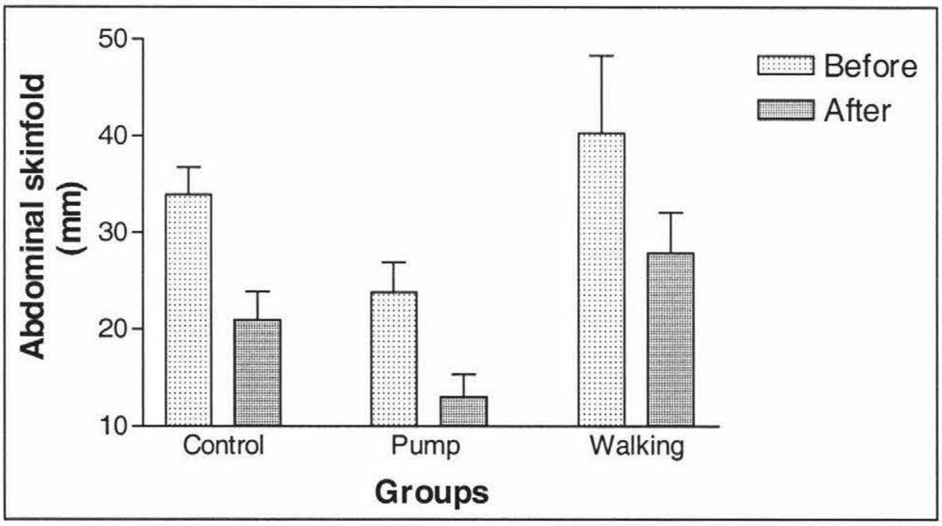


Figure 4.16. Abdominal Skinfold
Changes in abdominal skinfolds over 6 weeks for the Control, 'Pump It' and Walking groups.

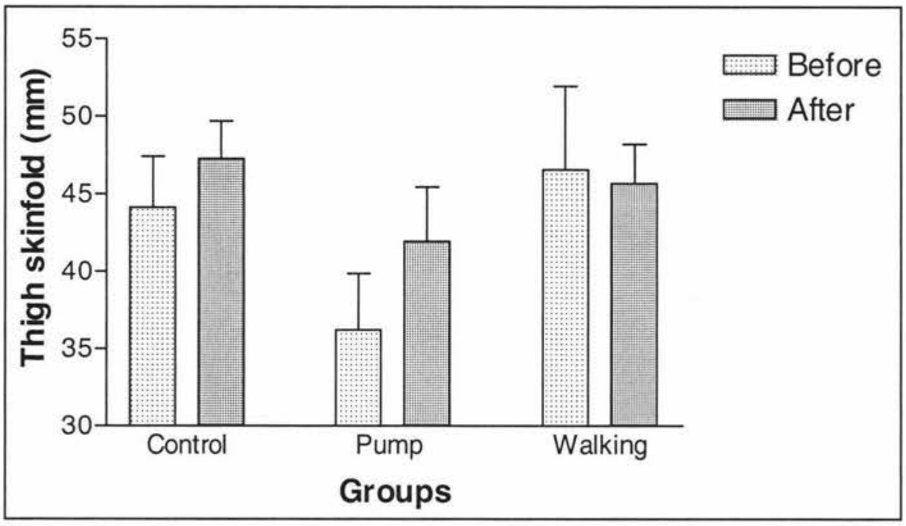


Figure 4.17. Thigh Skinfold
Changes in thigh skinfolds over 6 weeks for the Control, 'Pump It' and Walking groups.

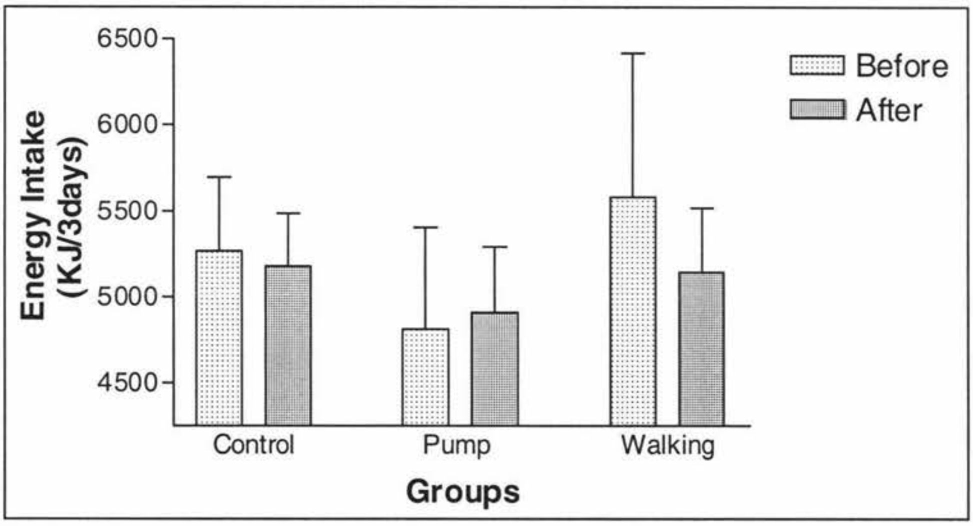


Figure 4.18. Energy Intake
Energy intake at week=0 and week=7 for the Control, 'Pump It' and Walking groups.

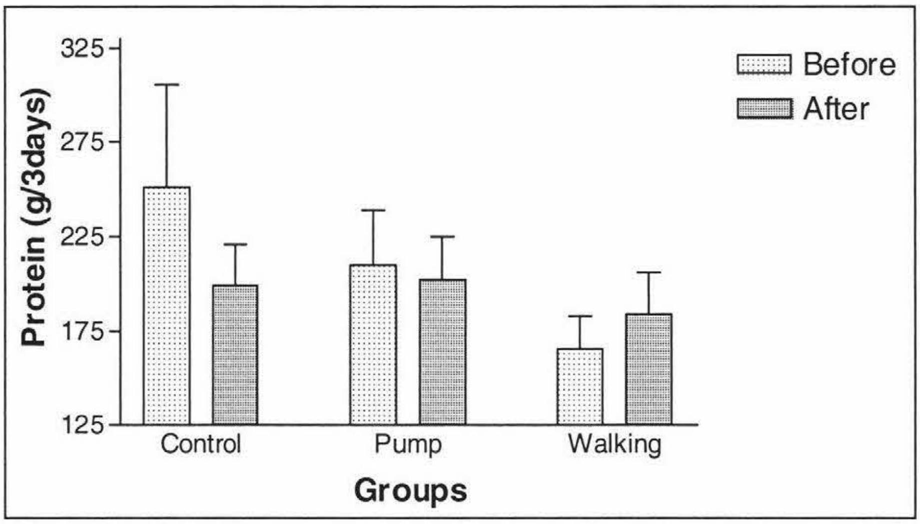


Figure 4.19. Protein Intake
Changes in protein intake over 6 weeks for the Control, 'Pump It' and Walking groups. Values are

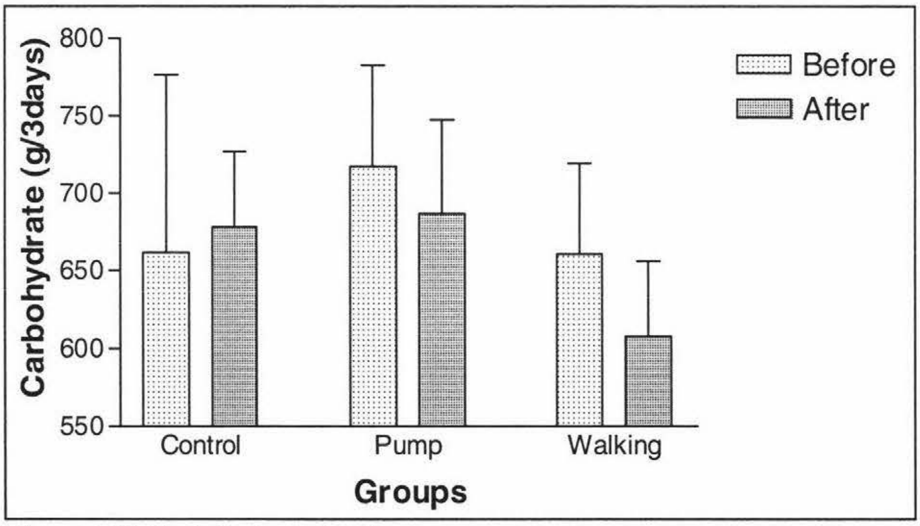


Figure 4.20. Carbohydrate Intake
Changes in carbohydrate intake over 6 weeks for the Control, 'Pump It' and Walking groups.

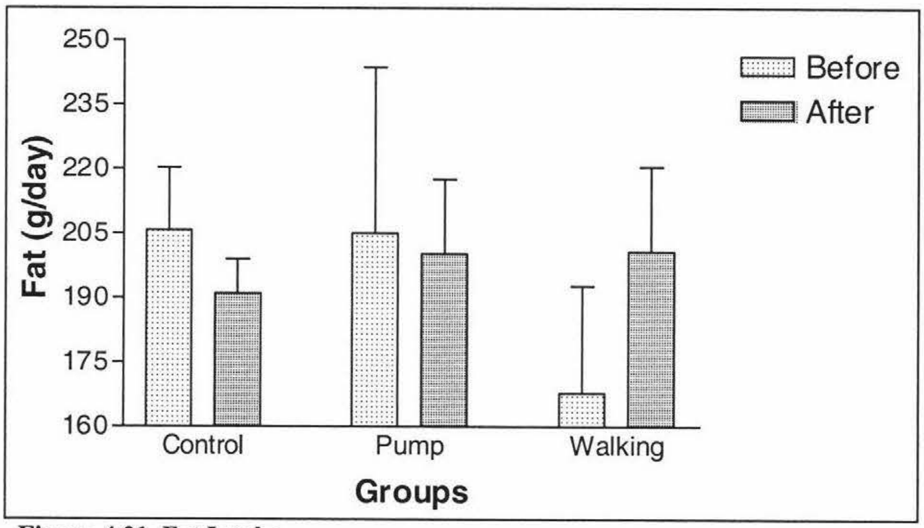


Figure 4.21. Fat Intake
Changes in fat intake over 6 weeks for the Control, 'Pump It' and Walking groups.

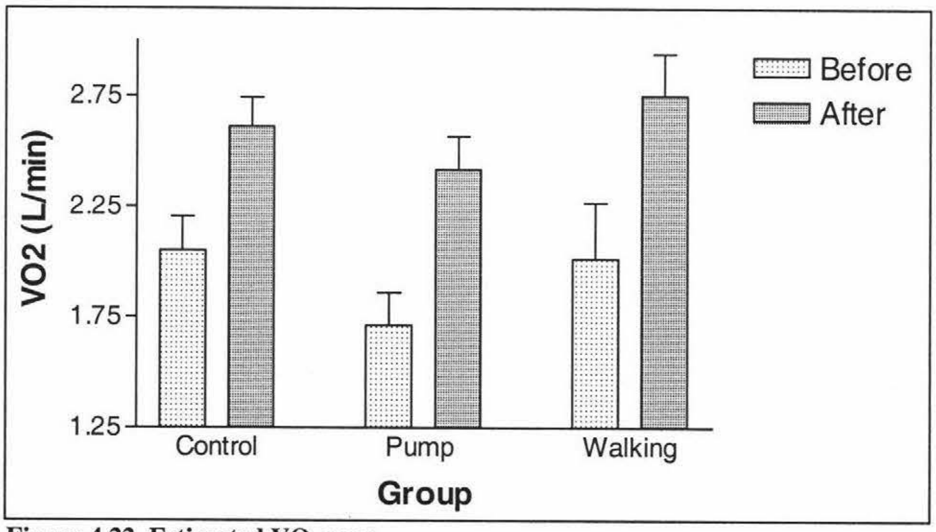


Figure 4.22. Estimated VO_2 max
Changes in estimated VO_2max over six weeks for the Control, 'Pump It' and Walking groups.

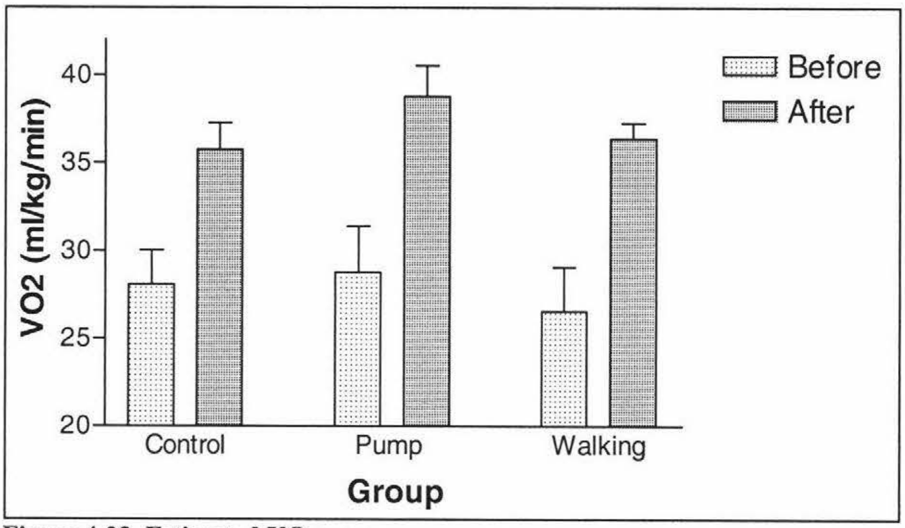


Figure 4.23. Estimated VO_2max.
Changes in estimated VO_2max over six weeks for the Control, 'Pump It' and Walking groups.

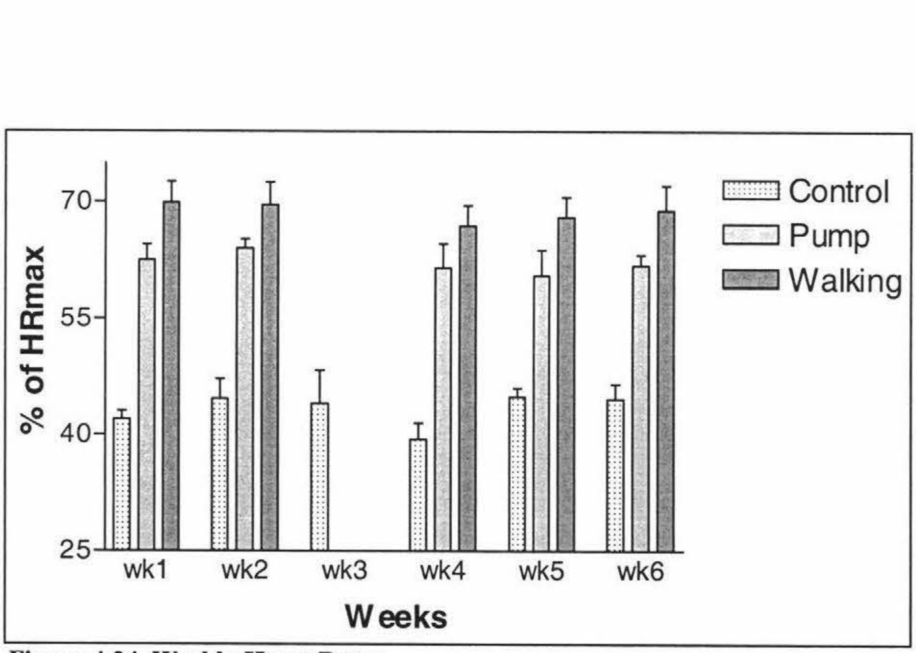


Figure 4.24. Weekly Heart Rates.
Changes in the percentage of Heart Rate maximum over 6 weeks for the Control, 'Pump It' and Walking groups. %HRmax was calculated from the mean HR over 60minutes. Note: equipment failure in week 3 meant that only heart rates for the Control group were obtained for this week.

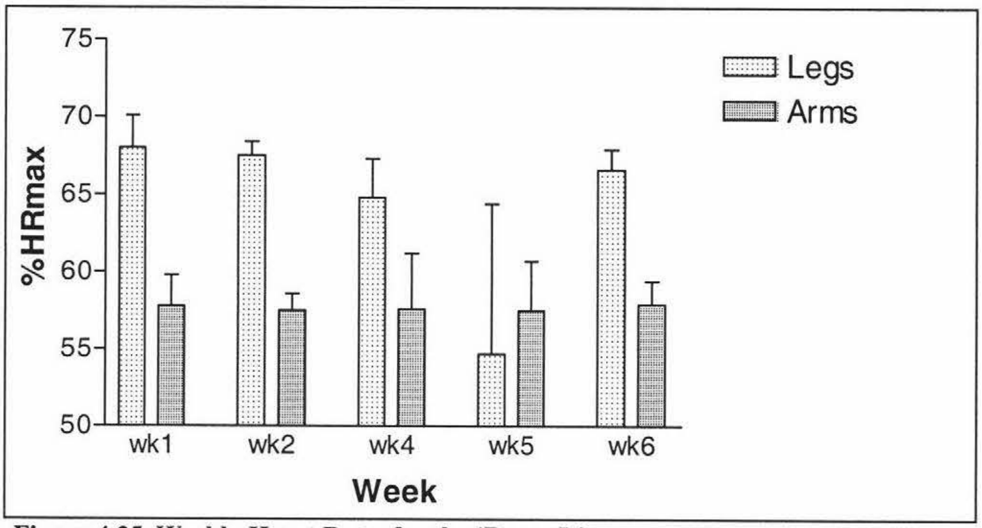


Figure 4.25. Weekly Heart Rates for the 'Pump It' group.
Changes in the percentage of Heart Rate maximum for the arms and leg sections of the 'Pump It' exercise sessions over 6 weeks. Values are means ± the standard error. Note. No heart rates were obtained for week 3 due to equipment failure.

Appendix B.

5. Summary Tables of post hoc ANOVA, Fitness Test I & II, Experiment 2

5.1. Pre-exercise Heart Rate (Control vs Exercise)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	127.45	127.45	0.392	0.536
Error 1	27	8771.275	324.862		
Subjects	28	8898.725	452.312		
Times	1	400.92	400.92	4.549	.042*
Times x group	1	18.989	18.989	0.215	0.646
Error 2	27	2379.735	88.138		
Total	57				

5.2. Pre-exercise Heart Rate ('Pump It' vs Walking)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	55.977	55.977	0.132	0.722
Error 1	15	6371.964	424.798		
Subjects	16	6427.941	480.775		
Times	1	101.295	101.295	2.472	0.137
Times x group	1	118.471	118.471	2.891	0.11
Error 2	15	614.764	40.984		
Total					

5.3. Sum of Circumferences (Control vs Exercise)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	4277.299	4277.299	2.813	0.105
Error 1	27	41051.428	1520.423		
Subjects	28	45328.727	5797.722		
Times	1	16.081	16.081	0.874	0.358
Times x group	1	3.791	3.791	0.206	0.654
Error 2	27	496.934	18.405		
Total	57				

5.4. Sum of Circumferences ('Pump It' vs Walking)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	8060.304	8060.304	7.957	.013*
Error 1	15	15195.101	1013.007		
Subjects	16	23255.405	9073.311		
Times	1	28.425	28.425	1.726	0.209
Times x group	1	19.224	19.224	1.167	0.297
Error 2	15	247.095	16.473		
Total	33				

5.5. Biceps Circumference (Control vs Exercise)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	71.24	71.24	2.484	0.127
Error 1	27	774.415	28.682	2.484	0.127
Subjects	28	845.655	99.922		
Times	1	0.82	.8/20	1.608	0.216
Times x group	1	8.452E-07	8.452E-07	0	0.999
Error 2	27	13.765	0.51		
Total	57				

5.6. Biceps Circumference ("Pump It' vs Walking)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	157.474	157.474	8.512	.011*
Error 1	15	277.496	18.5		
Subjects	16	434.97	175.974		
Times	1	0.905	0.905	1.655	0.218
Times x group	1	2.154	2.154	3.942	0.066
Error 2	15	8.197	0.546		
Total	33				

5.7. Hip Circumference (Control vs Exercise)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	522.455	522.455	4.948	.035*
Error 1	27	2850.852	105.587		
Subjects	28	3373.307	628.042		
Times	1	6.039	6.039	2.188	0.151
Times x group	1	1.104	1.104	0.4	0.532
Error 2	27	74.531	2.76		
Total	57				

5.8. Hip Circumference ('Pump It' vs Walking)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	228.78	228.78	3.018	0.103
Error 1	15	1137.018	75.801		
Subjects	16	1365.798	304.581		
Times	1	8.389	8.389	2.322	0.148
Times x group	1	1.448	1.448	0.401	0.536
Error 2	15	54.202	3.613		
Total	33				

5.9. Sum of Skinfolds (Control vs Exercise)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	4843.93	4843.93	0.909	0.349
Error 1	27	143908.49	5329.944		
Subjects	28	148752.42	10173.874		
Times	1	271.145	271.145	3.526	0.071
Times x group	1	69.856	69.856	0.908	0.349
Error 2	27	2076.368	76.903		
Total	57				

5.10. Sum of Skinfolds ('Pump It' vs Walking)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	41604.797	41604.797	14.824	.002**
Error 1	15	42098.209	2806.547		
Subjects	16	83703.006	44411.344		
Times	1	7.573	7.573	0.087	0.773
Times x group	1	382.602	382.602	4.375	0.054
Error 2	15	1311.804	87.454		
Total	33				

5.11. Triceps Skinfold (Control vs Exercise)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	309.061	309.061	1.448	0.239
Error 1	27	5761.462	213.387		
Subjects	28	6070.523	522.448		
Times	1	194.015	194.015	8.417	.007**
Times x group	1	110817	11.817	0.513	0.48
Error 2	27	622.392	23.052		
Total	57				

5.12. Triceps Skinfold ('Pump It' vs Walking)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	1535.304	1535.304	15.022	.001***
Error 1	15	1533.016	102.201		
Subjects	16	3068.32	1637.505		
Times	1	74.489	74.489	3.326	0.088
Times x group	1	11.711	11.711	0.523	0.481
Error 2	15	335.983	22.399		
Total	33				

5.13. Subscapular Skinfold (Control vs Exercise)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	279.577	279.577	1.015	0.323
Error 1	27	7438.036	275.483		
Subjects	28	7717.613	555.06		
Times	1	310.595	310.595	6.147	.02*
Times x group	1	5.758	5.758	0.114	0.738
Error 2	27	1364.317	50.53		
Total	57				

5.14. Subscapular Skinfold ('Pump It' vs Walking)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	2040.923	2040.923	17.299	.001**
Error 1	15	1769.723	117.982		
Subjects	16	3810.646	2158.905		
Times	1	64.944	64.944	1.454	0.247
Times x group	1	413.597	413.597	9.259	.008**
Error 2	15	670.021	44.668		
Total	33				

5.15. Suprailiac Skinfold (Control vs Exercise)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	137.636	137.636	0.446	0.51
Error 1	27	8337.783	308.807		
Subjects	28	8475.419	446.443		
Times	1	369.979	369.979	18.27	.000***
Times x group	1	26.834	26.834	1.325	0.26
Error 2	27	546.78	20.251		
Total	57				

5.16. Suprailiac Skinfold ('Pump It' vs Walking)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	2964.676	2964.676	18.982	.001***
Error 1	15	2342.726	156.182		
Subjects	16	5307.402	3120.858		
Times	1	153.132	153.132	13.585	.002**
Times x group	1	84.442	84.442	7.491	.015*
Error 2	15	169.081	11.272		
Total	33				

5.17. Abdominal Skinfold (Control vs Exercise)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	91.756	91.756	0.381	0.542
Error 1	1	8.13	8.13		
Subjects	2	99.886	99.886		
Times	1	2100.551	2100.551	104.318	0.000
Times x group	1	8.13	8.13	0.404	0.531
Error 2	27	543.672	20.136		
Total	31				

5.18.Abdominal Skinfold ('Pump It' vs Walking)

	Df	Sums Squares	Mean Squares	F	sig.
Groups	1	2023.274	2023.274	12.33	.003**
Error 1	15	2461.438	164.096		
Subjects	16	4484.712	2187.37		
Times	1	1108.96	1108.96	43.536	.000***
Times x group	1	5.595	5.595	0.22	0.646
Error 2	15	382.008	25.473		
Total	33				

Appendix C.

Tables of Results

Table 1. Body Composition Characteristics, Fitness test I & II, Experiment 2

Mean (± SD) of body mass, sum of 5 skinfolds and sum of 6 circumferences at weeks zero and seven.

		Weeks	
		Zero X ± SD	Seven X ± SD
Body Mass kg	Control	74.5 ± 10.1	74.9 ± 10.7
	'Pump It'	62.3 ± 8.3	62.7 ± 8.3
	Walking	74.9 ± 10.2	75.2 ± 10.3
SSK-5 mm	Control	159.7 ± 52.0	166.3 ± 53.0
	'Pump It'	111.3 ± 33.7	119.1 ± 31.2
	Walking	189.2 ± 48.3	183.3 ± 41.6
SC-6 mm	Control	351 ± 28	350 ± 29
	'Pump It'	321 ± 17	321 ± 18
	Walking	354 ± 28	350 ± 29

Control n=12, 'Pump It' n=10, Walking n=7. SSK-5 is the sum of the tricep, subscapular, suprailiac, abdomen and thigh skinfolds. SC-6 is the sum of the forearm, upper arm, waist, hips, thigh and calf circumferences.

Appendix C.

Tables of Results

Table 2. Pre-exercise Blood Pressure and Heart Rate, Fitness test I & II, Experiment 2

Mean (± SD) systolic blood pressure, diastolic blood pressure and heart rate prior to submaximal treadmill test, at weeks zero and seven.

		Weeks	
		Zero X ± SD	Seven X ± SD
SBP mmHg	Control	119 ± 10	117 ± 9
	'Pump It'	115 ± 13	112 ± 11
	Walking	113 ± 9	117 ± 14
DBP mmHg	Control	73 ± 8	69 ± 7
	'Pump It'	69 ± 8	69 ± 7
	Walking	75 ± 5	74 ± 8
Pre-exercise HR bpm	Control	79 ± 15	86 ± 12
	'Pump It'	83 ± 13	90 ± 11
	Walking	84 ± 21	84 ± 17

Control n=12, 'Pump It' n=10, Walking n=7. SBP is systolic blood pressure, DBP is diastolic blood pressure.

Appendix C.

Tables of Results

Table 3. Estimated Maximum Oxygen Consumption, Fitness test I & II, Experiment 2
VO_2max (ml/kg/min) weeks zero and seven.

		Weeks	
		Zero X ± SD	Seven X ± SD
Estimated Maximum Oxygen Consumption (ml/kg/min)	Control	28.1 ± 6.2	35.8 ± 4.8
	'Pump It'	28.8 ± 7.5	38.8 ± 5.2
	Walking	26.6 ± 6.7	36.4 ± 2.3

Control n=12, 'Pump It' n=10, Walking n=7.

Appendix C.

Tables of Results

Table 4. Dietary Intakes for Weeks One and Six, Experiment 2
Mean (± SD) energy, protein, carbohydrate and fat. Values are g/3day.

		Weeks	
		Zero X ± SD	Seven X ± SD
Energy	Control	5267 ± 1354	5180 ± 970
	'Pump It'	5425 ± 1773	5214 ± 1138
	Walking	5173 ± 2213	4826 ± 992
Protein	Control	251 ± 172	199 ± 69
	'Pump It'	214 ± 87	196 ± 68
	Walking	170 ± 45	193 ± 58
CHO	Control	662 ± 363	677 ± 363
	'Pump It'	742 ± 195	700 ± 182
	Walking	654 ± 156	606 ± 127
Fat	Control	206 ± 46	191 ± 25
	'Pump It'	215 ± 116	216 ± 52
	Walking	167 ± 66	186 ± 52

Control n=12, 'Pump It' n=10, Walking n=7. CHO is Carbohydrate.

Appendix D.

1. Multiple Regression Equation for changes in oxygen uptake with increasing workload (y is Oxygen Consumption, L/min).

Subject Number	Multiple Regression Equation	Cycle Z = 1	Treadmill Z = 0
1	$y = 0.15 + 1.20\ E^{-02}W + 0.12z - 1.20\ E^{-03}zW$ (p=.07) (p=.00) (p=.29) (p=.31)		
	$y = 0.43 + 8.49\ E^{-03}W$ (p=.02) (p=.00)	$y = 0.43 + 8.49\ E^{-03}W$	$y = 0.43 + 8.49\ E^{-03}W$
2	$y = 0.32 + 7.82\ E^{-03}W + 0.12z - 3.90\ E^{-03}zW$ (p=.01) (p=.00) (p=.12) (p=.02)		
	$y = 0.38 + 7.13\ E^{-03}W - 2.52\ E^{-03}zW$ (p=.00) (p=.00) (p=.00)	$y = 0.38 + 4.61E^{-03}W$	$y = 0.38 + 7.13\ E^{-03}W$
3	$y = 0.11 + 1.38\ E^{-02}W + 0.12z - 2.43\ E^{-02}zW$ (p=.36) (p=.00) (p=.47) (p=.27)		
	$y = 0.11 + 1.26\ E^{-02}W$ (p=.098) (p=.00)	$y = 0.11 + 1.26\ E^{-02}W$	$y = 0.11 + 1.26\ E^{-02}W$
4	$y = 0.11 + 1.33\ E^{-02}W + 0.28z - 2.65\ E^{-03}zW$	$y = 0.39 + 1.07\ E^{-02}W$	$y = 0.11 + 1.33\ E^{-02}W$

5	$y = 0.11 + 1.08\ E^{-02}W + 0.30z + 9.08\ E^{-05}zW$ (p=.21) (p=.00) (p=.045) (p=.93)		
	$y = 0.10 + 1.08\ E^{-02}W + 0.30z$ (p=.08) (p=.00) (p=.00)	$y = 0.40 + 1.08\ E^{-02}W$	$y = 0.10 + 1.08\ E^{-02}W$
6	$y = 0.20 + 1.18\ E^{-02}W + 0.17z - 2.03\ E^{-03}zW$ (p=.01) (p=.00) (p=.027) (p=.022)	$y = 0.37 + 9.77\ E^{-03}W$	$y = 0.20 + 1.18\ E^{-02}W$
7	$y = 0.28 + 1.11\ E^{-02}W + 0.12z - 1.45\ E^{-03}zW$ (p=.00) (p=.00) (p=.17) (p=.077)		
	$y = 0.34 + 1.04\ E^{-02}W$ (p=.00) (p=.00)	$y = 0.34 + 1.04\ E^{-02}W$	$y = 0.34 + 1.04\ E^{-02}W$

Appendix D.1. Multiple Regression Equations, Oxygen Consumption vs Workload

8	$y = 0.19 + 1.30\ E^{-02}W + 9.20\ E^{-02}z - 1.88\ E^{-03}zW$ (p=.00) (p=.00) (p=.15) (p=.01)		
	$y = 0.23 + 1.25\ E^{-02}W - 1.04\ E^{-03}zW$ (p=.00) (p=.00) (p=.00)	$y = 0.23 + 1.15E^{-02}W$	$y = 0.23 + 1.25\ E^{-02}W$
9	$y = 0.11 + 1.07\ E^{-02}W + 0.17z - 1.20\ E^{-03}zW$ (p=.098) (p=.00) (p=.07) (p=.23)		
	$y = 0.15 + 1.01\ E^{-02}W + 7.67\ E^{-02}z$ (p=.01) (p=.00) (p=.01)	$y = 0.15 + 7.33\ E^{-02}z + 1.01\ E^{-02}W$	$y = 0.15 + 1.01\ E^{-02}W$
All Subjects	$y = 0.15 + 1.12\ E^{-02}W + 0.12z - 1.19\ E^{-03}zW$ (p=.068) (p=.00) (p=.29) (p=.31)		
	$y = 0.21 + 1.13\ E^{-02}W$ (p=.00) (p=.00)	$y = 0.21 + 1.13\ E^{-02}W$	$y = 0.21 + 1.13\ E^{-02}W$

Z = 1 for the cycle group, Z = 0 for the treadmill group. Y is Oxygen Consumption (VO_2) (L/min). Two equations are shown for each measurement. The least significant variables/ interactions were then removed stepwise until all variables which were not significant ($p < .05$) had been removed (second equation).

Appendix D.

2. Multiple Regression Equation for changes in Heart Rate with increasing workload. (y is Heart Rate, bpm).

Subject Number	Multiple Regression Equation	Cycle $Z = 1$	Treadmill $Z = 0$
1	$y = 71.5 + .51W + 12.59z - 1.23\ E^{-03}zW$ (p=.00) (p=.00) (p=.31) (p=.92)		
	$y = 72.4 + 0.48W$ (p=.02) (p=.08)	$y = 72.4 + 0.48W$	$y = 72.4 + 0.48W$
2	$y = 76.2 + 0.61W + 23.4z - 1.28\ E^{-02}zW$ (p=.00) (p=.00) (p=.03) (p=.82)		
	$y = 76.8 + 0.60W + 22.3z$ (p=.00) (p=.00) (p=.00)	$y = 99.1 + 0.60W$	$y = 76.8 + 0.60W$
3	$y = 74.4 + 0.87W + 1.56z + 5.54\ E^{-02}zW$ (p=.00) (p=.00) (p=.71) (p=.33)		
	$y = 75.2 + 0.90W$ (p=.00) (p=.00)	$y = 75.2 + 0.90W$	$y = 75.2 + 0.90W$

4	$y = 53.3 + 0.68W + 12.37z + 3.33\ E^{-03}zW$ (p=.00) (p=.00) (p=.079) (p=.96)		
	$y = 53.1 + 0.68W + 12.7z$ (p=.00) (p=.00) (p=.00)	$y = 65.8 + 0.68W$	$y = 53.1 + 0.68W$
5	$y = 34.4 + 0.94W + 53.7z - 0.32zW$ (p=.01) (p=.00) (p=.007) (p=.039)	$y = 88.1 + 0.62W$	$y = 34.4 + 0.94W$
6	$y = 35.2 + 0.82W + 8.23z + 0.13zW$ (p=.159) (p=.04) (p=.75) (p=.65)		
	$y = 39.5 + 0.88W$ (p=.17) (p=.03)	$y = 39.5 + 0.88W$	$y = 39.5 + 0.88W$
7	$y = 65.8 + 0.52W + 4.83z + 5.60\ E^{-02}zW$ (p=.00) (p=.00) (p=.15) (p=.083)		
	$y = 68.3 + 0.50W + 9.89\ E^{-02}zW$ (p=.00) (p=.00) (p=.00)	$y = 68.3 + 0.60W$	$y = 68.3 + 0.50W$

8	$y = 62.2 + 0.49W + 14.07z - 0.13zW$ (p=.00) (p=.00) (p=.00) (p=.00)	$y = 76.27 + 0.36W$	$y = 62.2 + 0.49W$
9	$y = 67.8 + 0.48W - 3.94z + 6.40\ E^{-02}zW$ (p=.00) (p=.00) (p=.57) (p=.45)		
	$y = 65.8 + 0.51W$ (p=.00) (p=.00)	$y = 65.8 + 0.51W$	$y = 65.8 + 0.51W$
All Subjects	$y = 71.5 + 0.51W + 12.59z - 1.23\ E^{-02}zW$ (p=.00) (p=.00) (p=.30) (p=.92)		
	$y = 77.8 + 0.50W$ (p=.00) (p=.00)	$y = 77.8 + 0.50W$	$y = 77.8 + 0.50W$

Z = 1 for the cycle group, Z = 0 for the treadmill group. Y is Heart Rate (HR) (bpm). Two equations are shown for each measurement. The least significant variables/ interactions were then removed stepwise until all variables which were not significant ($p < .05$) had been removed (second equation).

Appendix D.

3. Predicted Oxygen Consumption (VO_2, L/min) during Pump It aerobics using Derived Regression equations.

Subject Number	Derived Regression Equation	Exercise	Predicted VO_2 (Cycle) (L/min)	Predicted VO_2 (TR) (L/min)	Actual VO_2 (Pump It) (L/min)
1	$y = 0.0177HR - 0.8506$	Squats	1.11	1.11	1.22
		Upright Rows	0.94	0.94	0.71
		Bench Press	0.56	0.56	0.46
2	$y = 1.19E^{-02}HR - 4.2\ E^{-03}HRz - 5.75\ E^{-02}z + 9.37\ E^{-02}z^2 - 1.21$	Squats	0.51	0.90	1.19
		Upright Rows	0.43	0.76	0.59
		Bench Press	0.21	0.42	0.44
3	$y = 1.4\ E^{-02}HR + 1.16$	Squats	0.85	0.85	1.09
		Upright Rows	0.84	0.84	0.49
		Bench Press	0.20	0.21	0.40

Subject Number	Derived Regression Equation	Exercise	Predicted VO_2 (Cycle) (L/min)	Predicted VO_2 (TR) (L/min)	Actual VO_2 (Pump It) (L/min)
4	$y = 1.96\ E^{-02}HR - 3.9\ E^{-03}HRz - 0.175z + 4.95\ E^{-02}z^2 - 0.929$	Squats	1.18	1.34	0.97
		Upright Rows	1.00	1.13	0.50
		Bench Press	0.58	0.60	0.35
5	$y = \frac{(1.08E^{-02}HR - 0.37 - 0.58z)}{(0.94 - 0.32z)} + 0.1 + 0.3z$	Squats	0.90	1.05	1.01
		Upright Rows	0.60	0.85	0.55
		Bench Press	0.21	0.59	0.39
6	$y = 1.34\ E^{-02}HR - 2.31\ E^{-03}HRz + 0.26z - 0.33$	Squats	1.40	1.44	1.03
		Upright Rows	1.13	1.12	0.53
		Bench Press	0.80	0.72	0.35

Appendix D.3. Derived Regression Equations, Oxygen Consumption During 'Pump It'

Subject Number	Derived Regression Equation	Exercise	Predicted VO_2 (Cycle) (L/min)	Predicted VO_2 (TR) (L/min)	Actual VO_2 (Pump It) (L/min)
7	$y = \frac{(1.04 E^{-02}HR - 0.71)}{(0.50 + 9.89 E^{-02}z)} + 0.34$	Squats	1.13	1.29	0.99
		Upright Rows	1.12	1.27	0.45
		Bench Press	0.63	0.69	0.34
8	$y = \left(\frac{1.01 E^{-02}HR - 62.2 - 0.14z}{(0.49 - 0.13z)} \right) + 0.15 + 7.67 E^{-02}z$	Squats	1.14	1.11	1.06
		Upright Rows	0.81	0.87	0.44
		Bench Press	0.16	0.39	0.33
9	$y = 1.98 E^{-02}HR + 7.67 E^{-02} - 1.45$	Squats	1.28	1.20	0.93
		Upright Rows	1.24	1.16	0.41
		Bench Press	0.67	0.60	0.35

Appendix D.3. Derived Regression Equations, Oxygen Consumption During 'Pump It'

All Subjects	$y = 2.2\,E^{-02}HR - 1.57$	Squats	1.05	1.05	1.05*
		Upright Rows	0.83	0.83	0.52*
		Bench Press	0.21	0.21	0.38*

* values are averages of VO_2 for Subjects 1 – 9.
Equations for VO_2 are derived from multiple regression equations given in Appendix E1 (tables 1 and 2). Z = 1 for the cycle group, Z = 0 for the treadmill group.

Appendix D.3. Derived Regression Equations, Oxygen Consumption During 'Pump It'

Appendix D.

4. Summary Table for Correlations, Experiment 1

Predicted VO_2 (L/min) vs Actual VO_2 (L/min)

Exercise	Groups	Correlation	Sig. (2-tailed)	N
Upright Rows	Tr + P	-.425	.254	9
Upright Rows	C + P	-.406	.279	9
Bench Press	Tr + P	-.320	.401	9
Bench Press	C + P	-.289	.450	9
Squats	Tr + P	-.557	.120	9
Squats	C + P	-.561	.116	9

Note: Tr = Treadmill, C = Cycle, P = Pump It

Appendix D.4. Summary Table of Correlations, Predicted VO_2 vs Actual VO_2

Appendix D.
5. Graphs Experiment 1.

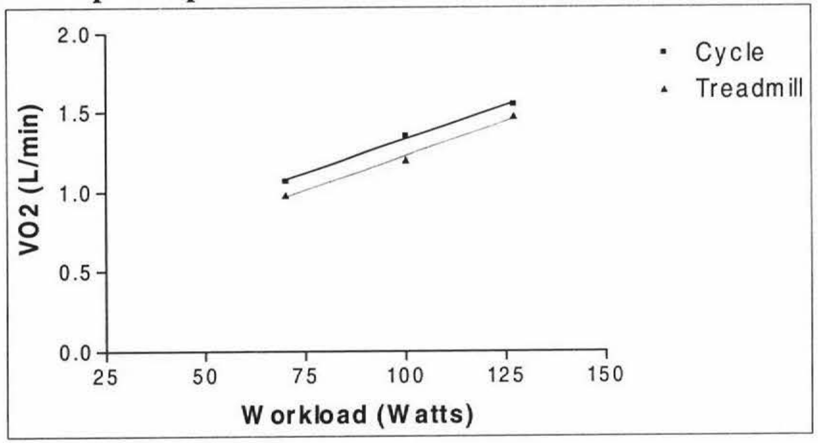


Figure 1. Workload vs VO2 for subject 1.

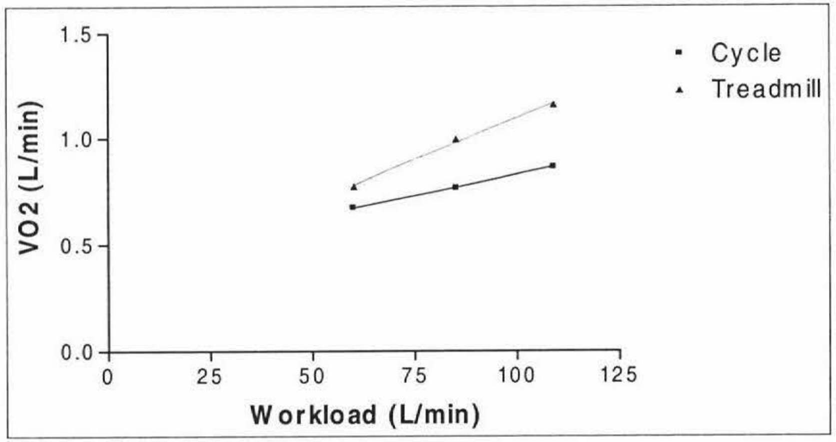


Figure 2. Workload vs VO2 for subject 2.

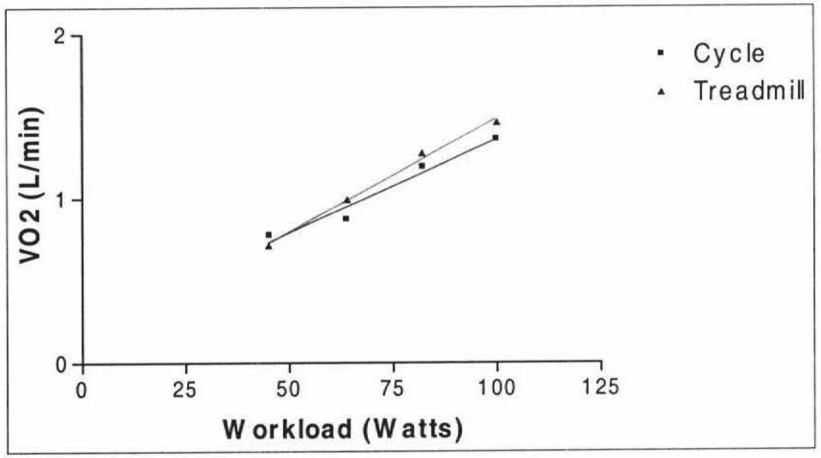


Figure 3. Workload vs VO2 for subject 3.

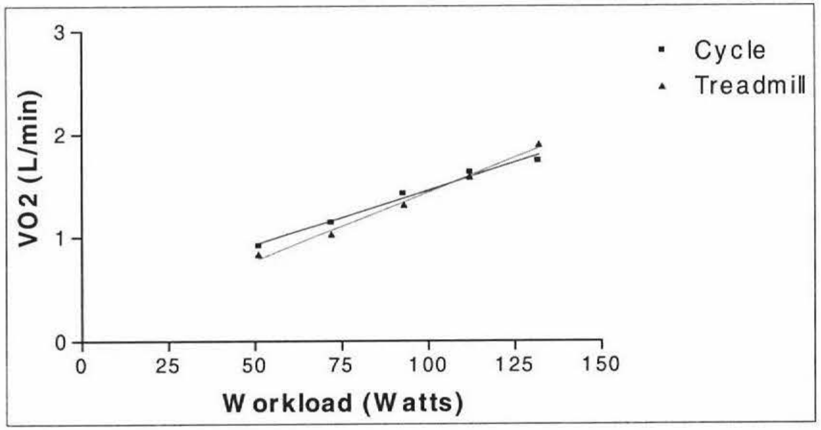


Figure 4. Workload vs VO2 for subject 4.

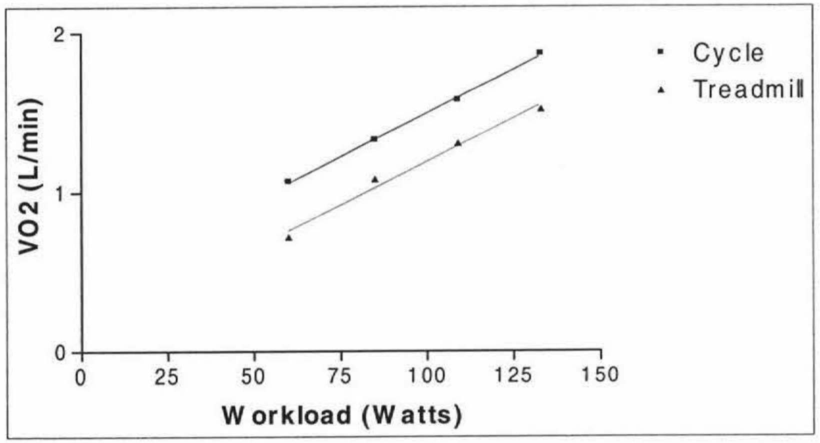


Figure 5. Workload vs VO2 for subject 5.

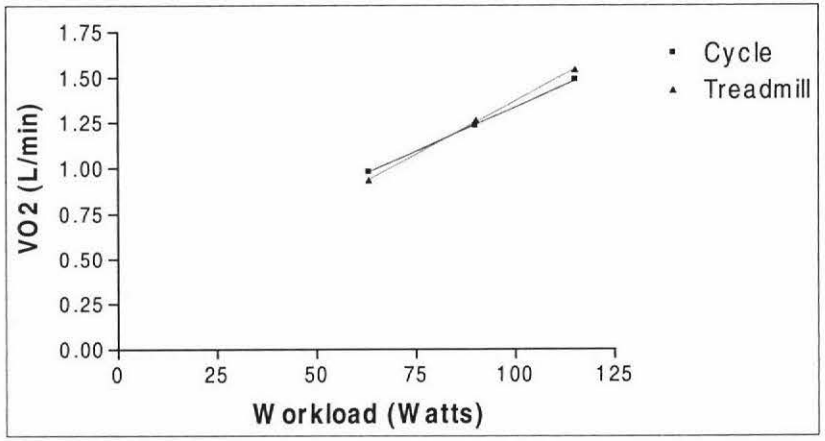


Figure 6. Workload vs VO2 for subject 6.

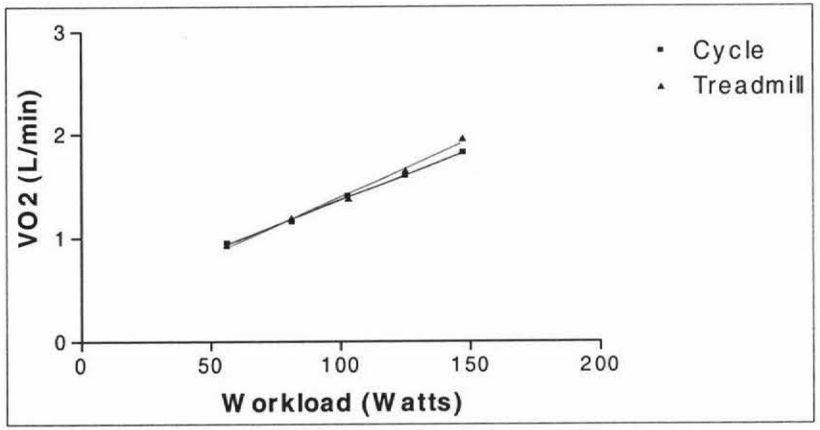


Figure 7. Workload vs VO2 for subject 7.

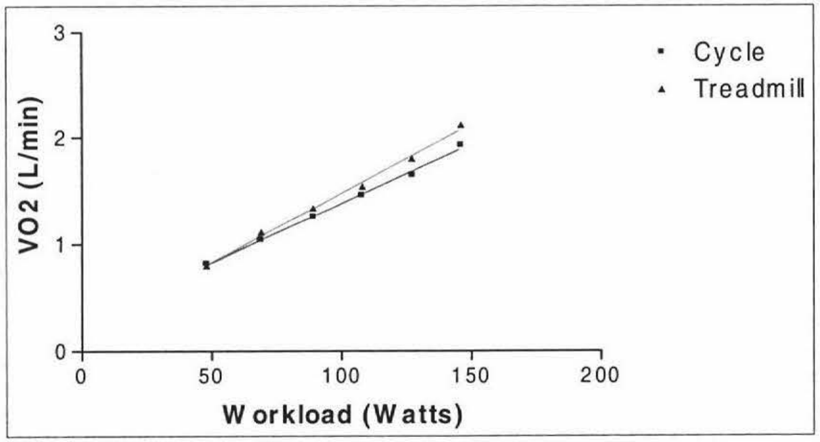


Figure 8. Workload vs VO2 for subject 8.

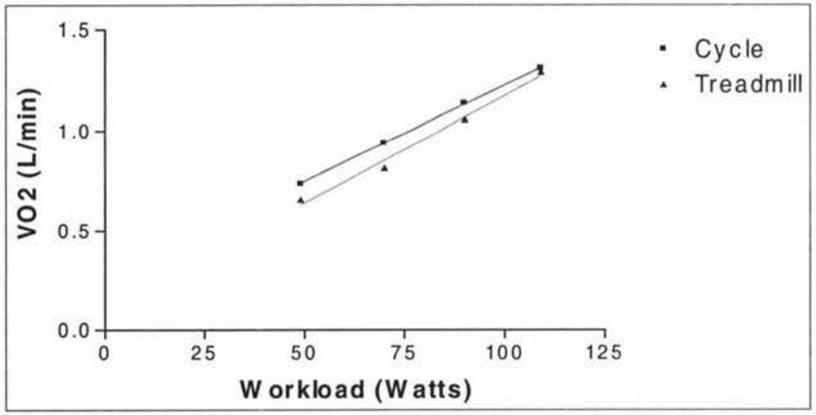


Figure 9. Workload vs VO2 for subject 9

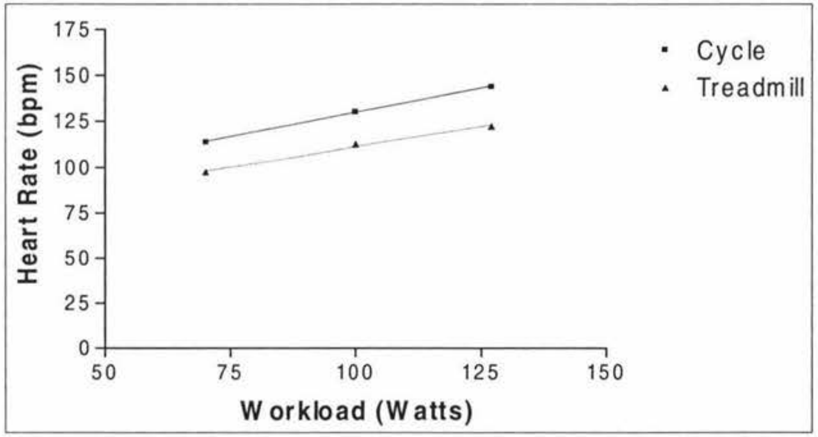


Figure 10. Heart rate vs workload for subject 1.

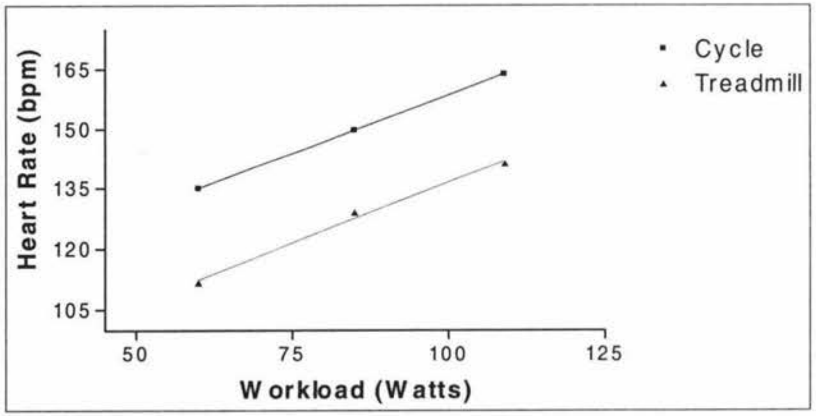


Figure 11. Heart rate vs workload for subject 2.

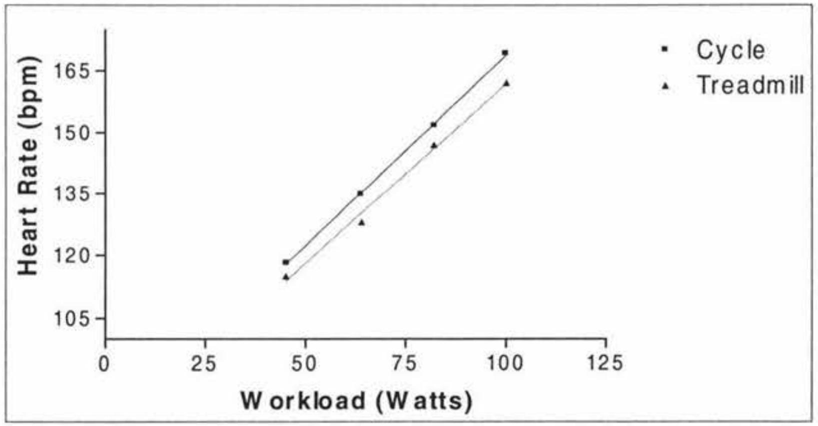


Figure 12. Heart rate vs workload for subject 3.

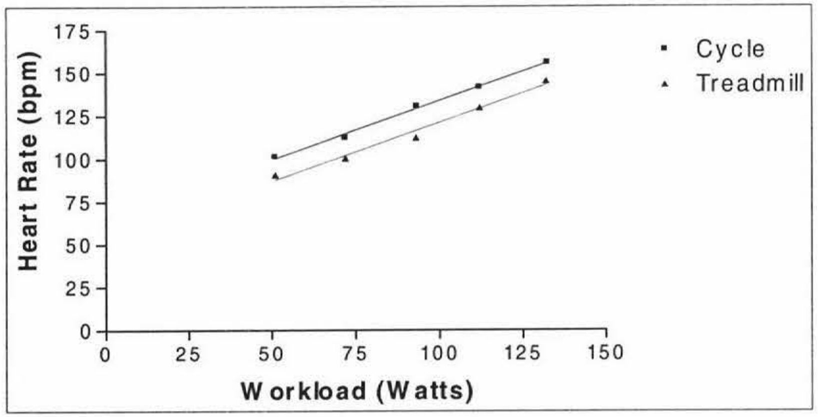


Figure 13. Heart rate vs workload for subject 4.

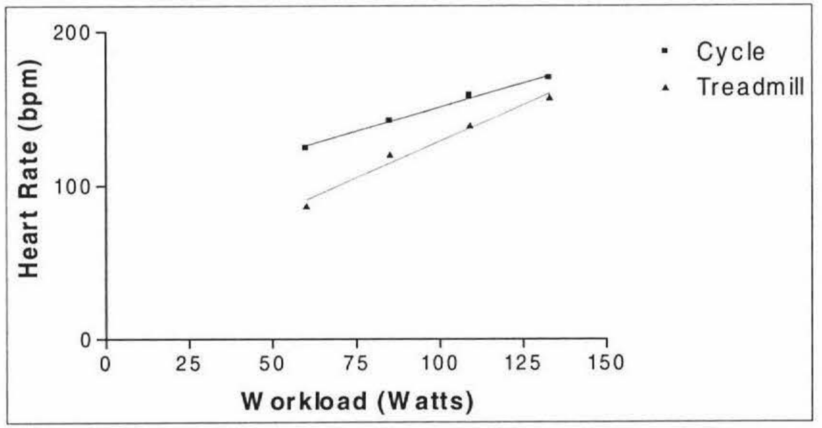


Figure 14. Heart rate vs workload for subject 5.

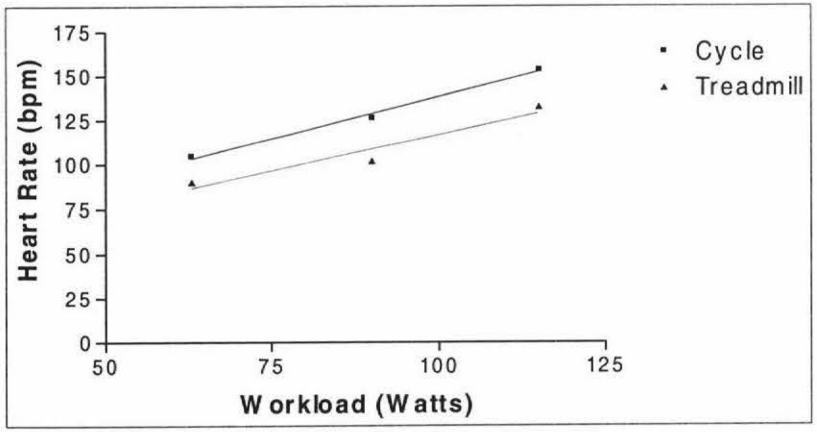


Figure 15. Heart rate vs workload for subject 6.

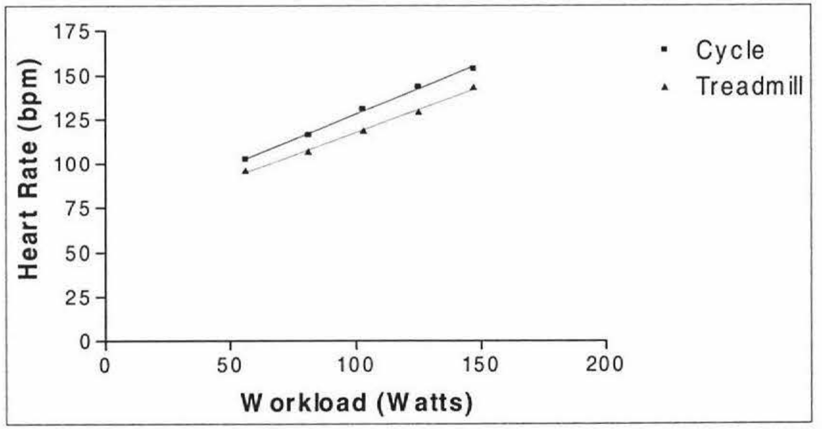


Figure 16. Heart rate vs workload for subject 7.

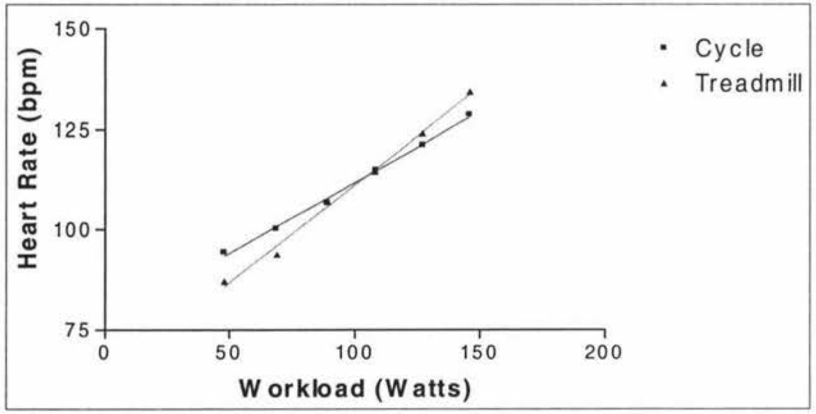


Figure 17. Heart rate vs workload for subject 8.

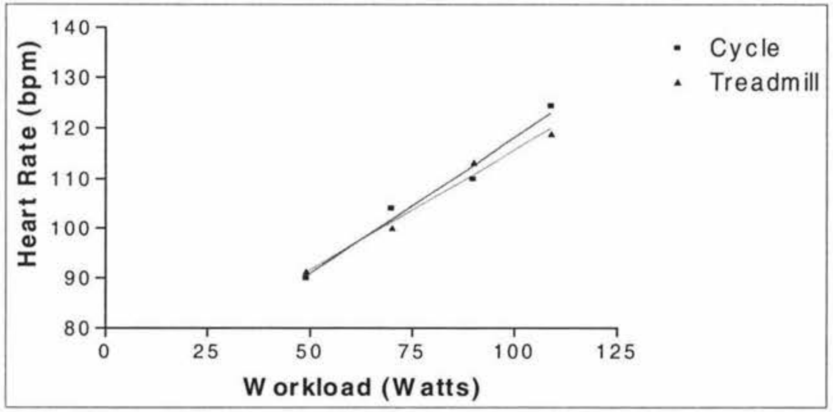


Figure 18. Heart rate vs workload for subject 9.

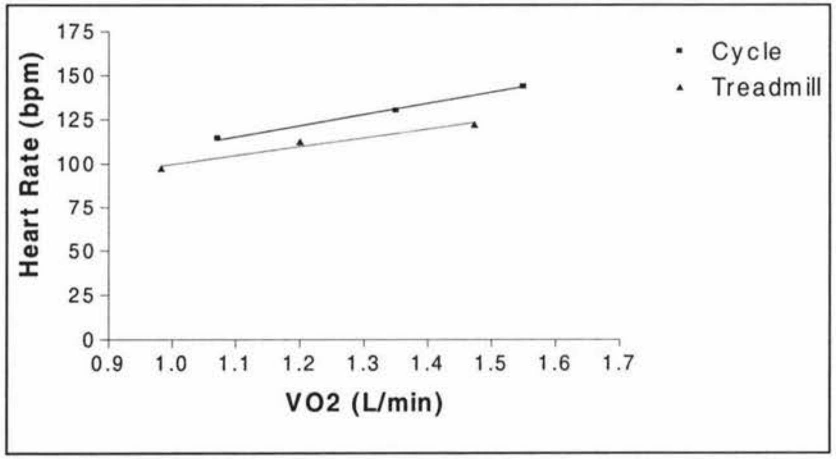


Figure 19. HR vs VO_2 for Subject 1.

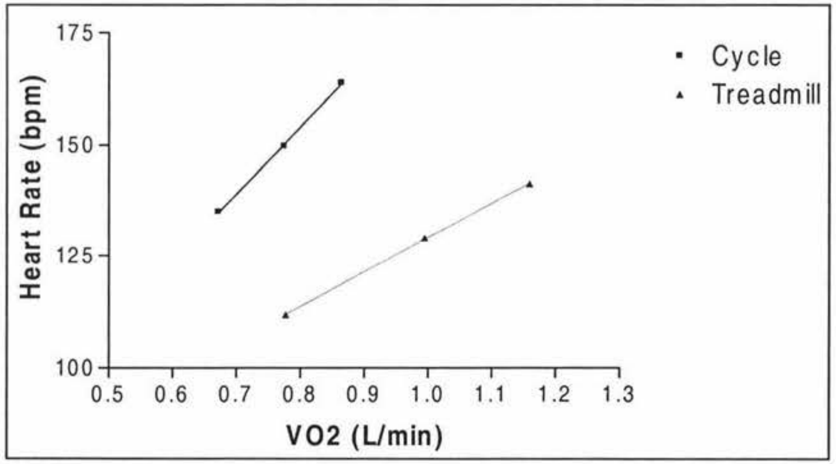


Figure 20. HR vs VO_2 subject 2.

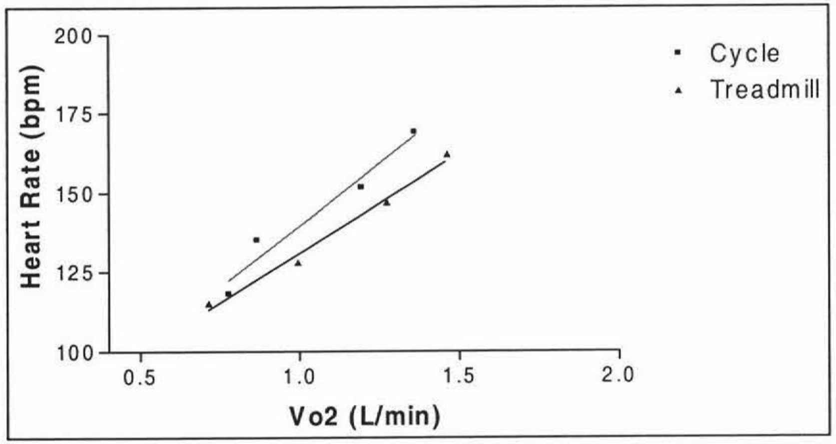


Figure 21. HR vs VO_2 for Subject 3.

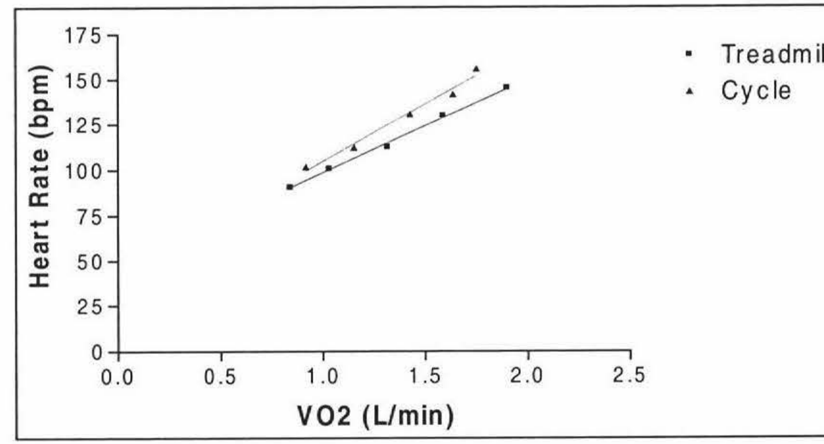


Figure 22. HR vs VO_2 for Subject 4.

Appendix E4. Continued

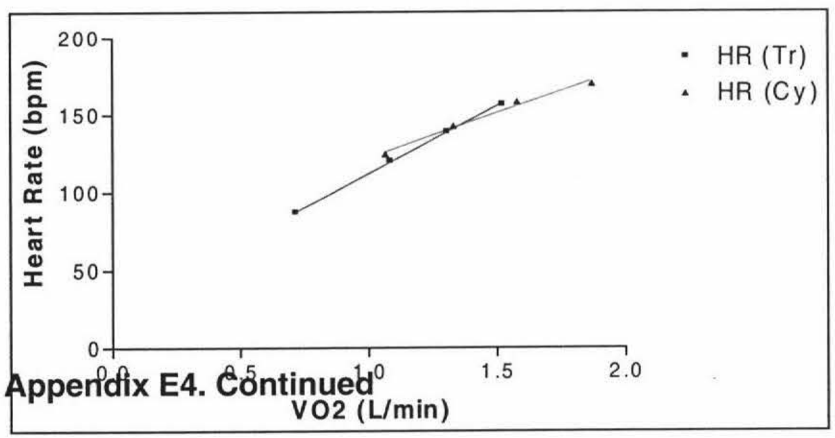


Figure 23. HR vs VO_2 for Subject 5.

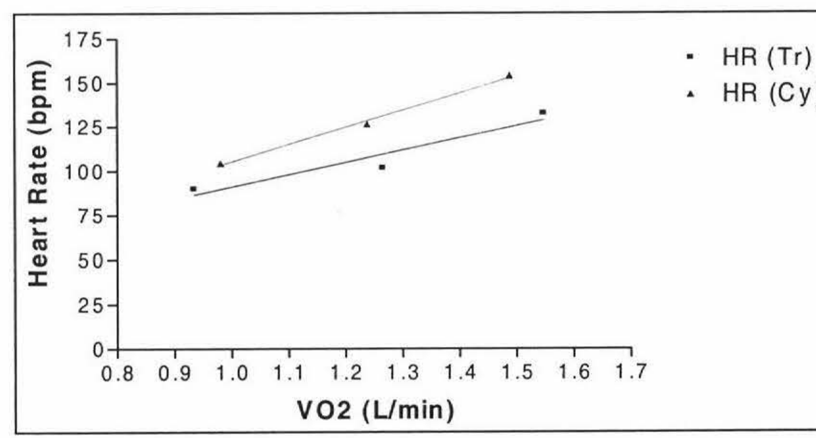


Figure 24. HR vs VO2 for Subject 6

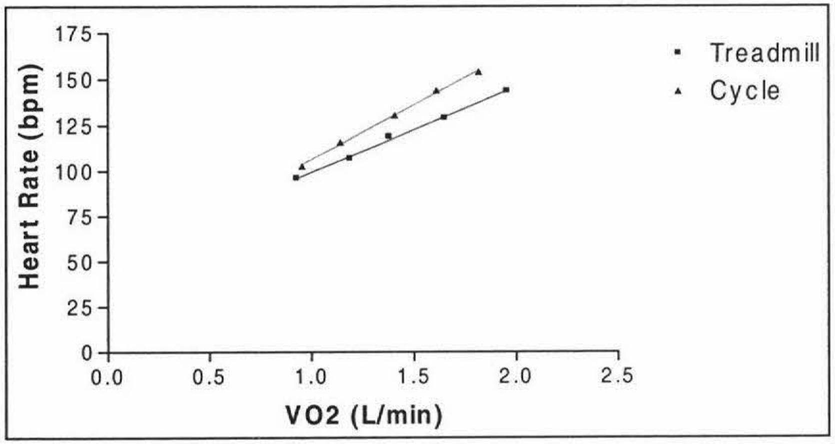


Figure 25. HR vs VO_2 for Subject 7.

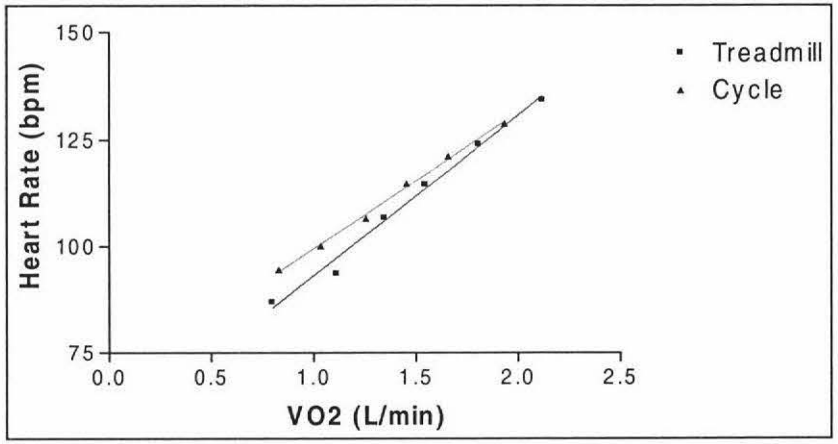


Figure 26. HR vs VO_2 for Subject 8.

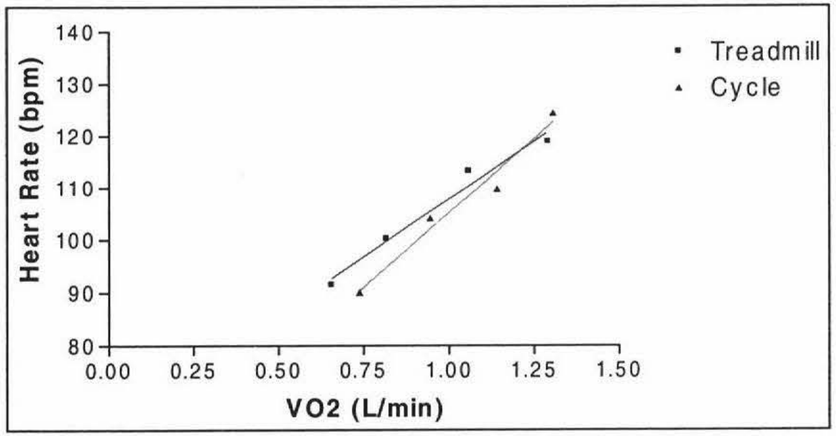


Figure 27. HR vs VO_2 for Subject 9.