THE EFFECTS OF A 12 WEEK GROUP EXERCISE PROGRAMME ON PHYSIOLOGICAL AND PSYCHOLOGICAL VARIABLES AND FUNCTION IN OVERWEIGHT WOMEN AGED 55-70 YEARS

KERRI TODD

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University of Glasgow

TABLE OF CONTENTS

Page

Page

Page

LIST OF TABLES

LIST OF FIGURES

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ABSTRACT

Objectives: The aim of this study was to investigate the effect of a 12 week class-based exercise programme on overweight women aged 55-70 years.

Methods: Twenty six subjects (n=13 exercisers, n=13 controls) age (mean $\pm$s.d.) 63 ($\pm$4) years completed the study. The exercise sessions were carried out twice per week for 12 weeks. The variables measured were body mass, body mass index (BMI), skinfold thickness, resting blood pressure, total blood cholesterol, chair rise, timed 'Up and Go' Test, 20 Metre Walk, lifting a 1kg and 2kg bag onto a shelf, stair walking, sit and reach flexibility test and Life Satisfaction. The exercise sessions consisted of 40 minute sessions during which the subjects performed aerobic, strength and flexibility exercises.

Results: Paired analyses showed that the exercise group decreased significantly for body mass, BMI, blood pressure (systolic and diastolic values), "up & go" time, time to complete a 20M walk, time to lift a 1kg bag with the right arm onto a shelf and a 2kg bag with both the right and left arms, stair climbing (total time and ascent time). The exercise group significantly improved their Life Satisfaction Index score compared with the control group.

Conclusions: The results indicate that a class-based exercise programme has the potential to improve performance in a number of physiological variables and functional activities in overweight women. The exercise programme enhanced life satisfaction.

CHAPTER 1

INTRODUCTION

The prevalence of obesity continues to cause concern in the Western world. Scottish levels of overweight and obesity are also continuing to rise. In the 55-64 year age group, nearly 70% of the Scottish female population can be classed as overweight (body mass index$\geq$25) with over 25% being defined as obese (BMI$\geq$30) (Scottish Health Survey, 1995).

Many chronic diseases are associated with increased body weight. Overweight people are twice as likely as those with normal BMI to suffer a major coronary heart disease event, and the mortality rate from all causes rises steeply when the BMI is over 30 (Little and Margetts, 1996). Obesity is associated with increased morbidity from musculoskeletal, psychosocial and medical conditions such as hypertension (Hseuh and Buchanan, 1994), diabetes (Helmrich et al, 1994) and heart disease (Bittner, 1994). However, obesity is considered to be one of the potentially easily preventable health risk factors in primary care (Little and Margetts, 1996), although research in this area of primary care is lacking.

Exercise has been shown to be helpful during weight reduction as it increases energy output and reduces the weight lost as fat free mass (Schaberg-Lorei et al, 1990; Svendsen et al, 1993) as well as providing psychological benefits (Fox, 1999; Goldwater and Collis, 1985). Exercise has also been shown to help maintain weight loss (Zelasko, 1995).

The Allied Dunbar National Fitness Survey (ADNFS) (1992) found that as age increases, physical activity decreases. Additionally, in recent years Blair and colleagues have established a positive link between regular physical activity and health (Blair et al, 1989; Blair et al, 1996). Lower activity levels have been found to correspond to a higher BMI. King et al (1992) reported that overweight and obese persons were less likely to be physically active, regardless of the type of activity. Being physically active during leisure time also plays an important role in the reduction of cardiovascular disease risk factors in the general population (Helmert et al, 1994).

The natural loss in functional capacity due to ageing from middle to later years is exacerbated by physical inactivity. It has been reported that 50% of what is currently noted as ageing is now considered to be hypokinesia, more commonly termed a disease of "disuse" (O'Brien and Vertinskey, 1991). When lower thresholds of functional capacity are reached, quality of life can be adversely affected (Bassey et al, 1988; Skelton et al, 1994).

Social class also influences BMI. This relationship is generally more pronounced in women than men. Overweight and obese women are more likely to be of a lower socio-economic status, i.e. social classes III (manual), IV or V (Gregory et al, 1990; Scottish Health Survey, 1995). Additionally, research by Greater Glasgow Health Board (1984) demonstrated a health divide between affluent and underprivileged areas of Glasgow in a range of variables including death rates and those who cannot work due to being "permanently sick".

Primary care teams have an important role to play in promoting diet and exercise in the management of obesity as well as other chronic diseases (Little and Margetts, 1996). However, despite the large numbers of studies investigating the efficacy of diet and exercise in weight loss programmes, very few have taken place within the general practice setting. As a result, there remains a dearth of information regarding the feasibility and efficacy of the management of obesity through diet and exercise in primary care.

The present study recruited subjects from a general practice in Shettleston Health Centre, which is located in the east end of Glasgow. Shettleston is classed as an area of social deprivation and was recently placed bottom of the UK parliamentary constituencies for health status (Shaw et al, 1999). The majority of patients in the practice receive income support payments. The Health Centre runs a Weight Reduction Clinic which is mainly attended by females and is a population which has been identified by the practice general practitioners as having a poor quality of life due to reduced functional capacity caused by their weight. The problem exists of introducing this population to a level of exercise that will be palatable for the subjects and still promote a physiological benefit.

Therefore, the aim of this study is to asses the efficacy and acceptability of a class-based exercise programme and/or weight reduction on functional status, physiological variables and psychological measurements in overweight and obese females aged 55-70 years.

CHAPTER 2

REVIEW OF LITERATURE

DEFINITION OF OBESITY

Obesity can be defined as an increased amount of adiposity (Hseuh and Buchanan, 1994; Sjostrom, 1993), while overweight is considered to be an increased body weight in relation to height (Sjostrom, 1993). Garrow (1988) states that the aetiology of obesity is complex with "genetic, social, cultural and psychological factors" all playing a role.

Body Mass Index (BMI), or Quetelet Index, is universally accepted as an indirect measure of obesity (James, 1976). It is calculated by dividing an individual's weight in kilograms by the square of their height in metres. Categories of BMI are defined in Table 1.

Table 1: Categories of BMI (Ref: SIGN Guidelines, 1996)

BMI (kg/m^2)	Category
<18.5	Underweight
18.5-24.9	Normal
25.0-29.9	Overweight
30.0-39.9	Obesity
$\geq$40	Extreme Obesity

PREVALENCE OF OBESITY

Region

The prevalence of obesity has been shown to vary markedly by region within Scotland (SIGN Guidelines, 1996), and across the UK as a whole (Gregory et al, 1990). At a national level, 12% of women and 8% of men aged 16-64 years were classed as obese (i.e. BMI$\geq$30). In Scotland, 17% of women were categorised as obese with 32% classed as overweight (SIGN Guidelines, 1996). Data published by Greater Glasgow Health Board (GGHB) in 1995 showed that 21% of women aged 18-60 years were classified as overweight and 9 % as obese, which is slightly better than the UK average (cited in SIGN Guidelines, 1996).

The most detailed information regarding the prevalence of obesity in Europe resulted from a study conducted by the World Health Organisation (Seidell, 1995) which collected data between 1983 and 1986 from 38 European centres. Of the centres studied, only three had less than 10% of the population which could be classified as obese (BMI$\geq$30). The average BMI (kg/m^2) 90th percentile was 31 for men and 33 for females. Interestingly, considering the large cultural and socio-economic differences between the countries included in the study, the distribution of BMI values seemed rather homogeneous over Europe. The authors concluded that many factors could be associated with overweight:

- demographic (age, gender, ethnicity)
- socio-cultural (education, income, marital status)
- biological (parity)
- behavioural (nutrition, smoking, alcohol, physical activity)

The prevalence of obesity is higher in the USA, where approximately two fifths of the adult population have been classed as obese (Tanaka and Nakanishi, 1996). Figures from New Zealand (Simmons et al, 1996) showed that the age standardised mean BMI for adults aged 35-64 years was 26.4 for males, and 25.1 for females. From these figures, it can be seen that the incidence of obesity in Scotland, while not quite as high as US norms, is comparable with that of other Western countries.

Increase in prevalence

The prevalence of obesity and overweight has been shown to be increasing in developed countries despite the numerous initiatives aimed at reducing the incidence of weight problems (Health of the Nation, 1992; Healthy 2000, cited in Tanaka and Nakanishi, 1996; Hillsdon and Thorogood, 1996; SIGN Guidelines, 1996). The Dietary and Nutritional Survey of British Adults (Gregory et al, 1990) observed a 4% increase in the prevalence of obesity in females from 8% in 1980 to 12% to 1990. There was a less marked increase of obesity in males with a rise from 6% to 8%.

A similar increase in the prevalence of obesity has been recorded in other Western countries (Galuska et al, 1996, Simmons et al, 1996). A multi-state telephone survey among US adults from 1987 to 1993 discovered that the age-adjusted prevalence of overweight (BMI≥27.8 for men and ≥27.3 for women) increased from 21.9% to 26.7% in men and 20.6% to 25.4% in women (Galuska et al, 1996). Additional analysis of the data revealed that the incidence of overweight had increased by 0.9% per year, and that there had been some acceleration of the rate of increase over time. The study also investigated the prevalence of "severe overweight" (BMI≥31.3 for men and ≥32.3 for women) in the same population and found an increase of 2.9% in men, taking the total to 9.4%, and 2.0% in women, resulting in a total of 7.9%. From the evidence, the authors concluded that the observed increase in prevalence of overweight reflected both an overall shift in distribution of weight in the population, and a tendency for overweight persons to be heavier.

The Third National Health and Nutrition Examination Survey (NHANES III) (Kuczmarski et al, 1994) found that there had been a dramatic increase in the prevalence of overweight (BMI≥27.8 for men and BMI≥27.3 for women) between NHANES II (1976-1980) and NHANES III (1988-1991). The largest increase in prevalence was recorded for white men and women at 8%. During this period, the mean BMI for men and women aged 20 to 74 years increased from 25.3 to 26.3. Mean weight also increased by approximately 3.6kg.

An explanation for the increase in obesity has been sought in New Zealand where Simmons and colleagues (1996) examined the increase in the prevalence of overweight and obesity (defined as BMI>25) from 1982 to 1993-4, to determine if the increase could be related to trends in smoking cessation and physical activity. The proportion of men who could be classified as overweight or obese were found to have risen from 52.8% to 64.2% while the number of women in the same category had also increased from 36.5% to 44.9%. Recent trends in smoking cessation could only account for 7% and 10% of the observed increase in BMI in men and women, respectively. Levels of physical activity could not explain the remainder of the increase. Thus, by exclusion, an increase in the total energy intake was offered as the most likely explanation for the observed trends.

A similar study by Galuska et al (1996) investigated possible explanations for the increase in obesity in US adults. Just over 3% of the increase in the prevalence of overweight could be explained by smoking cessation, however there was a concomitant increase in the level of leisure time physical activity which left 2% of the increase in the prevalence of overweight unaccounted for.

Specific targets have been published both in this country and in the USA (Health of the Nation, 1992; Promoting Health/Preventing Disease, cited in Casperson et al, 1986) aiming to reduce the prevalence of obesity. The UK target (Health of the Nation, 1992) is to reduce the proportion of obese adults to 7% or less by the year 2005. Bearing in mind that the prevalence of obesity steadily increased from 1980-1990 (Gregory et al, 1990); this will be a difficult target to meet. The American government have aimed to reduce the prevalence of obesity to no more than 20% of the adult population by the year 2000 (Healthy 2000, cited in Tanaka and Nakanishi, 1996). However, US officials face a similar problem to that encountered in the UK as evidenced by the findings of Galuska and colleagues (1996) detailed above showing an increase in the prevalence of obesity.

Age

The prevalence of obesity and overweight tends to increase with age in women, regardless of region, up to the age of 60 years, approximately. In the GGHB area, 29% of women aged 51-60 years were found to be overweight compared with only 11% of women aged 18-23 years. Similarly, 14% of women aged 51-60 years were obese while only 3% of females aged 18-23 years had a BMI$\geq$30 (SIGN Guidelines, 1996).

The results from the NHANES III data (Kuczmarski et al, 1994) showed that BMI increased in women from the age of 20-59 years and then slightly decreased. The prevalence of overweight females aged 50-59 years was 52% (mean BMI 28.5) decreasing to 42% for those aged 60-69 years (mean BMI 27.3). It is worth noting that although BMI began to decrease in this population from age 60 years, there was still a large proportion of the female population who were overweight (defined as BMI$\geq$27.3) and, hence, at increased risk of a number of medical conditions, e.g.

hypertension, non insulin dependent diabetes and cardiovascular disease (Bittner, 1994; Helmrich et al, 1994; Hseuh and Buchanan, 1994; Little and Margets, 1996).

Similar trends were observed in the Fels Longitudinal Study (Guo et al, 1999) in which 102 males and 108 females underwent biennial measures of a range of anthropometric and body composition variables, including weight, height and percent body fat. The mean period of follow up was 9 years (range 1-20 years). Women recorded their peak BMI at age 56 years, with a slight decrease thereafter.

Hamilton and colleagues (2000) reviewed the pattern of body weight changes for women over their lifetime and observed that cross sectional studies showed an increase in overweight from age 20-60 years with a slight decrease after this age, similar to that observed above. Longitudinal data suggested that body weight increased till age 65 years before a decrease was noted.

What is widely accepted is that the observed decrease in body weight occurring in females from age 55-65 years, is a result of a loss of fat free mass as opposed to any decrease in fat mass (Guo et al, 1999; Hamilton et al, 2000; Poehlman and Tchernof, 1998; Simkin-Silverman and Wing, 2000; Svendsen et al, 1995). In actual fact, research shows that fat mass increases in females at this time, especially in certain regions of the body.

MENOPAUSE AND CHANGES IN BODY COMPOSITION

Menopause is associated with a decrease in fat free mass (FFM) (Guo et al, 1999; Dionne et al, 2000; Hamilton et al, 2000; Svendsen et al, 1995) and an increase in central and upper body fat mass (FM) (Guo et al, 1999; Poehlman and Tchernof, 1998; Simkin-Silverman and Wing, 2000; Svendsen et al, 1995).

Several studies have demonstrated that age matched premenopausal females have significantly less total body fat, percent body fat and percent abdominal fat than postmenopausal females (Guo et al, 1999; Svendsen et al, 1995).

As part of the Fels Longitudinal Study, Guo et al (1999) compared the body composition measurements of age matched pre- and postmenopausal females. At the same age, postmenopausal women had significantly higher total body fat and percent body fat values than premenopausal women. The investigators also found that the longer the time since menopause, the greater the loss of FFM. Additionally, low levels of physical activity and oestrogen concentration were considered to be major risk factors for increased levels of body fat and decreased levels of FFM in postmenopausal women.

Svendsen and colleagues (1995) measured the body composition and fat distribution of 407 healthy females, aged 18-75 years by dual-energy x-ray absorptiometry. Comparison of females in the same decade (40-49 years) found that postmenopausal women had a significantly higher total body fat and percent abdominal fat than premenopausal females. The same study found that abdominal to total body fat tissue ratio increased with age and the number of years since menopause.

Svendsen et al also compared pre and postmenopausal females for changes in lean tissue mass (LTM). There was an inverse relationship between LTM and age, with the most pronounced decrease in LTM from 40-50 years. Comparison between groups found postmenopausal females had significantly less LTM when compared with age matched premenopausal females.

A similar study was carried out by Wang et al (1994) who measured the total and regional body composition variables in 373 early postmenopausal women, aged 40-60 years, by dual-energy x-ray absorptiometry. The study aimed to investigate whether the changes in body composition, noted around the time of the menopause, were a result of menopause, or merely due to the ageing process. Patterns of change in body fat mass were similar to those noted in the studies mentioned above, and the authors concluded that the observed increase in FM was correlated with ageing, but not menopause. However, the observed decrease in FFM was found to be mainly menopause-related.

An important consequence of the decrease of FFM associated with menopause is its effect on resting metabolic rate (RMR). Poehlman and Tchernof (1998) reviewed the available data regarding changes in energy expenditure and body composition around the time of the menopause and found that RMR is regarded as the main determinant of total daily energy expenditure as it is composed of metabolically active tissue, such as skeletal muscle (Walberg, 1989). The authors concluded from previous studies that RMR may be decreased by the menopause itself, over and above the accepted age related decrease. Poehlman and Tchernof suggested that this additional decrease may be due to the loss of FFM which occurs during the menopause.

There is a close association between menopausal changes in body composition and a decrease in physical activity (Astrup, 1999; Dionne et al, 2000; Guo et al, 1999; Hamilton et al, 2000; Simkin-Silverman and Wing, 2000). The longitudinal data collected by Guo et al (1999) found that physical activity had a protective effect in maintaining FFM. High levels of physical activity were shown to be associated with higher levels of FFM, by approximately 3.55kg, and lower levels of total body fat. Interestingly, the differences in FFM between females who recorded medium and high levels of physical activity were small.

ASSOCIATION OF OBESITY WITH MORTALITY

The relationship between mortality and BMI is regarded to be J- or U-shaped, and above average mortality rates appear at approximately BMI≥28 (Sjostrom, 1993) and continue in a linear fashion thereafter.

Lew and Garfinkel (1979) investigated the variations in mortality by weight in a prospective study of 750 000 US men and women drawn from the general population and free from established disease at baseline. Mortality causes were grouped into five broad categories: coronary heart disease (CHD), cancer (all sites), diabetes, digestive diseases, and cerebrovascular disease (CVD). The lowest mortality was found among males who were close to average weight and females who were 10-20% below average weight. With an increase in weight, mortality ratio increased progressively through the weight indexes reaching nearly 50% in both males and females 30-40% higher than average weight and nearly 90% for males and females ≥40% above average weight. A major factor in the observed increase in mortality rate was due to the increase in mortality from CHD. Those in the highest weight category had double the mortality rate compared with males and females of average weight.

Shaper and colleagues (1997) published a prospective study of 7735 British men aged 40-59 years who were followed over an average of 14.8 years to determine the BMI associated with the lowest morbidity and mortality. They found that all cause mortality was increased only in men with a BMI <20 and in those men with a BMI≥30. BMI 30-40 has previously been shown to carry a threefold increase in risk of mortality at age 45 years over someone of a desirable weight (BMI 20-25), while a BMI over 40 increased mortality 12-fold in those aged 25-35 years (West, 1994).

Manson et al (1990) followed middle-aged women for 8 years to examine the incidence of fatal and non-fatal coronary heart disease. The authors reported that for increasing levels of BMI (adjusted for age and smoking) the relative risk of combined non-fatal myocardial infarction and fatal coronary heart disease among middle-aged women increased more than threefold when subjects in the highest BMI quintile (>29) were compared with those in the lowest quintile (<21). Relative risk (RR) was elevated with increasing BMI. Women categorised as mildly and moderately overweight (BMI 25-28.9) had a risk of coronary artery disease 80% higher than their lean counterparts (BMI<21). 70% of coronary events in the highest BMI quintile (and 40% overall) could be attributed to adiposity and, therefore, were deemed by the authors as being preventable.

From a public health perspective, James (1995) considered the dominant effect of weight gain on cardiovascular mortality as being the result of its effects in promoting a rise in blood pressure and an increase in the ratio of low to high density cholesterol levels. Therefore, while from a patient's viewpoint, the individual responses are important, it is the underlying effects of weight gain with age which accentuate the risks of hypertension and hypercholesterolaemia in the larger scale.

Some researchers feel that, with the increasing emphasis placed on quality, as opposed to quantity, of life, mortality may not be the most appropriate dependent variable when attempting to explain the effect of obesity on health outcome (VanItallie and Lew, 1995). While death is an unequivocal end point, it has been proposed that morbidity, or some measure of disability, would be a preferable option as the dependent variable. There are a number of reasons for this change of opinion concerning the recognition of the importance of quality of life, as well as the greater amount, and more easily obtainable, information on morbidity.

ASSOCIATION OF OBESITY WITH MORBIDITY

While Shaper and colleagues (1997) found no increased risk of all cause mortality in men with BMIs ranging from 20-30, there was a progressive increase in risk of cardiovascular death, heart attack and diabetes from BMI 20 (i.e. risk of disease increased linearly with BMI). This risk remained once the sample had been adjusted for age, smoking, physical activity, social class and alcohol consumption. These observations led the authors to conclude that a healthy BMI in middle-aged British men was around 22. However, it should be noted that although the risk of morbidity increased progressively from a BMI of 20, the risk of coronary heart disease and diabetes increased significantly at indexes of ≥24 and ≥26, respectively. A slight increase in risk of all cause morbidity was seen at a BMI of 24 and a significant risk was observed at BMI≥26.

Distribution of Adiposity

It has been well documented that the distribution of adipose tissue is important with regard to health risk. Central adiposity (adipose tissue located in the abdominal region) is accepted as being a better marker for several diseases than overall magnitude of obesity. These include coronary heart disease (Bittner, 1994) and diabetes mellitus (Manson and Spelsberg, 1994).

As outlined previously, even in the absence of weight gain, the menopause is associated with a redistribution of adiposity in females, leading to an increase in abdominal fatness (Astrup, 1999; Guo et al, 1999; Hamilton et al, 2000; Svendsen et al, 1995; Wang et al, 1994). However, Svendsen and colleagues (1995) demonstrated that, through diet and exercise, postmenopausal females can reduce their levels of abdominal adiposity.

Cardiac Risk Factors

Investigating the effects of modest weight loss on changes in cardiovascular risk factors, Wing and Jeffery (1995) found that those subjects who lost modest amounts of weight and then maintained their weight loss through an 18 month period, experienced improvements in cardiovascular risk factors. Men were shown to have greater improvements in blood lipid profile and systolic blood pressure compared with women. However, once the data were corrected for baseline level of the variable and changes in BMI, these differences were removed. Long term improvements were observed in triglycerides, high density lipoproteins (HDL) and ratio of low density lipoproteins to total cholesterol (LDL-cholesterol), waist-to-hip ratio, systolic and diastolic blood pressure, and fasting and 2h insulin. Therefore, while noting that the study population was relatively young (<45 years), only moderately overweight (30-70lb) and healthy except for the obesity, the authors concluded that overweight individuals should be encouraged to achieve and maintain weight losses of 10-15% of their initial weight to improve their cardiovascular risk factors.

Hypertension - The risk of hypertension appears to parallel the degree of obesity since higher levels of BMI have consistently been associated with higher blood pressures in both sexes (Gregory et al, 1990; Hseuh and Buchanan, 1994; Yeater and Ullrich, 1992). US data showed that 53% of obese individuals were hypertensive, compared with only 22% of non-obese hypertensives (cited in Yeater and Ullrich, 1992). Although the mechanisms linking obesity to hypertension have yet to be determined, it has been shown that caloric restriction and weight loss are associated with a reduction in blood pressure. Additionally, even modest weight loss (i.e. 10%) has been demonstrated to improve blood pressure (Hseuh and Buchanan, 1994).

Hyperlipidaemia - Serum total cholesterol has been shown to be elevated in British adults with increasing levels of BMI (Gregory et al, 1990). Indeed, apart from age, BMI was the main predictor of serum total cholesterol in this representative sample of the British adult population. The same survey also found that HDL cholesterol (HDL-C) tended to be lower in those of both sexes who had a higher BMI.

Weight loss has been shown to improve lipid profiles in females who were 20%-50% overweight on entrance to a weight reduction trial (Bittner, 1994). Greater improvements were found in those subjects with a higher waist-to-hip ratio at the onset of the study. Such females had a rise in HDL-C while their triglycerides were reduced to a greater degree.

A study by Hagan (1988) investigating the benefits of aerobic exercise and diet for overweight adults found that weight loss resulting from a regime of physical activity, a caloric intake of at least 1200kcal per day and behavioural modification techniques over the course of 12 weeks, produced a more favourable blood lipid and lipoprotein profile.

Non insulin dependant diabetes mellitus

After reviewing the available literature regarding obesity and non insulin dependant diabetes mellitus (NIDDM), Manson and Spelsberg (1994) concluded that "despite the important role of genetic factors, NIDDM should be regarded as a largely preventable disease". They identified four major modifiable determinants of NIDDM: obesity, body fat distribution, physical inactivity and dietary factors.

From the available data, Manson and Spelsberg (1994) estimated that the risk of NIDDM decreased by 50%-75% when a desirable body weight (BMI$\leq$22.4 in women, BMI$\leq$22.7 in men) was maintained as opposed to being obese (BMI$\geq$27.3 in women, BMI$\geq$27.8 in men).

Cross sectional studies have shown that individuals with higher BMI values are under a greater risk of developing NIDDM. Indeed the Nurses Health Study (Manson et al, 1990) suggested that at least 90% of NIDDM cases may be attributable to overweight (BMI>22, as defined by the authors). The authors found that the risk of NIDDM in the highest decile of BMI was more than 60 times higher than among those in the lowest decile.

A prospective cohort study of Pennsylvania alumni (Helmrich et al, 1994) showed that BMI was positively associated with the development of NIDDM in men. Those with BMI≥26 had a greater than threefold increase in the likelihood of developing NIDDM than those with BMI<24. However, a protective effect of physical activity was observed in the heaviest individuals. Those in the most physically active category had a similar risk of developing NIDDM regardless of BMI, a finding consistent with the improvement in glucose tolerance in obese subjects after physical training (Manson and Spelsberg, 1994). An improvement glucose tolerance was also observed in overweight, postmenopausal women who completed an eleven month exercise programme (Evans et al, 2001).

As long as energy intake is less than expenditure - and therefore as soon as an obese individual starts a weight reduction programme - the number of insulin receptors begins to return to normal, as do the responses of target cells to insulin (Vander et al, 1986).

Cancer

The American Cancer Society found that cancer mortality was significantly higher only among those 40% or more above average weight (Lew and Garfinkel, 1979). Additionally a stronger relationship was observed in females where the risk was raised by 55% for females and by one third for males. The main site for cancer in males was colon-rectum, although prostate was also a common site. There was a much greater range in sites affected in females: gall bladder and biliary passages, endometrium, uterus, cervical, ovary and breast.

Osteoarthritis

A review of studies on obesity and exercise by Pacy et al (1986) concluded that osteoarthritis was common in overweight individuals although prevalence was not correlated with the degree of obesity. Also, osteoarthritis in both non- and weight-bearing joints was found to be more common in heavier females when compared with other females of normal BMI. However, the same trend was not observed in males.

ASSOCIATION OF OBESITY WITH PHYSICAL INACTIVITY

A number of studies have reported the association of obesity with physical inactivity (Allied Dunbar National Fitness Survey, 1992; Behavioural Risk Factor Surveillance System, 1996; Helmert et al, 1994; King et al, 1992). The Allied Dunbar National Fitness Survey (ADNFS) (1992) examined the activity habits of a representative sample of British adults aged 16-64 years. The results of the survey showed that BMI was inversely related to levels of physical activity.

The available evidence has proved to be inconclusive regarding the questions of the activity levels of the overweight and obese. Epstein and Wing (1980) reviewed numerous studies investigating the activity levels of obese individuals compared with those of normal weight and found that, in general, activity levels differ between the two populations such that the thinner individuals demonstrated higher activity levels. The authors did note, however, that the influence of the extra weight on the activity levels of the subjects, and not vice versa, could not be discounted. Wood (1996) concluded from the available evidence that lean individuals were more active than overweight individuals. Additionally it was found that those who are lean consume more calories, but expend more energy, than their overweight counterparts. Conversely, Pacy and colleagues (1986) in a similar review felt that obesity was not associated with either reduced activity or energy expenditure in the development and maintenance of obesity, while admitting that the data were by no means conclusive.

The Behavioural Risk Factor Surveillance System (1996) found that over a third (37%) of overweight (BMI$\geq$27.8 in men and BMI$\geq$27.3 in women) US adults reported no leisure time physical activity (LTPA). The overweight sample consisted of 33% men and 41% women. When this sample was further investigated the authors noted that the level of LTPA was inversely related to age and level of overweight and positively associated with educational achievement. Additionally those overweight persons attempting to lose weight were 1.7 times more likely to be active than overweight persons who were not trying to reduce their body weight.

Several other studies have produced similar findings to that of the ADNFS (1992) (Helmert et al, 1994; King et al, 1992). King et al (1992) found that overweight and obese persons were less likely to be physically active regardless of the type of activity (even mild walking).

After adjusting for age and social class, Helmert and colleagues (1994) found that LTPA was significantly associated with lower systolic and diastolic blood pressure (both sexes), total cholesterol (males only) and BMI (females only), and with higher HDL-cholesterol (both sexes) in 15 385 West German adults aged 25-69 years.

These observations are not too surprising when it is taken into account that exercise tolerance decreases with increasing BMI due to factors such as poor heat dissipation and increased strain on weight bearing joints. It has also been reported that the overweight and obese have a higher drop out rate from exercise programmes when compared with their normal weight counterparts (Pacy et al, 1986).

ASSOCIATION OF OBESITY WITH SOCIO-ECONOMIC STATUS

Data examining the relationship of obesity in females and socio-economic status (SES) provided striking consistency in the finding that SES is strongly related to obesity. Sobal and Stunkard (1989) reviewed 144 studies on the relationship between SES and obesity. Of 30 studies providing data on women, only 2 failed to conclude that there exists a strong inverse relationship between obesity and SES, and none of the studies found a positive relationship. This finding has been replicated world-wide providing the conclusion that obesity and SES are inversely related in women living in developed, westernised countries. A similar review by the authors focusing on males failed to find a conclusive relationship. However a prospective cohort study of British middle-aged men found that social class was positively associated with BMI (Shaper et al, 1997).

A possible explanation for the positive relationship between obesity and SES in men resulted from the Dietary and Nutritional Survey of British Adults (Gregory et al, 1990). The survey found that there was a lower average recorded daily energy intake for unemployed men and those receiving benefits. Such an explanation fails to hold for women as those claiming benefits also had lower average recorded energy intakes while displaying a strong inverse association between BMI and SES.

The SIGN Guidelines for Obesity in Scotland (1996) also found that SES had an inverse relationship with BMI but noted that the relationship was a complex one, integrating a genetic role.

Possible reasons for the strong inverse relationship of BMI and SES observed in women could be that those women in a higher social class have higher educational levels and an increased knowledge of nutrition and dieting (West, 1994). This hypothesis would appear to gain support from information regarding the average daily energy intakes of British adults (Ministry of Agriculture, Fisheries and Food, 1994), which found that those in social classes I and II had a significantly higher daily intake of vitamins, minerals, fibre and polyunsaturated fatty acids, compared with those in Social Classes IV and V. Respondents in the higher social classes were also more likely to consume fruit and vegetables than those from the lower social classes.

Avila and Hovell (1994) identified a population of female Latinas living in the US as being obese and of a low SES. Subjects were randomly assigned to either an exercise or control group. Exercisers carried out an 8 week intervention consisting of an educational and exercise class once per week, with additional exercise training at home. Controls attended weekly cancer screening education sessions, which did not mention diet or exercise. At the end of the intervention period, experimental subjects had significantly decreased their weight and BMI, and had significantly improved their estimated aerobic power compared with controls. By the three month follow up however, BMI was the only variable still decreasing while all other variables appeared to be returning to baseline values.

THE COST OF OBESITY

Application of the numbers of patients consulting their GP regarding treatment for overweight and obesity from the third National Survey of Morbidity in General Practice (cited in West, 1994) estimated that a total of 706,914 individuals consult their GP each year (West, 1994). Females are nearly four times as likely to consult their GP for treatment for overweight and obesity, and both sexes will visit their GP twice in the year. Translating the frequency of visits into an estimate of financial cost yields a figure of approximately £13.8 million. Other direct costs accrue as a result of treatment for overweight and obesity and are listed, along with their estimated cost, in Table 2.

Table 2: The cost of overweight and obesity to the National Health Service (from West, 1994)

Health Service Sector	**£million**
General Practice	13.8
In-patient	8.3
Out-patient	0.85
Pharmaceutical services	2.9
Dieticians	3.5
TOTAL	**29.35**

It should be noted, however, that the influence of overweight and obesity incur indirect costs to the National Health Service through the link between BMI and morbidity. This includes a proportion of the costs for treating heart disease, stroke, NIDDM, hypertension and post-operative care of surgical patients, among others (West, 1994). A conservative estimate for annual health care costs was calculated to be £195 million (James, 1995) for the UK, $39.3 billion (£26.6 billion) for the US (Colditz, 1992) and $A395million (£152million) in Australia (refers to obese individuals only). If the figure for the US included musculoskeletal disorders then it would rise to $56.3 billion (£38.0 billion). These figures highlight the huge financial strain placed on health care providers by overweight and obese individuals at a time when many health care budgets are already over-stretched.

There are also private costs associated with overweight and obesity. Many of those attempting to lose weight try over-the-counter diet products and about £80 million is spent on meal replacement diets each year with a further £5.5 million spent on slimming magazines (from West, 1994). Other factors affecting overweight and obese individuals are the higher cost of life insurance premiums (due to increased risk of mortality) and a poorer quality of life resulting from a reduced functional capacity.

EXERCISE AS PART OF A WEIGHT REDUCTION PROGRAMME

While the benefits of exercise as part of a weight reduction programme are well documented, it must be remembered that overweight and obese persons have a greatly reduced exercise tolerance. This can be explained by poor heat dissipation and added strain to weight bearing joints due to the excess weight. Another point to note is the great variability of the initial work capacity of obese individuals at the start of a training programme (Foss et al, 1976). In a previous study, Foss and colleagues (1975) demonstrated that exercise tolerance was diminished in those with BMI>30. From the performance of severely obese individuals (BMI>40) walking on a treadmill the authors concluded that even very light exercise may be beyond many obese individuals.

Exercise as a means to increase Energy Expenditure

Various forms of aerobic and resistance exercise have been used, either alone or in conjunction with calorie restriction, to increase energy expenditure when aiming to reduce body weight in overweight and obese individuals.

Aerobic exercise, of varying intensities, has been the favoured form of activity to increase energy expenditure (Schaberg-Lorei et al, 1990; Shinkai et al, 1994; Svendsen et al, 1993; Sweeney et al, 1993) in recognition of the fact that this type of exercise offers other physiological benefits besides increased energy expenditure. The role of aerobic exercise in improving fitness, lipid profile, insulin sensitivity, bone density and blood pressure is well documented (Bittner, 1994; Duncan et al, 1985; McMurdo et al, 1997; Shepard, 1989) and position statements regarding the benefit of aerobic exercise in the management of these chronic conditions have been issued in recent years (NIH Concensus Conference, 1996; World Hypertension League, 1993). Additionally, as discussed earlier, high aerobic fitness and physical activity levels are associated with longevity (Blair et al, 1989; Lee et al, 1997).

However, as Zelasko (1995) reports, there are several popular misconceptions regarding the role exercise has to play in weight reduction. The first, and most commonly held, of these is the idea that exercise expends large amounts of energy. In fact, the actual energy cost of exercise is less than many people suppose since it is often neglected to calculate the *net* energy cost of an activity. For example, walking for 45 minutes at 3 miles per hour may consume approximately 200kcal in a female of 80kg, but if the same person was to have used that time to sit and write a letter, she would still have expended 100 kcal. Therefore, the net energy cost of her exercise was approximately 100kcal; around half of the gross energy expenditure. Such an overestimation of energy expenditure becomes significant when it is taken into account that the female may exercise three times per week over the course of twelve weeks - the minimum period required to promote loss of body weight and fat while improving aerobics fitness and cardiac risk factors (Hagan, 1988).

Another popular dieting "myth" is that exercise will stimulate energy expenditure for a long time after completing a bout of activity (Zelasko, 1995). While this phenomenon, known as excess post-exercise oxygen consumption, or EPOC, exists, it would not significantly contribute to weight loss as a result of light or moderate exercise, i.e. the intensity of exercise that would be recommended to an overweight, and deconditioned, individual. Indeed, even exercising at high intensities leads to only a very small increase in energy expenditure post-exercise.

Exercise as a means to preserve fat free mass and promote fat loss

The evidence convincingly shows that including exercise as part of a weight reduction programme preserves fat free mass (FFM) while promoting fat loss (Evans et al, 2001; Garrow and Summerbell, 1995; Hagan, 1988; Leutholtz et al, 1995; Shinkai et al, 1994; Svendsen et al, 1993; Walberg, 1989; Wood, 1996).

The importance of preserving FFM is outlined above - it is the main determinant of RMR since its composition includes skeletal muscle (Walberg, 1989). Hence it is desirable to limit the loss of FFM when restricting calories in an attempt to lose weight. Also of importance is the loss of function which can be associated with a loss of skeletal muscle (Skelton et al, 1994[a])

Evans and colleagues (2001) investigated the independent and combined effects of exercise and hormone replacement therapy (HRT) on body composition and fat distribution in a group of 68 postmenopausal females (mean age (±sd) 68 (±5) years). Subjects were assigned to one of 4 groups: sedentary control (n=19), exercise (n=18), HRT (n=15), or exercise + HRT (n=16). The exercise programme consisted of two months of flexibility exercises (to limit the likelihood of participants becoming injured), followed by 9 months of endurance exercise (30-45 minutes of moderate intensity, weight bearing exercise, 3-4 x/wk). All subjects were instructed to maintain their usual eating habits. Statistical analysis showed that there were significant main effects for exercise for the reductions in waist area and total, trunk and leg FM. Exercise also significantly increased total and leg FFM. Additionally, the combined effect of HRT and exercise resulted in a disproportionate reduction of central body fat.

Svendsen et al (1993) employed a shorter intervention period of 12 weeks when investigating the effect of exercise, or exercise and diet, on body composition, fat distribution, RMR, and various cardiovascular risk factors on 118 overweight (mean BMI 29.7), postmenopausal women (mean age 53.8 years). Energy intake consisted of a diet formula and food, which was chosen using the "counter diet system". This diet system allowed subjects to chose from a variety of food portions which had a predetermined energy value. Subjects received diet support and advice from a physician and a nutritionist on a weekly basis. The supervised exercise programme aimed to promote fat loss through an aerobic regime (30-55min at 70% of maximum oxygen uptake) and limit fat free mass loss via an incremental resistance programme, incorporating 8-10 exercises.

At the end of the intervention, the exercise subjects had significantly improved their aerobic capacity, compared with the diet-only and control subjects. Both intervention groups significantly decreased their body mass, waist-to-hip circumference and abdominal-to-total body fat tissue mass ratio compared with their baseline measurements, and the control group. However, the diet + exercise group lost significantly more body fat, and significantly less lean tissue mass, compared with the diet-only and control groups. The diet + exercise group also had a significant reduction in skinfold thicknesses in comparison with the other two groups.

Interestingly, the diet + exercise group increased their RMR (per kg wt) compared with the control group.

Since the majority of studies to investigate the effect of diet and exercise on body composition have been carried out on premenopausal women, Schaberg-Lorei and colleagues (1990) compared the outcomes of an exercise programme on a group of pre and postmenopausal women (age 35-70 years). To meet the experimental questions posed, four groups were formed: premenopausal control (n=24), premenopausal exercise (n=19), postmenopausal control (n=30) and postmenopausal exercise (n=36). All subjects were instructed to maintain their current dietary habits and the sedentary control subjects were asked not to embark on any exercise programmes. The exercise programme consisted of 3-4 sessions per week in a supervised exercise class. The sessions lasted 45 minutes, increasing to 65 minutes throughout the duration of the 24 week intervention, and incorporated warm up, aerobic, light resistance and cool down sections. Thus pre and postmenopausal exercise groups had age matched controls, and both exercise groups underwent the same exercise protocol to allow comparison of outcomes of the training programme.

Both exercise groups showed similar improvements in aerobic capacity and body composition measures, regardless of age. When the each exercise group was compared to its control, the exercise groups were shown to have significantly decreased percent fat, fat weight, supra-iliac skinfold and abdominal skinfold thicknesses. The authors concluded that subjects' menopause status did not effect the exercise responses observed in this study.

A review of twenty eight studies published between 1966 and 1993 which investigated the effect of weight loss by calorie restriction alone, and calorie restriction combined with exercise (aerobic and resistance), on body composition was carried out by Garrow and Summerbell (1995). Statistical analysis was performed to examine the relationship between loss of weight and loss of FFM. On average, it was found that aerobic exercise alone did promote weight loss, but not of the magnitude observed when aerobic exercise was combined with calorie restriction. Resistance exercise had little effect on weight loss, but increased FFM by about 2kg in men and 1kg in women. Weight loss of 10kg by diet alone would be expected to comprise of a loss of 2.9kg of FFM in men and 2.2kg in women. However, similar weight loss achieved by diet and aerobic exercise would be expected to result in a loss of only 1.7kg of FFM in both men and women.

In contrast to the preceding body of evidence, Hill et al (1993) noted that while exercise may preserve FFM, the effect was small and unlikely to have a measurable influence on the decrease in RMR that accompanies weight loss. Shinkai et al (1994) meanwhile, suggested that the effects of exercise on FFM and RMR appear to vary so widely in the literature because they are affected by so many variables, e.g. energy deficit and intensity of exercise, which are either not described or differ between studies.

In view of such evidence, it is widely accepted that if the ultimate goal of an overweight individual is to reduce body weight and body fat, dieting and exercise will each help an individual achieve his/her goal, but that their combination is more effective than each alone (Epstein and Wing, 1980; Garrow and Summerbell, 1995; Hagan, 1988; Pacy et al, 1986; Svendsen et al, 1993; Wood, 1996; Zahorska-Markiewicz, 1981; Zelasko, 1995).

Efficacy of exercise programmes in weight loss

Many formats of exercise programme have been investigated for their effects on body composition and various other physiological measurements. Broadly, these can be divided into exercise only, and combined diet and exercise regimes. However, the intensities and duration of the programmes vary markedly as is shown below.

Obese, middle-aged females exercised at a moderate intensity (60% $\dot{V}O_{2\,max}$) for two hours every day over a three month period (Katoh et al, 1994). BMI and percent of body fat decreased by 10.3% and 17.9% respectively, while lean body mass did not change significantly. Additionally, systolic blood pressure decreased by 16.3% and diastolic blood pressure was reduced by 13.1%. Although absolute $\dot{V}O_{2\,max}$ and maximum heart rate did not change significantly, $\dot{V}O_{2\,max}$ relative to body weight increased by 15.3%. While desirable results were found, the prescription is rather extreme in nature and would probably not be palatable for the majority of people due to the time involved. Rate of compliance to this extremely time consuming regime could not be calculated as no values were given.

Leutholtz et al (1995) compared the effects of exercising at 60% of heart rate reserve (HRR) on body composition changes with those resulting from exercising at 40% of HRR. It was found that there were no advantageous changes associated with exercising at the higher intensity provided that the total volume of training was the same. This has implications for the overweight as it demonstrates that exercise at the lower intensity, which may be more safe and acceptable for overweight individuals, results in the same benefits as observed when exercising at the higher intensity.

As Hillsdon and Thorogood (1996) observed, walking is an ideal method of increasing energy expenditure as part of a weight reduction programme. This mode of exercise was used during a five month weight reduction programme which incorporated an energy intake of 1500kcal per day and 10 000 walk steps per day to investigate the effect on coronary risk factors in 332 middle-aged obese subjects (Ohta et al, 1990). The number of steps walked per day was verified by a pedometer. At the end of the intervention, body weight, body fat - as measured by skinfold thicknesses - systolic and diastolic blood pressure, serum lipid and lipoproteins had improved significantly. Statistical analysis demonstrated a significant correlation between number of daily steps and decrease in body weight, diastolic blood pressure and increase in the ratio of high density lipoproteins to cholesterol (HDL-C). As would be expected, those demonstrating abnormal blood pressure, lipid profiles and lipoproteins at baseline had greater improvements than those with baseline values for these measures within the normal ranges.

In reviewing the efficacy of diet and exercise in weight loss trials, Hagan (1988) concluded that while starvation and low calorie diets (energy intake of <500kcal/day) produced the most dramatic weight loss, best results (as defined by improved cardiac risk profile and long term weight loss) occurred when a weight loss programme provided:

- $\geq$1200 kcal per day of a proper mix of foods including those that the individual found palatable;
- an energy deficit of between 500 and 1000 kcal per day which promoted a maximum weight loss of 1kg per week;
- behavioural modification techniques aimed at promoting compliance to the programme;
- a physical activity programme of at least three days per week, 20 to 30 minutes or longer in duration, and at a minimum intensity of 60% of maximum heart rate.

Hagan recommended that such a programme be followed for at least twelve weeks to promote the loss of body weight and body fat, to spare the loss of muscle tissue, to increase cardiorespiratory functional capacity, and to produce a more favourable blood lipid and lipoprotein profile.

FUNCTIONAL STATUS IN OLDER ADULTS

The ageing process has traditionally been viewed as a progressive decline in health, leading to disability and death. A distinction, however, has been noted between the decline in function due to biological ageing, and that associated with reduced levels of physical activity which have been observed in older adults (ADNFS, 1992). Such a difference first became apparent when the similarities between the loss of function due to ageing and the loss in function due to enforced inactivity, e.g. bed rest, were observed. Since then a growing number of studies have proved that physical activity and exercise have a role to play in the maintenance of function, and therefore independence, in older adults (Bassey et al, 1988; Binder et al, 1994; Fiatarone et al, 1990; Skelton and McLaughlin, 1996; Skelton et al, 1994[a]).

The term "threshold of independence" has become widely used to encompass the level of muscular strength, endurance and flexibility required to prevent an elderly individual becoming institutionalised. It is necessary for older adults to be able to perform certain everyday tasks (e.g. rise from a toilet seat, climb stairs, walk short distances) in order to remain free living in the community. If individuals fall below this threshold, they are no longer able to look after themselves.

The ADNFS (1992) identified a lower limb extensor power (LEP) of $2Wkg^{-1}$, below which it was hypothesised that individuals would be compromised in their functional ability, e.g. to climb stairs and rise from a sitting position unaided. The study found that 50% of females aged over 55 years were indeed below this threshold. This statement was contradicted by Skelton and Young (1993) who cited evidence of an unrelated study stating that females aged between 75 and 93 years with LEP below $2Wkg^{-1}$ were able to rise from a chair and climb stairs unaided. Indeed, Bassey et al (1992) projected that such a functional threshold was closer to $0.5Wkg^{-1}$. They hypothesised that subjects may fall below this limit either because of low muscle power, carrying too much adipose tissue, or a combination of both.

Muscle strength has consistently been shown to correlate with levels of functional ability (Bassey et al, 1988; Bassey et al, 1992; Hyatt et al, 1990; Skelton et al, 1994 [a]) and the menopause is regarded as a time when females are shown to lose strength as a result of a decrease in FFM and, hence, muscle mass (Dionne et al, 2000; Guo et al, 1999; Hamilton et al, 2000; Svendsen et al, 1995).

Various studies have compared levels of strength between pre and postmenopausal women (Dionne et al, 2000; Phillips et al, 1992; Phillips et al 1993). Phillips and colleagues (1993) investigated the age-related decline in specific muscle force (maximum voluntary force per cross sectional area) of the adductor pollicis muscle in men and women aged 17-90 years. The authors also sought to determine if the loss of specific muscle force in women was hormone-dependent, by measuring the specific muscle force of 25 women (aged 42-72 years) who were receiving hormone replacement therapy (HRT). The results showed that there was no difference in specific muscle force between men and women up to the time of menopause. Thereafter, there was a dramatic decline in strength in women, which was not observed in men until approximately 15 years later than women. Indeed, it was not until males and females reached 75 years of age, that their specific muscle force reached similar levels again. Comparison of age matched postmenopausal females, 25 of whom were receiving HRT and 67 of whom were not, found that those not receiving HRT were significantly weaker than those taking HRT. The protective effect of HRT on muscle strength was further supported by the observation that there was no difference in strength between the HRT group and the premenopausal females.

As discussed earlier, regular participation in physical activity has been shown to protect against the loss of FFM associated with ageing (Astrup, 1999; Guo et al, 1999; Hamilton et al, 2000; Schaberg-Lorei et al, 1990). Many studies have investigated the effect of training programmes on various indices of fitness in postmenopausal females (De Vito et al, 1997; De Vito et al, 1999; Macaluso et al, 2001; Schaberg-Lorei et al, 1990; Svendsen et al, 1993). De Vito and colleagues (1999) aimed to investigate the efficacy of a non-specific, low intensity exercise programme in improving anthropometric measures, $\dot{V}O_{2\,max}$ and maximal instantaneous power in healthy women (mean age 63 years). This latter measure of fitness was of interest because it has been shown to decrease more rapidly than both $\dot{V}O_{2\,max}$ and strength (cited in De Vito et al, 1999).

The exercise group (n=11) completed a supervised class-based exercise programme three times per week, for 12 weeks. The sessions consisted of walking, stretching and flexibility exercises and were of approximately 60 minutes duration. Using heart rate monitors, intensity was maintained below 60% of the heart rate reserve. The control group (n=9) remained sedentary throughout the study period. At the end of the intervention, exercise subjects did not significantly improve their $\dot{V}O_{2\,max}$. In addition there were no significant changes observed in the subjects' body fat or cross sectional area of the quadriceps muscles in both legs. However, the exercise subjects significantly improved their maximal instantaneous peak power (measured via a vertical jump on a force platform), while the control group failed to record an improvement. The authors proposed that the observed improvement in maximal instantaneous peak power was a result of an improved level of neural activation in the exercise subjects and demonstrated this system's sensitivity to training.

Macaluso et al (2001) used a novel training approach to compare three variations of a cycling programme, using low and heavy dynamic resistance, on maximal isometric voluntary contraction (MVC) and peak power in a group of 37 females of mean age 69 years. Subjects were assigned to one of three exercise groups, or a sedentary control group. All groups were matched for age and MVC. The exercise groups aimed to train subjects' speed, strength, or a combination of these factors. After 16 weeks training, all three exercise groups significantly increased their MVC and peak power from baseline. There were no significant changes between exercise groups. From these results, the authors concluded that the training regimes employed in this study were as effective in increasing the strength and power of this cohort of females as conventional resistance programmes.

As mentioned above, females experience a dramatic reduction in strength around the time of the menopause and are then significantly weaker than men until age 75 years Phillips et al (1992). However, Hyatt and colleagues (1990) noted that, even when corrected for muscle area, elderly men had significantly greater muscle strength compared with women (mean age 77 years). In addition, power to weight ratio was also shown to be greater in men. Women were shown to have a higher percentage body fat at the expense of muscle bulk and power. The authors found though, that such differences failed to affect functional ability and physical activity levels, which were similar for both sexes.

Similar findings showing women to have less muscle strength and power to weight ratio compared with men have been found elsewhere (Bassey et al, 1988; Skelton et al, 1994 [a]). Women have been found to have a slower walking speed than men although they completed the same total amount of walking over the course of one week. As it has been noted that women are functionally dependent for four years longer than men (Skelton et al, 1994[a]), it makes sense to initially target women in initiatives to maintain functional strength.

Although females experience a substantial decrease in strength at age 45-50 years (Phillips et al, 1992) published studies investigating the effect of exercise on functional status in postmenopausal women, tend to be carried out in much older subjects (Binder et al, 1994; Fiatarone et al, 1990; Fiatarone et al, 1994; McMurdo and Rennie, 1993; Skelton and McLaughlin, 1996).

Studies investigating the role of exercise in the maintenance and improvement of functional status have generally taken two forms: strength training only (Fiatarone et al, 1990; Fiatarone et al, 1994; Skelton and McLaughlin, 1996; Skelton et al, 1994[b]) and multi-component programmes (Binder et al, 1994; McMurdo and Burnett, 1992 ; McMurdo and Rennie, 1993; Province et al, 1995). Multi-component programmes attempt to encompass a range of exercises which relate closely to functional activities.

Strength Training Programmes

The types of exercises used in a strength training programme have been shown to be of importance for two reasons. Firstly, Sale and MacDougall (1981) reviewed the role of the specificity of strength training, advocating that exercises should simulate the target movement as closely as possible to allow maximal neural and muscular adaptation. Secondly, Fiatarone et al (1990) illustrated that although strengthening the quadriceps muscle will reduce the time taken to rise from a chair, increasing the strength of the hip extensor muscle may explain the greater improvements found in a similar population completing the same test. In other words, strengthening one muscle in isolation, while effective in improving related functions, will not achieve the same benefits as a more expansive programme.

Fiatarone and colleagues (1990, 1994) have shown that strength gains can be accomplished in the very elderly. The authors have documented improvements in quadriceps strength of 174% in males and females in their tenth decade. Such improvements transferred into functional ability by the observed increase in tandem gait of 48% (Fiatarone et al, 1990). By increasing the number of lower extremity muscles trained, Fiatarone and her team (1994) improved the outcome of the functional ability tests of a similar elderly population (mean age 87.1 years). Based on these interventions, the authors concluded that "functional tasks rely on the complex integration of cardiovascular, musculoskeletal and nervous systems" and that any exercise programme aimed at improving such variables should reflect this.

Skelton et al (1994[b]) reached a similar conclusion after forty female subjects (mean age 79.5 years) completed a 12 week strength programme in which none of the training exercises mirrored the outcome tests. While subjects showed increases in absolute strength (isometric knee extensor strength, isometric elbow flexor strength, lower limb extensor power), only two out of 9 assessments of functional ability showed improvement with training. The authors therefore suggested that task independent increases in strength and power had little effect on functional status. A more recent study by Skelton and associates (1996) with females aged over 74 years, aimed to correct these observations and incorporated an exercise programme which mimicked the functional tasks being tested. At the end of the 8 week intervention, significant improvements were seen in quadriceps and hamstring strength, flexibility, balance, time to rise from a chair, timed "up and go", stair walk, time to rise from the floor and step rate over a 6.1 metre course.

Multi-component Programmes

As has been mentioned previously, functional ability is influenced by the integration of various systems which is why multi-component programmes have been used in the investigation into the most effective way to maintain or improve functional ability. It should be remembered that flexibility is an important component in any functional programme for an older adult as they need to have the suppleness in, say, their finger joints to enable them to tie their shoe laces. Multi-component programmes acknowledge the importance of such tasks to enable an elderly individual to remain functionally independent and aim to incorporate them into their regimes (Binder et al, 1994; McMurdo and Burnett, 1992; McMurdo and Rennie, 1993; Province et al, 1995). Findings of such multi-component programmes are described below.

McMurdo and Burnett (1992) recognised the importance of preserving function to prolong "active life expectancy" in older adults. The authors carried out a randomised control trial of exercise in a group of adults (mean age 65.8 years) where subjects were assigned to either an exercise class or a control group. The exercise subjects attended a class three times per week for 32 weeks. Each session consisted of a warm up period, followed by endurance activities and muscle strengthening and flexibility exercises. Compliance was very high in the exercise group with 93% of the experimental group completing the eight month intervention. The control group participated in sessions designed to improve health education. At the end of the intervention, the exercise group demonstrated significant improvements compared with the health education group in spine flexion, perceived health status, Life Satisfaction Index, and maximal physical exertion. Overall, this study was successful in illustrating the efficacy and palatability of an exercise class for older adults.

Fifteen community dwelling adults aged 66-97 years attended a thrice weekly exercise class for eight weeks (Binder et al, 1994). Subjects had at least one risk factor for recurrent falls, which was determined by screening procedures. The exercise classes were of one hour duration, included warm up and cool down periods, and were designed to increase lower extremity strength, flexibility and speed of movement. Functional measures included chair to stand time (single rise and five consecutive rises), gait speed and static balance. Compliance was extremely high with 99.4% of the 24 sessions being completed. It should be noted however, that the intervention period of 8 weeks was rather short. At the end of the study, the exercise subjects had significantly increased their self reported daily activities and had improved their chair to stand times (single and five consecutive), gait speed and balance. Unfortunately, these improvements were no longer evident during re-testing one year later.

McMurdo and Rennie (1993), looked at the effects of twice weekly, seated exercises on elderly residents (age range 64-91 years) in local authority homes on flexibility, strength and functional outcomes, as well as psychological measurements. Participants in the seven month intervention were randomly assigned to either the exercise group or a control group, who took part in reminiscence sessions. The exercise programme consisted of 45 minute exercise to music sessions comprising of a 10 minute warm up period and a 35 minute section which sought to improve joint flexibility and upper and lower limb strength. Compliance with the exercise sessions was high, with an average attendance of 91% over the experimental period. In comparison with the control group, it was found that the exercise group significantly improved their grip strength, spinal flexion, chair to stand time, activities of daily living, and self rating of depression.

PSYCHOLOGICAL EFFECTS OF OBESITY

The negative psychological effects associated with being overweight and obese are well documented (Harris et al, 1990; Wooley, 1987), and are similar across all sections of society (Wooley, 1987). The obese are considered by others to be lazy, inferior, unattractive and responsible for their own condition. This is especially true for females for whom physical appearance is considered particularly important. What is surprising is that these attitudes have been found to be present across all ages, races and social classes (Wooley, 1987). Even those who were expected to be more tolerant (for example, the elderly and those on low incomes) expressed opinions that further strengthened the observation that attitudes to the overweight and obese are universal.

Several authors have found that even those who are overweight view themselves in a similar light (Harris et al, 1990; Wooley, 1987). A group of US overweight men (n=8) and women (n=47) of mean BMI 28.9, who were trying to lose weight, were asked about their experiences of being overweight (Harris et al, 1990). 93% of the sample blamed themselves for being overweight and said that they felt guilty and responsible for their excess weight. A large percentage (48%) also stated that they felt their relationships with the opposite sex had been affected by their appearance. The majority of this cohort (80%) felt that this was because they were viewed as being less desirable. Females considered losing weight to be of more importance than males, and wanted to weigh 6.3lbs *less* than the weight they considered to be the healthiest for them. This skewed view of appearance was found in another group of females who responded to a questionnaire published in a US women's magazine. Of the 33 000 women who returned the questionnaire, 76% considered themselves "too fat". Although 97% of the of the respondents who were classed as overweight by Metropolitan Life Insurance Tables said that they viewed themselves as too fat, so too did 82% of those who were considered normal weight and 45% of those who were underweight.

Unsurprisingly, overweight and obesity are associated with lower levels of general well being (GWB) and higher levels of depression (Istvan et al, 1992; Rumpel et al 1994; Stetson et al, 1992). Rumpel and colleagues (1994) examined the relationship between weight change and psychological well being in 3747 females aged 25-50 years and found that recent weight gain was associated with poorer well being, as measured by the GWB Scale, in both overweight and non-overweight women. The association became stronger with higher BMI (i.e. obese women demonstrated the poorest well being). Those with stable weight, regardless of their BMI, had a higher GWB.

Such observations prompted Ross (1994) to investigate the question: "is overweight distressing?" Her findings seemed to contradict some of the conclusions drawn from earlier research. From the available information, Ross decided to investigate three possibilities in an attempt to explain the negative effect being overweight has on psychological well being.

1. The direct association of negative self appraisal
2. The 'stress' of dieting in an effort to fit social norms of acceptable physical appearance
3. The health consequences of being overweight, i.e. overweight is directly related to ill health which will impact on psychological well being.

A sample of 2020 US adults, aged 18-90 years, were surveyed by telephone. The subjects' mean BMI was 24.65, with males being found to have a higher BMI than females (BMI 25.32 and 24.25, respectively).

Considering the negative societal attitudes to obesity, it was hypothesised that overweight subjects would view themselves as others did (self appraisal) and hence see themselves as lazy and undesirable. Ross predicted that this would lead to feelings of low self esteem and poor self image causing high levels of depression. In social groups where being overweight is less common (e.g. upper social classes), it was expected that there would be the greatest effect on depression. However, contrary to previous reports (Wooley, 1987; Harris et al, 1990; Rumpel et al, 1994), Ross found that, in general, reflected self appraisal was not a contributing factor in depression in overweight respondents. An exception to this was amongst those subjects who were well educated, where being overweight was found to affect mental well being, as was predicted, due to the low prevalence in this population.

The second possibility suggested that *trying* to fit social norms (through dieting) was more distressing than not fitting them (i.e. dieting is more stressful than being overweight and being overweight may not be distressing in itself). Questioning the sample found that this was indeed the case and that dieting explains a large part of the effect of weight on depression. Those who were overweight were significantly more likely to diet than those of normal weight ($p<0.0001$), explaining the greater incidence of depression amongst those who were overweight. Controversially, Ross concluded that, in the US, there was no stigma associated with being overweight and this was why being overweight in itself is not distressing.

Ross also found that the more overweight a person was, the poorer their self reported health. As predicted, poor physical health was directly associated with higher levels of depression. Combining the effects of dieting and poor self reported physical health explained 92% of the effect of overweight on depression.

PSYCHOLOGICAL EFFECTS OF EXERCISE

A growing body of evidence supports the assertion that regular exercise is beneficial for mental health (Di Lorenzo et al, 1999; Fox, 1999; Goldwater and Collis, 1985; Hassmen et al, 2000; Heller et al, 1992; Hill, 1987; McMurdo and Burnett, 1992; Ross, 1994; Stetson et al, 1992). Hassmen et al (2000) surveyed 3403 (1856 female) participants in the Finnish cardiovascular factor study, aged 25-64 years, regarding their exercise habits and perceived health and fitness status. Subjects were also asked to complete a range of psychological instruments: Beck Depression Inventory, State-Trait Anger Scale, Cynical Distrust Scale and Sense of Coherence Inventory. The authors found that those who exercised at least twice per week experienced significantly less depression, anger, cynical distrust and stress than those exercising less, or not at all. Additionally regular exercisers perceived their health and fitness to be better, had higher levels of sense of coherence, and a stronger feeling of integration.

Di Lorenzo and colleagues (1999) carried out a longitudinal study to look at the physiological and psychological benefits of a 12 week exercise programme, consisting of cycle ergometry, with 82 adult participants. At the end of the intervention period, the exercisers demonstrated positive fitness changes and psychological improvements when compared with controls. Subjects were re-tested after 12 months and the experimenters found that the exercise induced fitness and mental health improvements had remained. Having established that the exercisers had not increased the amount of exercise they participated in over the 12 month follow up period, the authors concluded that the long term psychological benefits were a result of the same, or lower, exercise levels.

McMurdo and Burnett (1992) focussed on older adults (age range 60-81 years) in their 32 week, randomised controlled trial of exercise. Subjects were randomly assigned to an aerobics class, designed for older adults, or a health education class. As well as improving various physiological measures, the exercisers also significantly improved their score on the Life Satisfaction Index and perceived health status post-intervention, compared with their baseline results.

Ross' (1994) survey, discussed above, found that total distanced walked was positively correlated with positive psychological profiles. As a result, the author suggested that, when trying to lose weight, individuals should increase their levels of physical activity as opposed to dieting, in an effort to maintain/improve mental well being.

In his review paper of mental health and exercise in the context of public health promotion, Fox (1999) concluded that moderate regular exercise should be considered as a viable means of treating depression and anxiety and enhancing mental well being in the general public. After reviewing the available evidence, Fox stated that exercise has a moderate reducing effect on state and trait anxiety and can improve physical self perception and, in some cases global self esteem.

CHAPTER 3

METHODOLOGY

INCLUSION CRITERIA

Subjects were female (aged 55-70 years) who were overweight (BMI≥25). They were invited to participate in the study (Appendix A) if they were a member of a general practice in Shettleston Health Centre and deemed sufficiently mobile to take part in the exercise class.

EXCLUSION CRITERIA

Patients with insulin dependent diabetes, unstable hypertension and unstable angina, were excluded from the study. Baseline physical activity levels were assessed using a short questionnaire compiled by the investigator. If a subject was deemed to be moderately active on most days of the week, they were excluded from the study.

RELIABILITY STUDY

A reliability study (Appendix B) was performed to investigate the reliability of the test battery. Seven subjects completed all tests (except total blood cholesterol) on two occasions, seven days apart. Statistical analysis showed that there were no significant differences between tests, except for diastolic blood pressure. It was hypothesised that subjects felt anxious at test 1 as they did not know what to expect, and that this was reflected in their diastolic blood pressure measurement. Verbal reports with subjects confirmed that they had felt anxious at test 1, and more relaxed at test 2 as they knew what to expect. It was concluded that the test battery was reliable and could be used in the main study.

ASSESSMENT PROCEDURES

Pre- and post-intervention assessments were carried out in the general practice surgery of participating subjects. Each test battery was carried out at the same time of day. Subjects were instructed to avoid consuming any food or smoking tobacco for 2 hours prior to their assessment. Prior to baseline testing, subjects read an information sheet about the study (Appendix C) and the assessor answered any questions they had. Subjects then signed a consent form to participate in the study. Ethical approval was granted by the Greater Glasgow Community and Primary Care Ethics Committee.

All subjects completed the following:

Physiological Tests

1. **Height** (stadiometer) and **body mass** (seca scales) were measured. Measurements were made without shoes and while wearing light clothing. Body mass was taken to the nearest 0.1 kg.

2. **Body mass index** (BMI) assessment. The BMI was calculated by dividing the body mass (in kg) by the square of the height (measured in metres).

3. **Skinfold measurement** using Durnin and Womersely (1974) method, i.e. four skinfold measures were taken from the right side of the body with the subject in a standing position.

i) Triceps:

The measurement was taken midway between the acromion and the olecronon processes with the arm hanging loosely at the subject's side.

ii) Biceps:

The measurement was taken at the middle of the muscle belly with the arm supinated.

iii) Subscapular:

The skinfold was picked up below the inferior angle of the scapula, at an angle of 45 degrees to the vertical.

iv) Supra-iliac:

The skinfold was grasped just above the iliac crest on the mid axilliary line. The skinfold was horizontal due to the subjects' excess fat in this area.

Procedures for measuring skinfold thicknesses:

a) The thumb and forefinger were used to lift the skinfold allowing the calliper jaws to catch the fold 1cm below the forefinger and thumb.

b) Two seconds were allowed to elapse before a reading, to the nearest 0.2mm, was made.

c) Three readings were taken at each site with the average value used as the skinfold score.

4. **Resting blood pressure.** Blood pressure was taken by the Practice Nurse. Subjects sat at rest for 5 minutes before the measurement was taken using a mercury sphygmamometer (Trimline Pymah). The subjects were accustomed to regular blood pressure measurement.

5. **Total blood cholesterol.** Total blood cholesterol was taken by the Practice Nurse. A Lipotrend C analyser (Boehringer Mannheim) calculated cholesterol from a thumb prick of blood. Measurements were made with subjects sitting upright in a chair.

Functional Status Tests

All tests were explained and demonstrated to the subjects by the assessor prior to each measurement. A seated rest of 3 minutes was given before each test. Due to time constraints, subjects were unable to practise each test prior to assessment.

1. ***Chair rise*** Subjects were required to rise, with their arms folded and as fast as possible, from a chair with a level seat 0.42 metres from the floor (British Standards Institution (BSI) recommended height for a toilet pedestal plus an amount added for a toilet seat). The subjects were asked to rise 10 times consecutively and the time taken was recorded.

2. ***Timed 'Up and Go' Test*** The subjects were asked to rise from a chair (0.42m in height), walk 3 metres, turn and return to the chair and sit down, as fast as possible. The whole movement was timed. Subjects were asked to rise and sit down without using their arms for support if possible (Skelton and McLaughlin, 1996). The assessor noted if the subject complied with this.

3. ***20 Metre Walk*** The subjects were asked to walk 20 metres as fast as possible. The time taken to complete the walk was recorded.

4. ***Lifting a 1kg and 2kg Bag onto a shelf*** Subjects were asked to lift a bag of sugar (1kg) in a plastic bag lying on the floor, on to a 1.34 metre high shelf (1.3 m is the BSI recommended height of the bottom of a wall unit), but standing 0.3 m away from the shelf (BSI recommended width of a base unit in a kitchen). The test was performed once using each arm with the time for each arm recorded. After a rest of three minutes, subjects repeated the same procedure with a bag weighing 2kg (2 bags of sugar) (Skelton and McLaughlin, 1996).

5. ***Stair Walking*** The subjects were asked to walk up a small flight of stairs (12 stairs, each of height 16cm), turn on the landing and descend the stairs without stopping, at a pace as fast as possible, but still safe, without using the handrail as support. The task was timed and the assessor recorded if the subjects hesitated or used the handrails. The stairs were conveniently placed in the Health Centre and the height and number of stairs were considered to be appropriate for the ability of the subjects.

Flexibility Test

Flexibility was measured using the Sit and Reach test (Wells and Dillon, 1952). Subjects were given three attempts and the best of these scores was recorded to the nearest centimetre.

Psychological Test

Subjects were asked to complete the **Life Satisfaction Index** (Neugarten et al, 1961) as a measure of their mental well-being.

TRAINING PROGRAMME

Those subjects assigned to the exercise intervention, were asked to attend a supervised, group exercise session twice per week for 12 weeks. The exercise sessions were of 40 minutes duration during which the subjects performed aerobic exercises. In addition, they performed a series of progressive muscular strength and endurance exercises and flexibility exercises which targeted important functional muscle groups, e.g. the quadriceps. All exercises were adjusted to suit individual capabilities. Subjects were encouraged to work at an intensity which made them sweaty and out of breath, although not so breathless that they were unable to speak.

Warm up - 10min

Gentle large body movements were performed which were designed to gradually increase heart rate and prepare the body for exercise. Exercises performed included joint mobilisation exercises (e.g. shoulder raises and arm circles), walking, side steps and squats. Preparatory stretches (held for 8-10 seconds) were also performed in this section. Muscles stretched were: gastrocnemius, quadriceps, hamstrings, and triceps.

Aerobic section - 20min

Subjects performed rhythmical continuous movements in time with the music, adjusting the magnitude of movement to enable them to exercise safely, if necessary. The class leader instructed participants to exercise at an intensity which they considered to be "somewhat hard" or "hard" (Borg, 1982). Due to the fact that all exercise subjects had been sedentary prior to the initiation of the study, all movements were low impact (i.e. one foot was in contact with the floor at all times). This was to reduce the likelihood of subjects sustaining an injury during the exercise class.

The intensity of each movement was raised by including large arm moves and a gradual, slight increase in the tempo of the music. Subjects were continually reminded that they should be breathing harder than normal and be feeling hot and sweaty. If a subject required to reduce the intensity of an exercise, she was shown how to do this safely, e.g. reduce arm work/generally make movements smaller.

Strength and Endurance - 5min

Exercises which related to functional activities and focused on postural muscles were selected. The exercises included squats (simulating rising from a chair), wall press ups and triceps presses, (both to increase upper body strength) and abdominal exercises.

Over the course of the 12 weeks, subjects were shown how to increase the intensity of the strength and endurance section by increasing the number of repetitions of an exercise, and/or by exercising the same muscle(s) using a more advanced move.

Flexibility – 5 min

Developmental stretching of the main joint complexes was performed. Those subjects who were able to comfortably lower themselves to the floor were instructed to do so for the flexibility section. Those subjects who were unable to complete the stretching section on the floor, stretched using adaptations in either a standing or seated position. Each stretch was held for a minimum of 30 seconds.

DIETARY ADVICE

All subjects in the study were given dietary advice from the Practice Nurse. Advice focused on information which it was considered, had the potential to change long term behaviour. The subjects were shown how to improve their diet (e.g. through changing cooking methods, increasing fruit and vegetable consumption, and decreasing energy intake from fats).

Subjects visited the Practice Nurse every two weeks to receive dietary advice and have their body mass measured.

SUBJECTS

Recruitment

Initially, recruitment letters (Appendix A) were sent to females matching the inclusion criteria (i.e. age 55-70 years and BMI$\geq$25) and who had previously attended the Weight Reduction Clinic held in a general practice in Shettleston Health Centre. Due to a poor response, a second round of letters was sent to a random list of females taken from the general practice records who matched the age and BMI criteria but who had not previously attended the Weight Reduction Clinic.

Response Rate

Sixty five females were interested in taking part in the study while twenty three responded negatively. Six of those interested had to be excluded for two reasons; either they could not be randomly assigned because they could not attend the exercise class due to other commitments (four), or they were already physically active (two). In total, fifty nine appointments were made for baseline testing.

Forty four, out of the original fifty nine, subjects completed baseline testing. Of the fifteen subjects who did not complete baseline testing, twelve failed to attend the initial assessment (each subject was given two opportunities to attend), two were recovering from illness, and one could not be randomly assigned as she was unable to attend the exercise class.

Randomisation

Subjects formed a stratified random sample and were assigned in randomly permuted blocks of five (3 exercisers: 2 controls). Stratification was done by age and body mass as these were the factors which would influence baseline data and the potential for improvement. Hence the intervention and control groups were balanced for these factors via the stratification. Assigning three subjects to the exercise group for every two subjects to the control group provided the larger exercise group at baseline which was necessary to offset the higher expected drop out from the exercise group.

Due to the failure of 15 subjects to complete baseline testing, only twenty three subjects were assigned to the exercise group while twenty one subjects were assigned to the control group. This failed to meet the expected 3:2 ratio as the calculations were based on the expected original sample of fifty nine.

A total of ten, of the initial 23 exercise subjects, dropped out of the study. Thus, thirteen (56.5%) subjects presented for re-testing. Of the 21 subjects assigned to the control group, 13 presented for re-testing.

Due to the large drop out, baseline characteristics were recalculated for the exercise subjects (n=13) and control subjects (n=13) who completed the study. There were no significant differences between the exercise and control groups at baseline (see Table 3). Notably subjects were still well matched for age and BMI.

Table 3: Mean (s.d.) physical characteristics for exercise and control subjects at baseline.

Characteristic	**Exercise Subjects** n=13	**Control Subjects** n=13	**Mean Difference** (95% Confidence Intervals)
Age (years)	63.1 (3.8)	63.0 (3.7)	0.1 (-3.0, 3.1)
Body Mass (kg)	78.6 (10.3)	81.7 (15.9)	-3.0 (-13.9, 8.0)
Height (cm)	153.8 (6.3)	156.7 (4.8)	-2.9 (-7.4, 1.8)
Body Mass Index (kg/m^2)	33.3 (4.5)	33.4 (6.9)	-0.1 (-4.8, 4.7)
Total Skinfold Thickness (mm)	95.8 (20.7)	104.2 (17.4)	-8.4 (-25.2, 8.4)
% Body Fat	36.1 (3.5)	36.9 (3.4)	-0.8 (-3.8, 2.2)
Systolic Blood Pressure (mmHg)	151.1 (29.5)	142.9 (20.1)	8.2 (-12.4, 28.8)
Diastolic Blood Pressure (mmHg)	85.1 (11.1)	84.0 (12.4)	1.1 (-8.5, 10.6)
Total Cholesterol ($mmol\ L^{-1}$)	5.8 (0.9)	5.8 (1.1)	0 (0.8, 0.9)

CHAPTER 4

RESULTS

SUBJECTS

Reasons for Drop Out

A total of ten, of the initial 23 exercise subjects, dropped out of the study. Eight subjects failed to attend the class and did not respond to any attempts made by the investigator to contact them to discover a reason for their failure to attend. Of the two other exercise subjects who did not complete the study, one moved house and the other sustained an injury outwith the exercise class. Thirteen (56.5%) subjects presented for re-testing.

Of the 21 subjects assigned to the control group, 13 presented for re-testing. There were various reasons for the remaining eight subjects failing to complete re-testing: deceased (one), family illness (one), initiating own exercise programme (one), family bereavement (one), appointment for re-testing but failed to keep appointment or make themselves available for rescheduling (four).

Adherence to the Exercise Class

The mean adherence rate of the 13 exercisers was 67.9% (range 21%-100%). Two subjects attended only 5 of a possible 24 sessions (21%) due to ill health. If their attendance figures are removed, the adherence rate increases to 76.5%.

STATISTICAL ANALYSIS OF THE DATA

Paired t-tests were carried out to investigate whether there was a mean improvement from test 1 to test 2 for each group separately.

Two sample t-tests were used to assess whether exercisers showed a greater average improvement over controls from test 1 to test 2.

Differences were deemed significant at the level of $p<0.05$.

Results are presented for each investigated variable in the same manner. The first table shows the mean score and standard deviation for each group at test 1 and test 2. Beneath the relevant table, box plots give a graphic display of the test 1 and test 2 scores for each graph. For each box plot the middle line shows the median, the bottom line signifies the 25th percentile and the top line the 75th percentile.

The second table for each variable shows the average improvement for each group from test 1 to test 2, the level of significance and the 95% confidence intervals for the difference.

The final table for each variable shows if the exercise group improved by a significantly greater amount compared with the control group between tests.

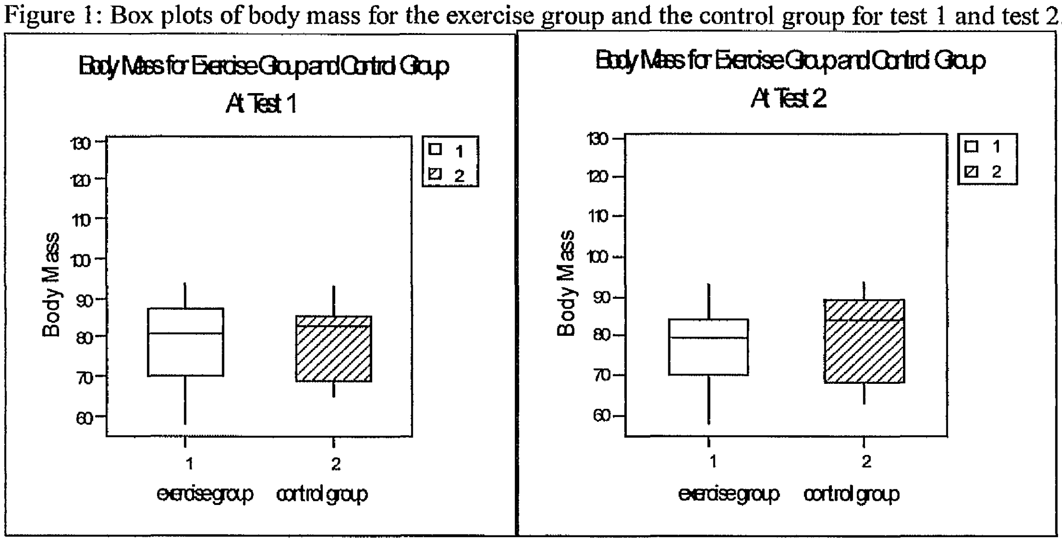
PHYSIOLOGICAL MEASURES

BODY MASS (Kilogrammes)

Table 4: Mean body mass and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group (n=13)	Test 1	78.7	10.3
	Test 2	77.0	10.3
Control Group (n=13)	Test 1	81.7	15.9
	Test 2	82.0	16.3

Figure 1: Box plots of body mass for the exercise group and the control group for test 1 and test 2.



BODY MASS (Kilogrammes)

Statistical Analysis:
Paired t-test and 95% Confidence Intervals

Table 5

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	1.7 (2.35)	2.6	0.023	(0.27, 3.11)
Control Group	-0.3 (2.57)	-0.38	0.71	(-1.82, 1.28)

Two Sample t-test of Differences and 95% Confidence Interval of
Average Improvement (Exercisers minus Controls)

Table 6

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	1.7	-2.03	0.054	(-0.04, 3.96)
Control Group	-0.3			

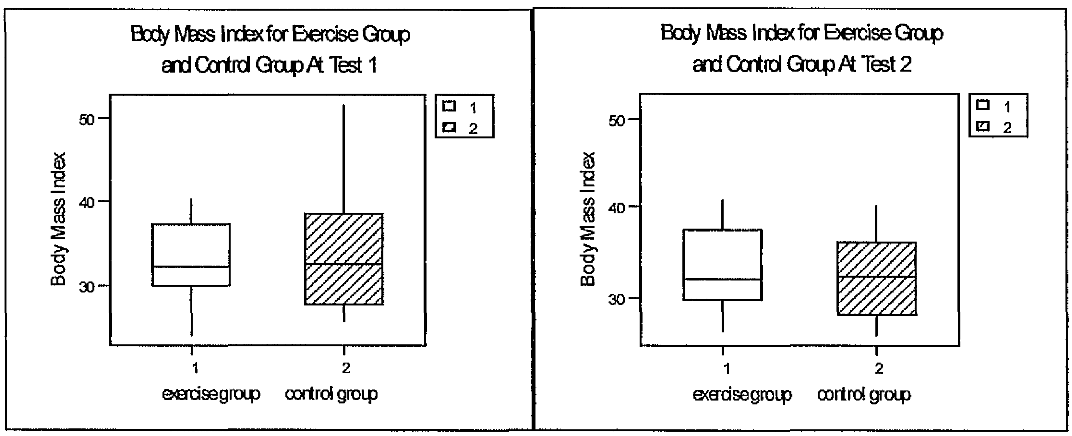
Although the exercise group decreased their body mass at test 2, a two sample t-test showed that this just failed to reach significance (table 6).

BODY MASS INDEX (kg/m^2)

Table 7: Mean body mass index and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group (n=13)	Test 1	33.3	4.5
	Test 2	32.7	4.6
Control Group (n=13)	Test 1	33.4	6.9
	Test 2	33.6	7.1

Figure 2:
Box plots of body mass index for the exercise group and the control group for test 1 and test 2.



BODY MASS INDEX (kg/m^2)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 8

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	0.6 (0.97)	2.19	0.049	(0.004, 1.181)
Control Group	-0.2 (1.31)	-0.53	0.61	(-0.982, 0.598)

Two Sample t-test of Differences and 95% Confidence Interval of Average Improvement (Exercisers minus Controls)

Table 9

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	0.6	-1.74	0.097	(-0.15, 1.72)
Control Group	-0.2			

As for body mass, despite the exercise group showing a trend to decrease their BMI (table 8), a two sample t-test showed that the exercise group had not significantly improved compared with the control group (p=0.097).

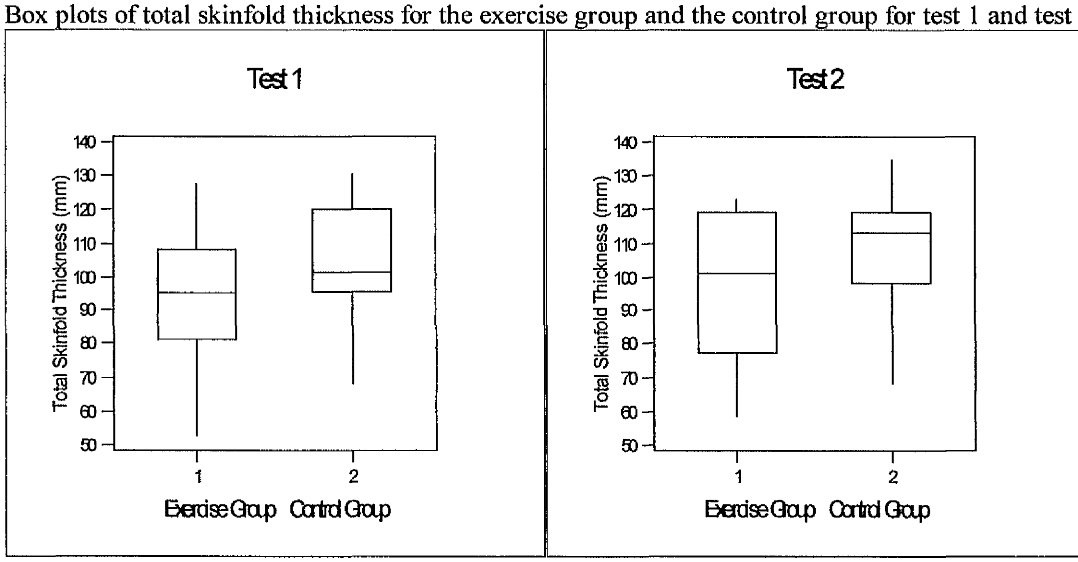
TOTAL SKINFOLD THCKNESS (mm)

Data was not available for 3 exercise subjects and 2 control subjects because skinfold measurements could not be taken at the supra-iliac site. This was due to the excess fat the subjects had in this area, resulting in the skinfolds not being able to fit the callipers.

Table 10: Mean total skinfold thickness and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group (n=10)	Test 1	95.8	20.7
	Test 2	96.8	22.8
Control Group (n=11)	Test 1	104.2	17.4
	Test 2	109.4	17.5

Figure 3:
Box plots of total skinfold thickness for the exercise group and the control group for test 1 and test 2.



TOTAL SKINFOLD THICKNESS (mm)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 11

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	-0.4 (11.4)	-0.12	0.91	(-8.61, 7.73)
Control Group	-6.7 (11.3)	-1.97	0.08	(-14.25, 0.89)

Two Sample t-test of Differences and 95% Confidence Interval of Average Improvement (Exercisers minus Controls)

Table 12

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	-0.4	-1.26	0.22	(-4.2, 16.7)
Control Group	-6.7			

Neither group reduced their total skinfold thickness from test 1 to test 2, as evidenced by paired t-tests (table 11). There was no significant difference between groups post-intervention (table 12).

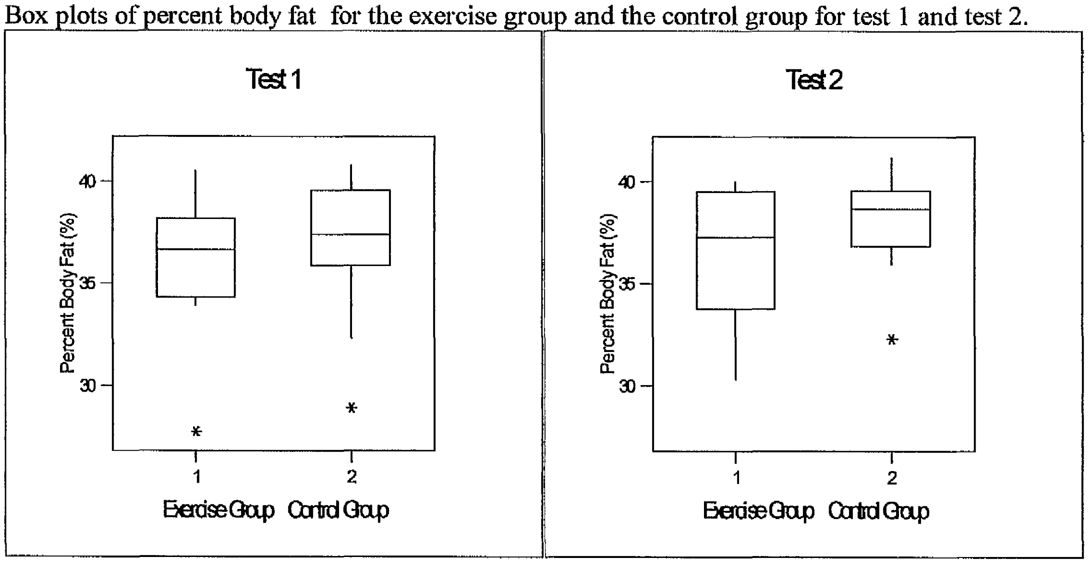
PERCENT BODY FAT (%)

The percent body fat could not be calculated for a total of 5 subjects (3 exercisers and 2 controls) as the assessor was unable to record measurements at all four skinfold sites (see page 55 for explanation).

Table 13: Mean body fat percentage and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group (n=10)	Test 1	36.1	3.5
	Test 2	36.4	3.4
Control Group (n=11)	Test 1	36.9	3.4
	Test 2	38.2	2.4

Figure 4:
Box plots of percent body fat for the exercise group and the control group for test 1 and test 2.



PERCENT BODY FAT (%)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 14

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	-0.24 (2.08)	-0.37	0.72	(-1.73, 1.25)
Control Group	-1.45 (2.43)	-1.98	0.08	(-3.09, 0.18)

Two Sample t-test of Differences and 95% Confidence Interval of Average Improvement (Exercisers minus Controls)

Table 15

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	-0.24	-1.23	0.23	(-0.86, 3.28)
Control Group	-1.45			

As expected, based on the skinfold thickness results, neither group decreased their percent body fat (table 14).

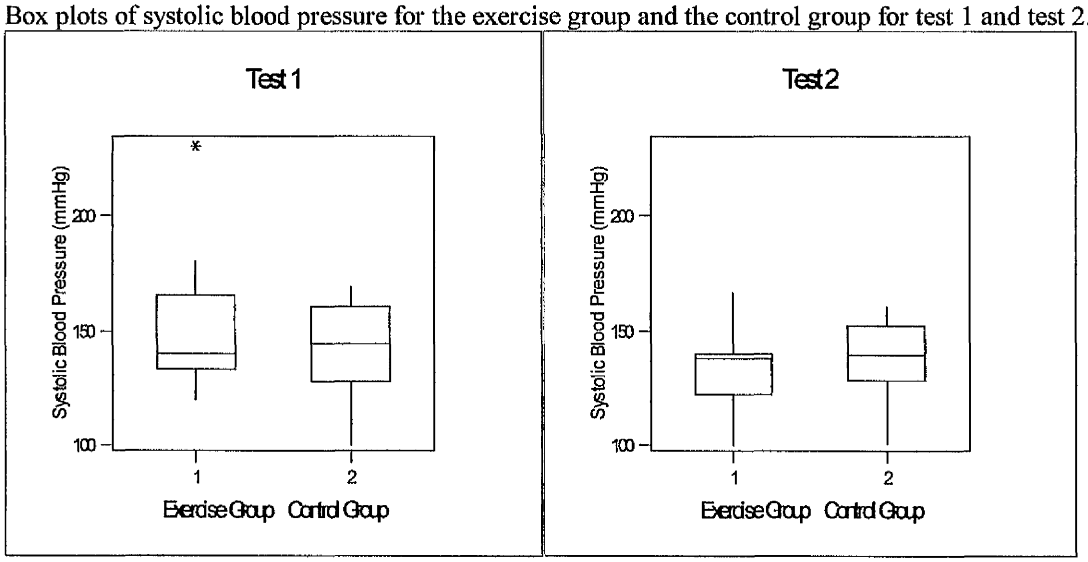
SYSTOLIC BLOOD PRESSURE (mmHg)

As outlined in the Methods section, the Practice Nurse took the blood pressure measurements (page 43). During baseline testing, the Practice Nurse was unable to record a blood pressure measurement for one of the control subjects.

Table 16: Mean systolic blood pressure and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group (n=13)	Test 1	151	29.5
	Test 2	134	15.8
Control Group (n=12)	Test 1	143	20.1
	Test 2	139	17.0

Figure 5:
Box plots of systolic blood pressure for the exercise group and the control group for test 1 and test 2.



SYSTOLIC BLOOD PRESSURE (mmHg)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 17

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	17.1 (23.9)	2.57	0.024	(2.6, 31.5)
Control Group	3.2 (18.9)	0.58	0.57	(-8.8, 15.2)

Two Sample t-test of Differences and 95% Confidence Interval of Average Improvement (Exercisers minus Controls)

Table 18

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	17.1	-1.62	0.12	(-3.9, 31.7)
Control Group	3.2			

The exercise group reduced their systolic blood pressure from 151mmHg to 134mmHg from test 1 to test 2 (table 16). Although the two sample t-test failed to show significance (p value 0.12), the 95% Confidence Interval, given in table 18, shows there was a positive trend.

It should be noted that, although the exercise group did not improve by a significant margin compared with the controls, the mean systolic blood pressure at test 2 is within the desired range for this physiological measure (Scottish Health Survey, 1995).

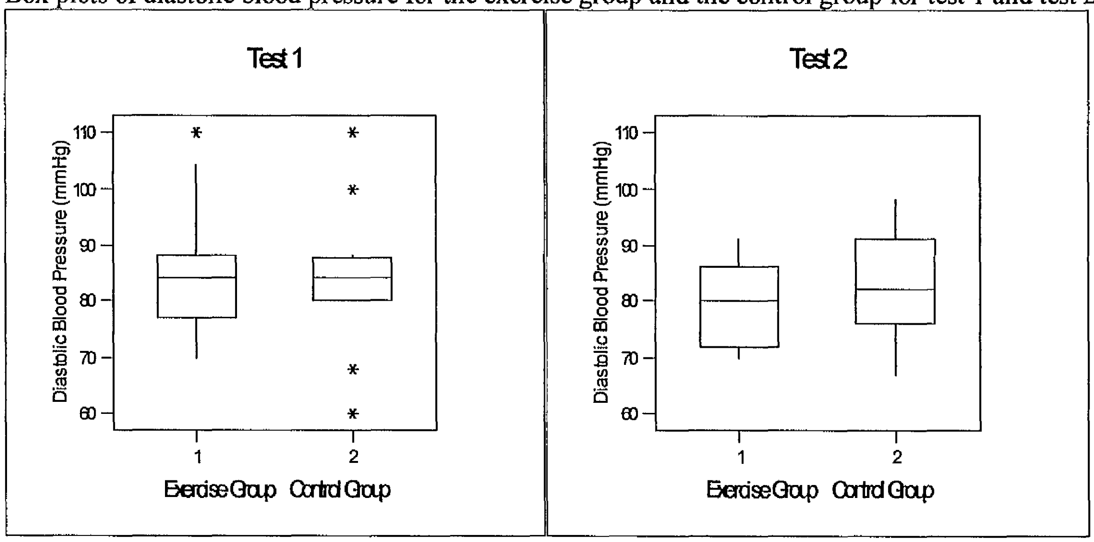
DIASTOLIC BLOOD PRESSURE (mmHg)

There are only diastolic blood pressure measurements for 12 control subjects for the reasons outlined previously (page 59).

Table 19: Mean diastolic blood pressure and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group (n=13)	Test 1	85	11.1
	Test 2	79	7.2
Control Group (n=12)	Test 1	84	12.4
	Test 2	82	9.6

Figure 6:
Box plots of diastolic blood pressure for the exercise group and the control group for test 1 and test 2.



DIASTOLIC BLOOD PRESSURE (mmHg)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 20

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	5.8 (9.1)	2.28	0.042	(0.2, 11.3)
Control Group	1.9 (7.7)	0.86	0.41	(-3.0, 6.8)

Two Sample t-test of Differences and 95% Confidence Interval of Average Improvement (Exercisers minus Controls)

Table 21

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	5.8	-1.14	0.27	(-3.2, 10.9)
Control Group	1.9			

Exercise subjects decreased their diastolic blood pressure measurement from 85mmHg at test 1 to 79mmHg at test 2 (table 19). Although a decrease was observed, when the mean difference for both groups was compared, there was no significant difference (table 21).

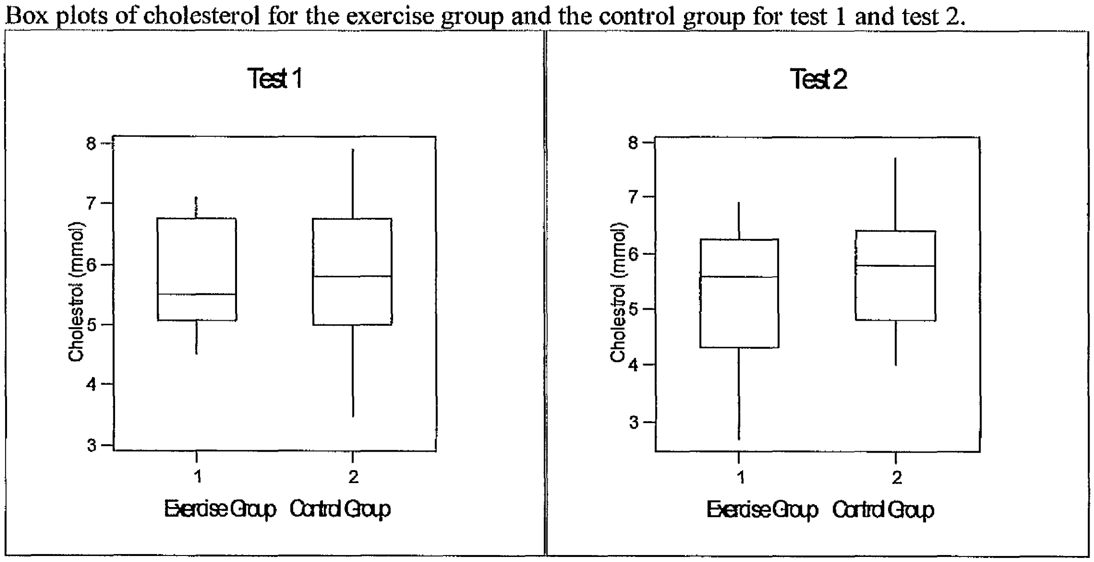
CHOLESTEROL (mmol L^{-1})

Similar to the blood pressure measurement, the Practice Nurse collected subjects' total cholesterol data. Two of the control subjects were unable to provide blood specimens for this measure.

Table 22: Mean total cholesterol and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group	Test 1	5.8	0.9
(n=13)	Test 2	5.3	1.3
Control Group	Test 1	5.8	1.1
(n=11)	Test 2	5.9	1.2

Figure 7:
Box plots of cholesterol for the exercise group and the control group for test 1 and test 2.



CHOLESTEROL (mmol L^{-1})

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 23

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	0.57 (1.60)	1.28	0.22	(-0.40, 1.54)
Control Group	-0.39 (0.91)	-1.42	0.18	(-1.00, 0.22)

Two Sample t-test of Differences and 95% Confidence Interval of Average Improvement (Exercisers minus Controls)

Table 24

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	0.57	-1.04	0.081	(-0.13, 2.05)
Control Group	-0.39			

Paired t-tests revealed that neither group had significantly reduced their total blood cholesterol. Indeed the control group showed a trend to increase their cholesterol reading (table 23).

Unsurprisingly, a two sample t-test showed there was no significant difference between groups (table 24).

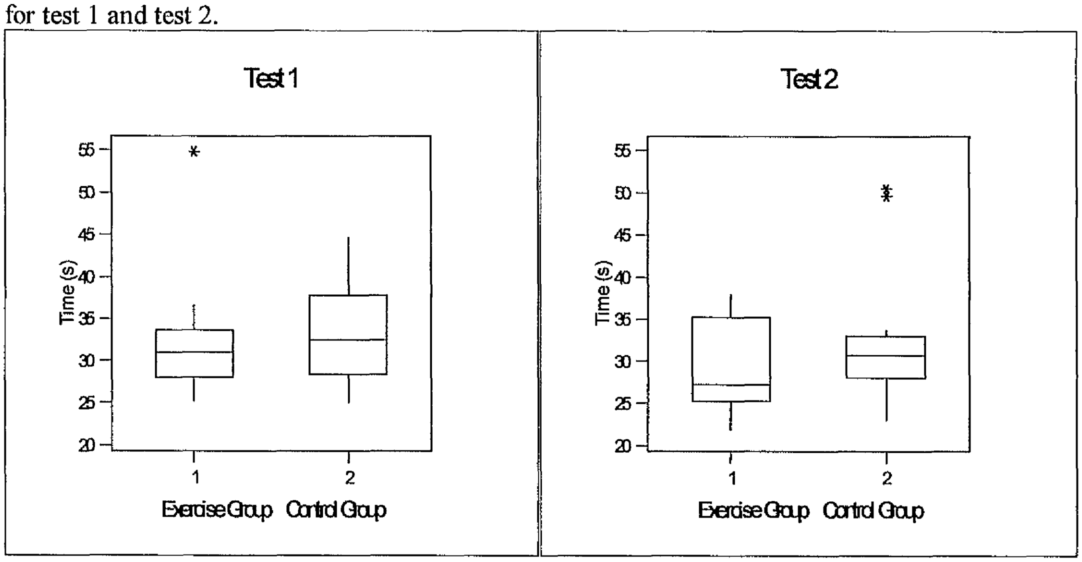
FUNCTIONAL STATUS MEASURES

CHAIR RISE x10 (seconds)

Table 25: Mean time for ten consecutive chair rises and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group (n=13)	Test 1	32.35	7.44
	Test 2	29.13	5.46
Control Group (n=13)	Test 1	33.22	5.98
	Test 2	32.61	8.26

Figure 8:
Box plots of time to complete ten consecutive chair rises for the exercise group and the control group for test 1 and test 2.



CHAIR RISE x10 (seconds)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 26

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	3.22 (6.13)	1.89	0.08	(-0.48, 6.93)
Control Group	0.61 (6.71)	-1.42	0.18	(-3.44, 4.67)

Two Sample t-test of Differences and 95% Confidence Interval of Average Improvement (Exercisers minus Controls)

Table 27

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	3.22	-1.04	0.31	(-2.6, 7.8)
Control Group	0.61			

Although the exercise group decreased the time taken to complete ten consecutive chair rises by over 3 seconds (table 25), a paired t-test showed that this just failed to reach significance (p value 0.08).

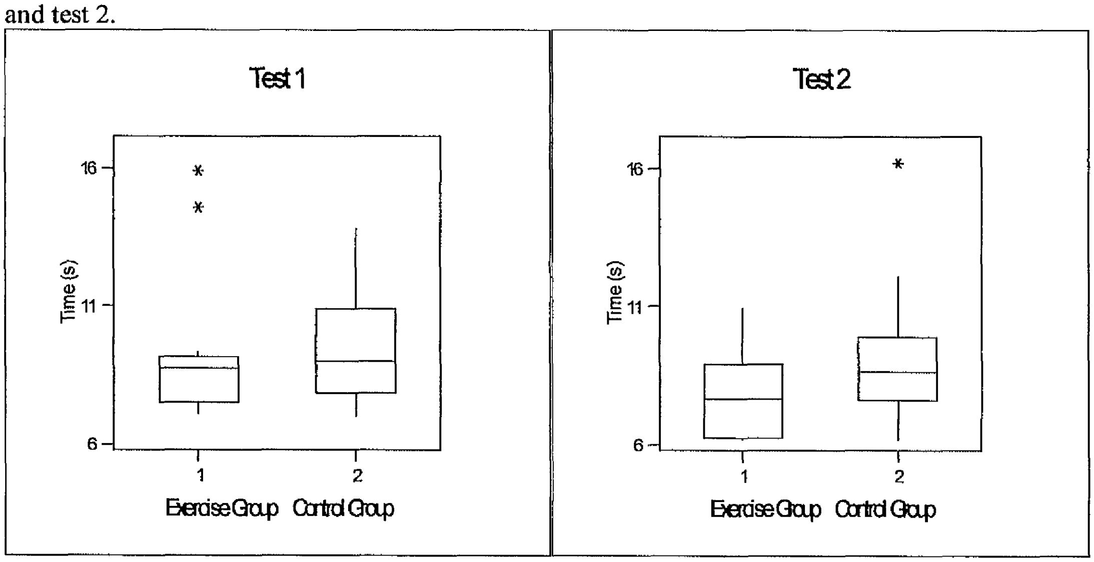
There was no significant difference between groups post-intervention (table 27).

"UP & GO TEST" (seconds)

Table 28: Mean time taken to complete "up & go" test and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group	Test 1	9.36	2.71
(n=13)	Test 2	7.86	1.60
Control Group	Test 1	9.50	2.00
(n=13)	Test 2	9.23	2.57

Figure 9:
Box plots of time to complete "up & go" test for the exercise group and the control group for test 1 and test 2.



"UP & GO TEST" (seconds)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 29

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	1.50 (1.67)	3.23	0.007	(0.49, 2.31)
Control Group	0.26 (1.87)	0.51	0.62	(-0.87, 1.40)

Two Sample t-test of Differences and 95% Confidence Interval of Average Improvement (Exercisers minus Controls)

Table 30

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	1.50	-1.77	0.09	(-0.21, 2.68)
Control Group	0.26			

After the exercise programme, exercisers decreased the time taken to complete the "up & go" test by 1.5 seconds. Conversely the control group failed to decrease their time for this test.

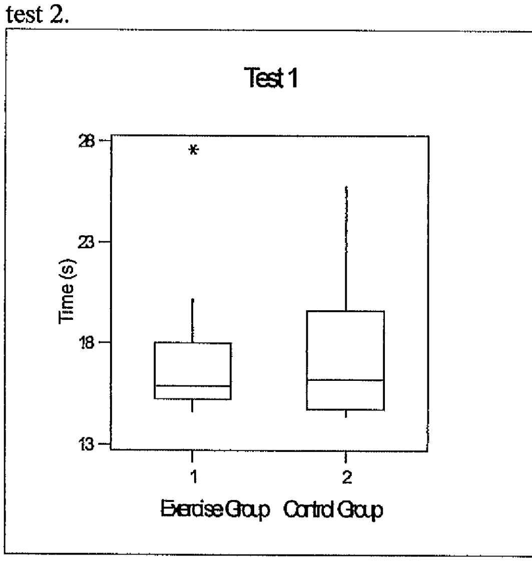
When the mean difference for each group was compared, it just failed to reach significance [95% Confidence Interval (-0.12, 2.68)].

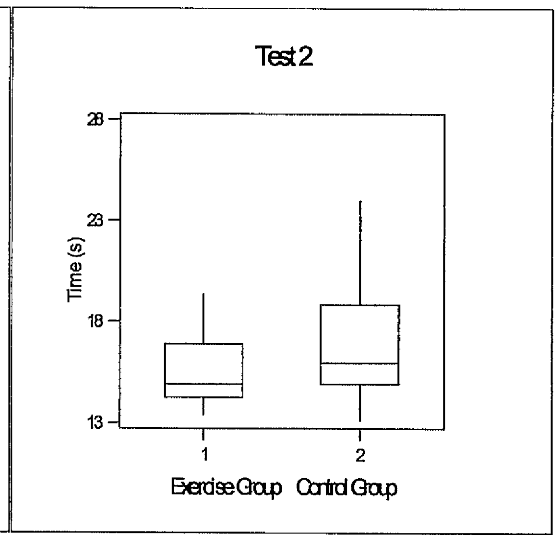
20M WALK (seconds)

Table 31: Mean time taken to complete a 20M walk and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group (n=13)	Test 1	17.35	3.45
	Test 2	15.68	1.73
Control Group (n=13)	Test 1	17.57	3.59
	Test 2	16.98	2.99

Figure 10:
Box plots of time to complete 20M walk for the exercise group and the control group for test 1 and test 2.





20M WALK (seconds)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 32

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	1.67 (2.56)	2.35	0.037	(0.12, 3.21)
Control Group	0.59 (2.75)	0.78	0.48	(-1.07, 2.26)

Two Sample t-test of Differences and 95% Confidence Interval of
Average Improvement (Exercisers minus Controls)

Table 33

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	1.67	-1.03	0.31	(-1.08, 3.23)
Control Group	0.59			

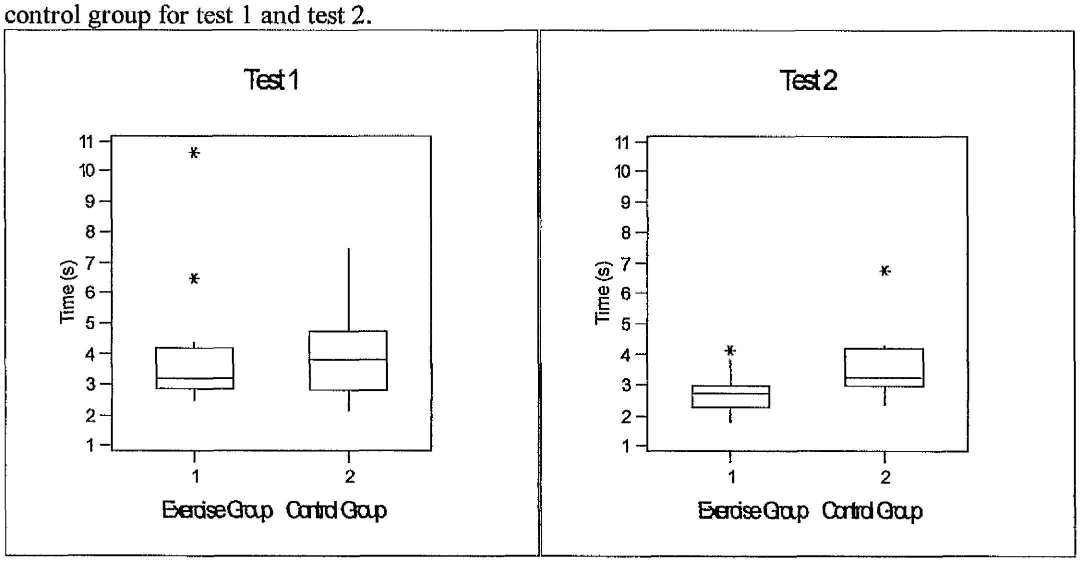
Post-intervention, the exercisers decreased the mean time to complete a 20metre walk by 1.67 seconds. A paired t-test showed there was a positive trend for this variable (table 32). However, comparison between groups showed that there was no significant difference at the end of the study period (p value 0.31).

1KG BAG LIFT - RIGHT ARM (seconds)

Table 34: Mean time and standard deviation (s.d.) to lift a 1kg bag onto a 1.83m shelf using the right arm only for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group (n=13)	Test 1	4.05	2.23
	Test 2	2.76	0.65
Control Group (n=13)	Test 1	3.89	1.43
	Test 2	3.82	1.42

Figure 11:
Box plots of time to lift 1kg bag onto a 1.34m shelf with the right arm for the exercise group and the control group for test 1 and test 2.



1KG BAG LIFT - RIGHT ARM (seconds)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 35

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	1.29 (1.99)	2.34	0.038	(0.09, 2.19)
Control Group	0.07 (1.45)	0.18	0.86	(-0.80, 0.95)

Two Sample t-test of Differences and 95% Confidence Interval of Average Improvement (Exercisers minus Controls)

Table 36

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	1.29	-1.78	0.089	(-0.20, 2.64)
Control Group	0.07			

Exercisers decreased the time taken to lift a 1kg bag onto a shelf with their right arm by over one second (table 35). In comparison, controls improved their time by an extremely small margin. However, when the mean difference of each group was compared, there was no significant difference (p value 0.089).

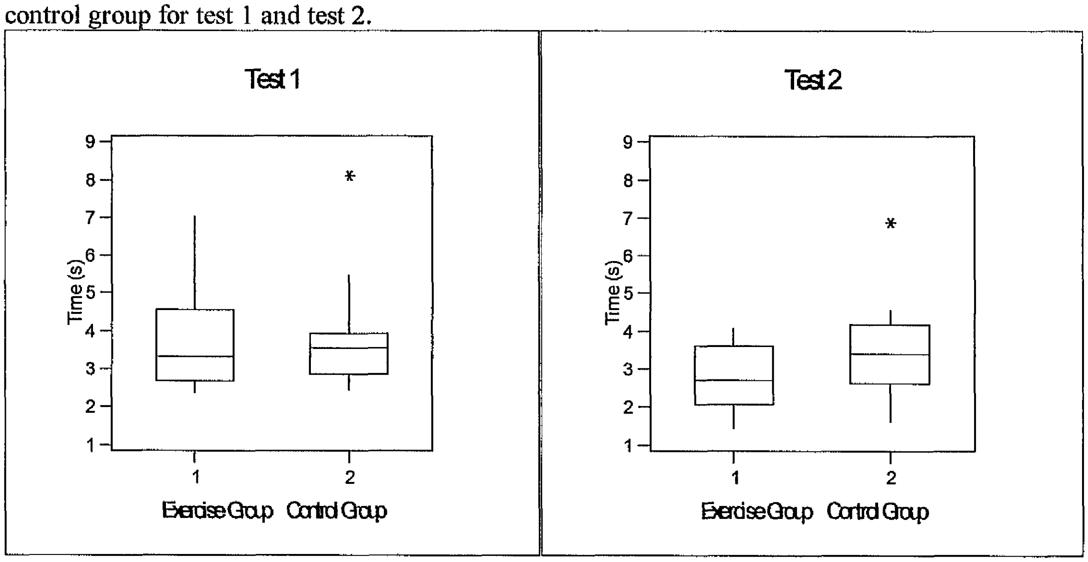
1KG BAG LIFT - LEFT ARM (seconds)

Data is missing for one exercise subject and one control subject as both were unable to reach the shelf. For the exercise subject, this was due to a shoulder injury sustained prior to baseline testing. The control subject had a residual weakness in her left shoulder.

Table 37: Mean time and standard deviation (s.d.) to lift a 1kg bag onto a 1.83m shelf using the left arm only, for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group (n=12)	Test 1	3.84	1.57
	Test 2	2.82	0.87
Control Group (n=12)	Test 1	3.77	1.34
	Test 2	3.57	1.29

Figure 12:
Box plots of time to lift 1kg bag onto a 1.34m shelf with the left arm for the exercise group and the control group for test 1 and test 2.



1KG BAG LIFT - LEFT ARM (seconds)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 38

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	0.68 (1.23)	1.92	0.08	(-0.10, 1.46)
Control Group	0.36 (0.85)	1.47	0.17	(-0.18, 0.90)

Two Sample t-test of Differences and 95% Confidence Interval of
Average Improvement (Exercisers minus Controls)

Table 39

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	0.68	0.74	0.47	(-0.58, 1.22)
Control Group	0.36			

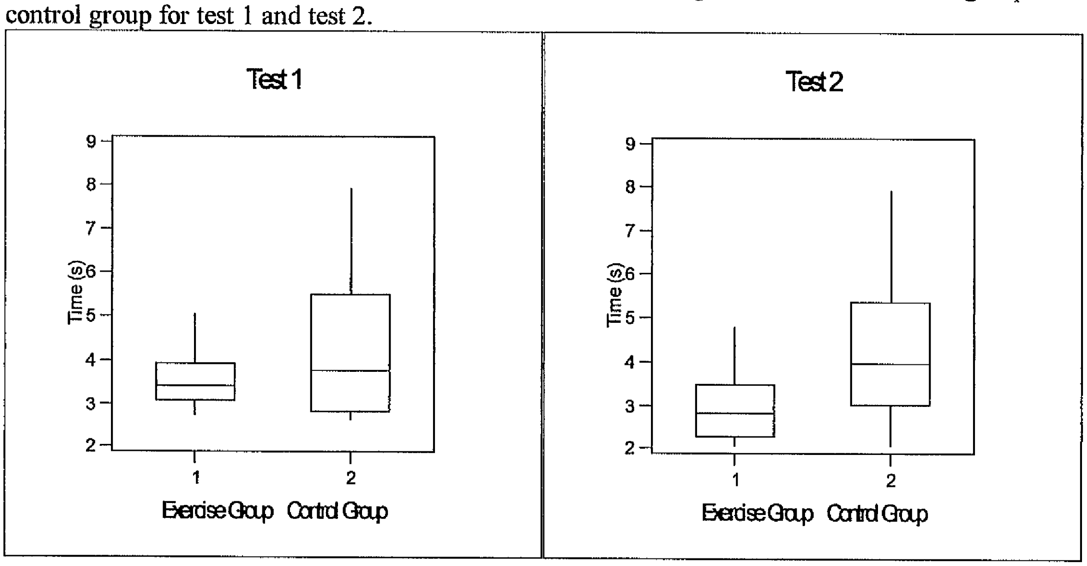
As for the right arm, exercisers showed a positive trend in this measure. However, there was no significant difference between groups (table 39).

2KG BAG LIFT - RIGHT ARM (seconds)

Table 40: Mean time and standard deviation (s.d.) to lift a 2kg bag onto a 1.83m shelf using the right arm only, for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group (n=13)	Test 1	4.01	2.05
	Test 2	2.97	0.78
Control Group (n=13)	Test 1	4.33	1.63
	Test 2	4.27	1.66

Figure 13:
Box plots of time to lift 2kg bag onto a 1.34m shelf with the right arm for the exercise group and the control group for test 1 and test 2.



2KG BAG LIFT - RIGHT ARM (seconds)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 41

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	1.04 (1.55)	2.44	0.03	(0.11, 1.98)
Control Group	0.06 (1.39)	0.16	0.88	(-0.78, 0.90)

Two Sample t-test of Differences and 95% Confidence Interval of Average Improvement (Exercisers minus Controls)

Table 42

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	1.04	-1.71	0.10	(-0.21, 2.18)
Control Group	0.06			

Although paired t-tests revealed that exercisers had significantly decreased the time taken to lift a 2kg bag onto a shelf with the right arm and controls had not, comparing the mean difference between groups just failed to reach significance [95% Confidence Interval (-0.21, 2.18)].

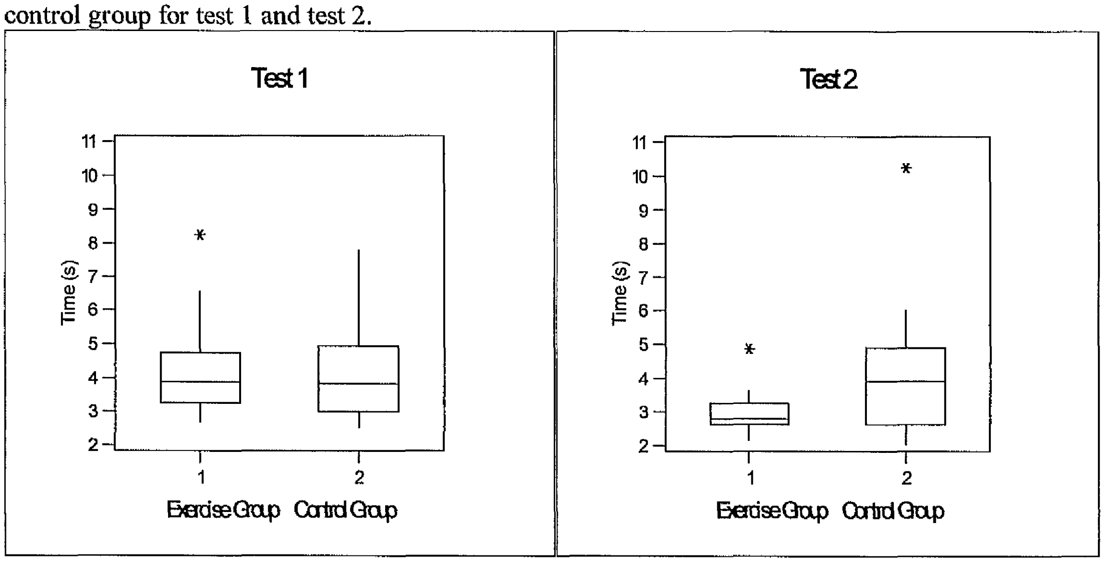
2KG BAG LIFT - LEFT ARM (seconds)

As for the 1kg bag lift with the left arm, a member of each group was unable to complete this test (page 73).

Table 43: Mean time and standard deviation (s.d.) to lift a 2kg bag onto a 1.83m shelf using the left arm only, for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group	Test 1	4.16	1.46
(n=12)	Test 2	3.04	0.70
Control Group	Test 1	4.28	1.57
(n=12)	Test 2	4.20	2.17

Figure 14:
Box plots of time to lift 2kg bag onto a 1.34m shelf with the left arm for the exercise group and the control group for test 1 and test 2.



2KG BAG LIFT - LEFT ARM (seconds)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 44

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	0.91 (1.09)	2.89	0.02	(0.22, 1.61)
Control Group	-0.06 (1.32)	-0.17	0.87	(-0.90, 0.77)

Two Sample t-test of Differences and 95% Confidence Interval of
Average Improvement (Exercisers minus Controls)

Table 45

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	0.91	1.98	0.061	(-0.05, 2.00)
Control Group	-0.06			

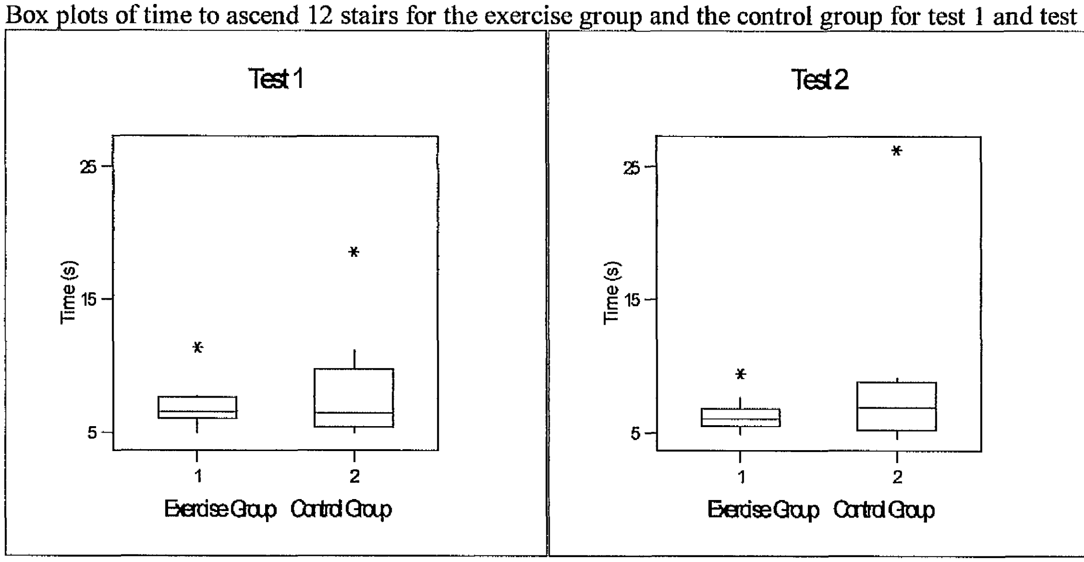
As for the other bag lift tests, exercise subjects decreased the time taken to lift a 2kg bag onto a shelf with the left arm (table 44). Although a two sample t-test failed to reach significance, the 95% Confidence Interval only just contained zero (-0.05, 2.00) demonstrating a positive trend.

STAIR CLIMB - ASCENT (seconds)

Table 46: Mean time to climb 12 stairs and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group (n=13)	Test 1	6.98	1.55
	Test 2	6.36	1.21
Control Group (n=13)	Test 1	8.06	3.78
	Test 2	8.15	5.69

Figure 15:
Box plots of time to ascend 12 stairs for the exercise group and the control group for test 1 and test 2.



STAIR CLIMB - ASCENT (seconds)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 47

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	0.62 (0.77)	2.92	0.013	(0.16, 1,09)
Control Group	-0.09 (2.93)	-0.11	0.91	(-1.86, 1.68)

Two Sample t-test of Differences and 95% Confidence Interval of
Average Improvement (Exercisers minus Controls)

Table 48

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	0.62	-0.85	0.41	(-1.10, 2.53)
Control Group	-0.09			

Exercise subjects recorded a mean decrease of 0.62seconds to climb 12 stairs (table 47). A paired t-demonstrated a positive trend. Conversely, control subjects marginally increased their mean time to compete this task.

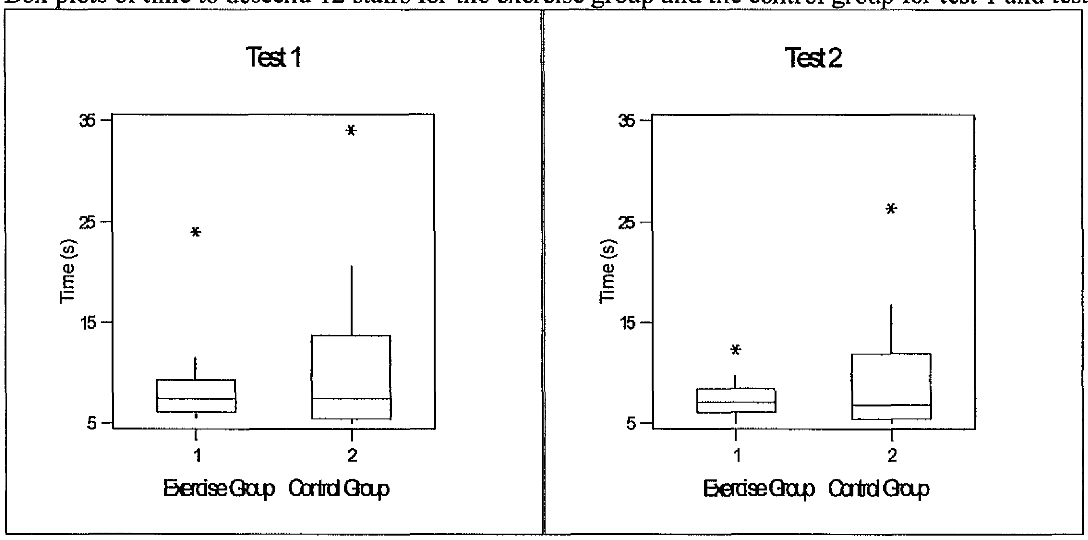
However, the exercise group did not decrease their time by a statistically significant time compared with the controls (table 48).

STAIR CLIMB – DESCENT (seconds)

Table 49: Mean time to descend 12 stairs and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group	Test 1	8.96	4.80
(n=13)	Test 2	7.52	1.93
Control Group	Test 1	10.88	8.41
(n=13)	Test 2	9.55	6.17

Figure 16:
Box plots of time to descend 12 stairs for the exercise group and the control group for test 1 and test 2.



STAIR CLIMB – DESCENT (seconds)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 50

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	1.44 (3.13)	1.66	0.12	(-0.43, 3.33)
Control Group	1.33 (4.28)	1.12	0.28	(-1.25, 3.92)

Two Sample t-test of Differences and 95% Confidence Interval of Average Improvement (Exercisers minus Controls)

Table 51

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	1.44	-0.07	0.94	(-2.95, 3.20)
Control Group	1.33			

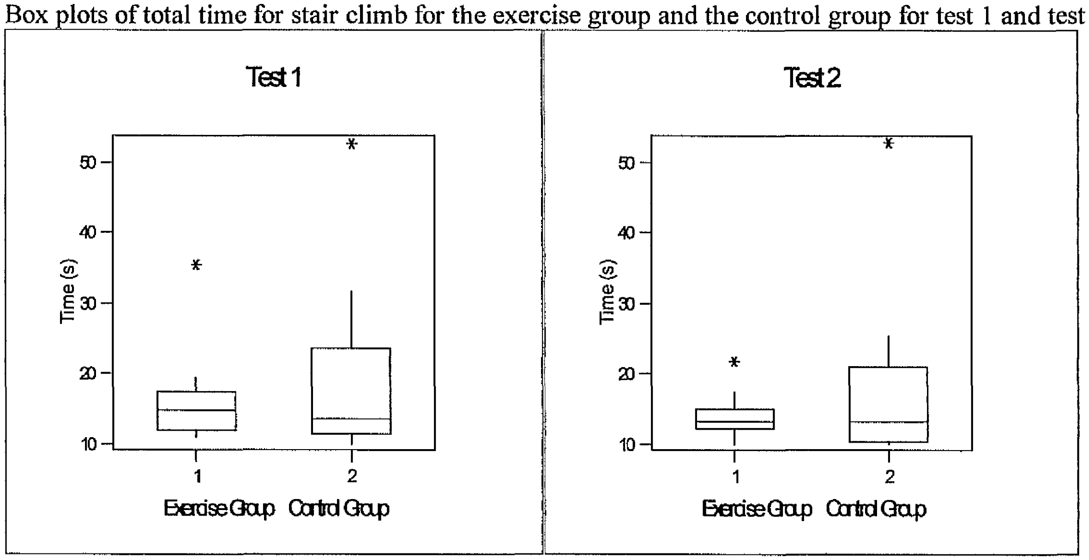
Neither group managed to decrease the time taken to descend a set of 12 stairs by a significant margin (table 50). There was no significant difference between groups (table 51).

STAIR CLIMB – TOTAL (seconds)

Table 52: Mean total time for stair ascent and descent and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group (n=13)	Test 1	16.17	6.28
	Test 2	13.88	3.07
Control Group (n=13)	Test 1	18.90	12.1
	Test 2	17.70	11.7

Figure 17:
Box plots of total time for stair climb for the exercise group and the control group for test 1 and test 2.



STAIR CLIMB - TOTAL

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 53

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	2.29 (3.70)	2.24	0.04	(0.06, 4.53)
Control Group	1.23 (5.58)	-0.86	0.41	(-3.03, 4.12)

Two Sample t-test of Differences and 95% Confidence Interval of
Average Improvement (Exercisers minus Controls)

Table 54

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	2.29	-0.57	0.57	(-2.8, 4.9)
Control Group	1.23			

The exercise group decreased the total time to ascend and descend a set of 12 by over 2 seconds. However the control group also decreased the mean time taken to complete this test, hence there was no significant difference between groups post-intervention (table 54).

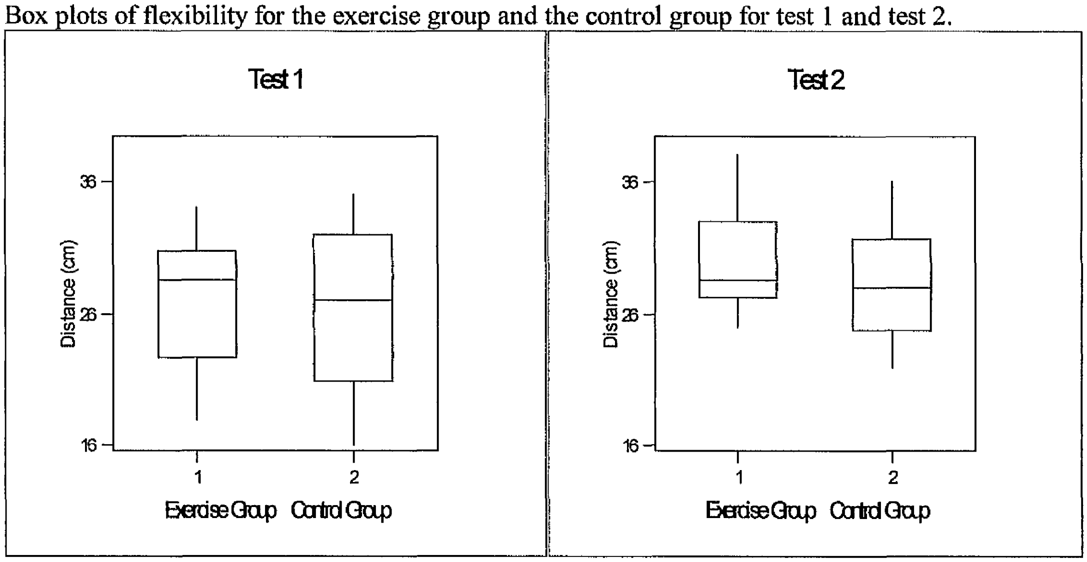
FLEXIBILITY (centimetres)

Four members of each group were unable to complete the flexibility test as it required them to sit on the floor and they reported they would be unable to rise from this position (even with assistance).

Table 55: Mean flexibility sit and reach score and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group (n=9)	Test 1	27.13	5.19
	Test 2	29.88	4.19
Control Group (n=9)	Test 1	26.56	6.27
	Test 2	28.30	4.52

Figure 18:
Box plots of flexibility for the exercise group and the control group for test 1 and test 2.



FLEXIBILITY (centimetres)

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 56

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	2.75 (4.83)	-1.61	0.15	(-1.29, 6.79)
Control Group	1.67 (3.54)	-1.41	0.20	(-1.05, 4.39)

Two Sample t-test of Differences and 95% Confidence Interval of
Average Improvement (Exercisers minus Controls)

Table 57

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	2.75	0.52	0.61	(-3.4, 5.6)
Control Group	1.67			

Both groups slightly improved their flexibility scores (table 56) although neither group reached significance. As expected, there was no significant difference between groups post-intervention (table 57).

PSYCHOLOGICAL MEASURE

LIFE SATISFACTION INDEX

Table 58: Mean Life Satisfaction Index score and standard deviation (s.d.) for the exercise and control group at Test 1 and Test 2.

		Mean	s.d.
Exercise Group	Test 1	12.0	5.85
(n=13)	Test 2	15.2	3.58
Control Group	Test 1	13.5	4.42
(n=13)	Test 2	12.8	5.64

LIFE SATISFACTION INDEX

Statistical Analysis
Paired t-test and 95% Confidence Intervals

Table 59

	Mean Difference (s.d.)	t	P Value	95% Confidence Interval
Exercise Group	3.15 (3.58)	3.18	0.008	(0.99, 5.32)
Control Group	-0.67 (2.15)	-1.08	0.30	(-2.03, 0.70)

Two Sample t-test of Differences and 95% Confidence Interval of
Average Improvement (Exercisers minus Controls)

Table 60

	Mean Difference	t	P Value	95% Confidence Interval
Exercise Group	3.15	3.27	0.0041	(1.37, 6.27)
Control Group	-0.67			

Th exercise group improved their Life Satisfaction Index (LSI) score from test 1 to test 2 (table 59) to a statistically significant level (p value 0.008). Conversely the control group slightly decreased their score in this psychological measure.

When the mean difference between groups was compared using a two sample t-test, the exercise group were found to have improved their LSI score by a significantly greater margin (p value 0.004).

CHAPTER 5

DISCUSSION

A group of thirteen, overweight females (mean age 63.0 years) participated in a twice weekly exercise class for 12 weeks. A control group, of 13 subjects (mean age 63.1 years), remained sedentary throughout the duration of the study. Both groups attended a Weight Reduction Clinic held in their General Practice. Statistical analysis showed that there were no significant differences between groups for any variable at baseline.

Comparison of pre-and post-intervention results found that, when compared with the control group, the exercise group recorded a significant improvement in Life Satisfaction Index (p value 0.004), only. Comparison neared significance in several physiological measures (body mass (kg/m^2) (95% CI [-0.04, 3.96]), systolic blood pressure (mmHg) (95% CI [-3.9, 31.7]) and total blood cholesterol ($mmol\ L^{-1}$) (95% CI [-0.13, 2.05])), and functional status measures ('up & go' test (s) (95% CI [-0.21, 2.68]), 1kg bag lift with the right arm (s) (95% CI [-0.20, 2.64]) and 2kg bag lift with the left (s) (95% CI [-0.05, 2.00]) and right arm (s) (95% CI [-0.21, 2.18])).

The results for individual variables shall be discussed below and, where possible, explanations offered for observations recorded.

PHYSIOLOGICAL MEASUREMENTS

Body Mass

The present study found that after twelve weeks of twice weekly exercise sessions and dietary restriction, the intervention group had lost, on average, 1.7 kg which was found to be a significant loss within the group (p value 0.023). However when the mean change from test 1 to test 2 was compared for the two groups, the difference just failed to reach significance (p value 0.054).

Several studies incorporating regular exercise and dietary restriction have found a similar or, more commonly, a greater amount of weight loss (Ohta et al, 1990; Shinkai et al, 1994; Svendsen et al, 1993; Sweeney et al, 1993). However, it remains difficult to compare results directly as the duration of the intervention differed in some instances (Ohta et al, 1990), and the number of exercise sessions per week ranged from 3 times per week to daily. Hence exercise subjects in these studies would have had a greater energy expenditure than the subjects in the present study, which may account for the larger weight loss observed elsewhere. Additionally, dietary restriction was more strictly monitored in previous interventions. In the present study, all subjects received dietary advice from the Practice Nurse as part of their general practice Weight Reduction Clinic as opposed to being given meal replacements (Leutholtz et al, 1995), a structured diet plan to follow (Sweeney et al, 1993) or being treated as an inpatient at a clinic (Zahorska-Markiewicz, 1981). While these studies gained positive results in terms of weight loss, they offered little choice of meals. It was decided that, in order to increase the likelihood of a long term behaviour change, subjects should be taught ways in which to improve their diet (e.g. through changing cooking methods, increasing fruit and vegetable consumption, and decreasing energy intake from fats).

Adherence to diet was checked verbally by the Practice Nurse, however subjects were not asked to record their energy intake. It is acknowledged that this may have adversely affected the results.

It could be hypothesised that, had the protocol recommended exercise three times per week, the exercise group would have had a greater energy expenditure and hence lost more weight during the intervention period. However, an important aspect of the present study was to devise an exercise regime that would be palatable, acceptable and effective in this population. After discussion with the primary care health professionals from the intervention general practice, the opinion was formed that anything more frequent than two exercise sessions per week would affect the adherence of the exercise group and possibly increase drop out rate. Additionally, it was thought that as the exercise group was starting with such a low fitness level, two exercise sessions per week would be a sufficient stimulus to solicit an improvement in the measured variables.

Body Mass Index

As expected with the observed loss in mean body mass, there was a concomitant reduction in BMI for the exercise group when the results for this group were compared pre- and post-intervention. However, although a reduction in body mass and BMI for the exercise subjects was observed, this relates to a modest weight loss in real terms of 1.7kg on average.

It should be noted that both groups of subjects remained in the category defined as obese (i.e. BMI$\geq$30) and hence were still at increased risk of a variety of chronic conditions including coronary heart disease and hypertension (Hseuh and Buchanan, 1994; Wing and Jeffery, 1995). Therefore, although positive trends were observed at the end of the intervention, the duration of the study would require to be extended to provide the necessary stimulus to lower the health risk of obesity.

Skinfold Thickness and Percent Body Fat

Although exercise subjects did decrease their body mass during the twelve week intervention, measurement of body fat using skinfold thickness failed to show an improvement. In fact both groups actually showed a trend to increase the recorded total of skinfold thicknesses. This result was not expected as it is well documented that exercise promotes the loss of fat mass while preserving fat free mass (Evans et al, 2001; Garrow and Summerbell, 1995; Hagan, 1988; Leutholtz et al, 1995; Shinkai et al, 1994; Svendsen et al, 1993; Walberg, 1989; Wood, 1996). However, as was noted above, there was only a small loss in body mass in the exercise group which was possibly too small to translate to an improvement in percent body fat.

While the effect of regular exercise on percent body fat has been investigated in several studies (Katoh et al, 1994; Ohta et al, 1994; Schaberg-Lorei, et al, 1990; Shinkai et al, 1994; Svendsen et al, 1993; Sweeney et al, 1993), few interventions have measured body fat using skinfold thickness (Ohta et al, 1994; Schaberg-Lorei et al, 1990). Direct comparison between these studies and the present proved impossible due to lack of information given, or differing methods used, in the aforementioned studies.

Anecdotally, skinfold thicknesses are more difficult to measure accurately in an individual of greater fat mass. Additionally, it is more difficult to separate fat from muscle in an obese subject which is essential to obtain accurate readings from skinfold callipers. The tester reported particular difficulty in measuring the supra-iliac skinfold as some subjects had “too many skinfolds” to fit in the callipers (as evidenced by the five subjects for whom a measure of percentage body fat is not recorded due an inability to record a skinfold measure at the supra-iliac site). This finding is supported by Garrow (1988) who reported the difficulty in measuring the supra-iliac site in obese subjects. Consequently, it may have been more accurate to use other methods of measuring body fat such as hydrostatic weighing. However, as testing took place in a general practice, the skinfold technique was considered to be the best method which could be used in such a ‘field’ setting.

Blood Pressure

The exercise group decreased their systolic and diastolic blood pressure measurements from test 1 to test 2 by 17.1mmHg and 5.8mmHg, respectively. This resulted in the mean systolic blood pressure for the exercise group decreasing from 151mmHg to 134mmHg (a decrease of 11.3%). The observed lower value at test 2 is regarded as being within a desirable range, and lower than the mean value found in the Scottish Health Survey (1995), for the equivalent age group of 55-64 years, recorded as 139mmHg. Similarly, although not as conclusively, the reduction in diastolic blood pressure moved the exercise group toward a more desirable value, by going from 85mmHg to 79mmHg, translating to a decrease of 7.1%.

The observed reduction of blood pressure was greater than expected as weight loss was modest when considering it has been documented frequently that it is necessary to reduce weight by 10%-15% to receive physiological benefits and a reduction in cardiac risk factors, including a reduction in blood pressure (Hseuh and Buchanan, 1994; Wing and Jeffery, 1995). It is possible that the combined effects of aerobic exercise and weight loss resulted in the observed decrease in blood pressure in the intervention group. However it cannot be discounted that subjects' familiarity with the assessment procedures and the assessor at test 2 may have contributed to the observed decrease in blood pressure.

A similar large improvement in blood pressure was found by Katoh and colleagues (1994) where a decrease in systolic blood pressure from 146.9mmHg to 122.9mmHg (16.3%) was found. Again, in keeping with the present results, diastolic blood pressure was lowered from 89.5mmHg to 77.8mmHg, equivalent to a decrease of 13.1%. However there is a substantial difference in total volume of exercise between the interventions with Katoh's subjects undertaking two hours of aerobic exercise daily while the present population completed only two, thirty minute sessions per week. While it has to be noted that Katoh's cohort saw a more favourable reduction in body mass index (32.4 to 29.0), the frequency and duration of exercise was extreme and is very unlikely an exercise prescription that would be adhered to in the long term.

Cholesterol

Although neither group showed a significant improvement in total cholesterol between tests, the exercise group showed a mean decrease of 8.6% while the control group showed a trend toward increasing their cholesterol. As a result, the two sample t-test neared significance (95% CI [-0.13, 2.05]). At test 2 the exercise group had a cholesterol of 5.3mmol L^{-1}, which is just outside the desirable range of 5.2mmol L^{-1} or less (Gregory et al, 1990; Scottish Health Survey, 1995), and is actually less than the national average for females aged 50-64 years which was reported in the Scottish Health Survey (1995) as being 6.8mmol L^{-1}.

Such findings are in keeping with similar studies where regular aerobic exercise and weight loss have been shown to reduce total cholesterol (Ohta et al, 1990).

It seems plausible that the exercise group did not lose a sufficient amount of weight to influence total cholesterol. Additionally it is accepted that dietary modification, along with weight loss, is necessary for an improvement in cholesterol (Hagan, 1988).

It has been reported (Hagan, 1988) that any intervention seeking to improve total cholesterol would need to be of at least twelve weeks duration. The present intervention was at the minimum end of this criteria/time range. If the study had been of longer duration it is possible that the trend in reduction would continue to a significant level or at least to within a desirable range. It also remains possible that the subjects' initial cholesterol values for were not high enough to allow sufficient room for improvement (Hagan, 1988).

It is acknowledged that the subjects in the current study did not fast prior to the cholesterol measurement. Due to the constraints of carrying out the assessment procedures in the general practice setting, testing could not be carried out in the morning. It was felt that it would be unfair to ask subjects to fast for 10 hours prior to testing and that this would decrease the number of subjects willing to participate. The author consulted with the Biochemistry Lipid Specialist at the Western Infirmary, Glasgow, who confirmed that it was not essential to have subjects in the fasted state to determine if the exercise intervention had an effect on total cholesterol levels (Pettigrew, personal communication).

Conclusion

Several physiological measurements showed a trend toward improvement when compared with the controls (body mass, systolic blood pressure and cholesterol) which, while in keeping with other weight reduction and exercise studies, show that the present study was not just as effective as these similar interventions. Therefore, based upon the methodology of these authors, it seems plausible to suggest that the results would have been more favourable had the duration of the study, or the intensity or frequency of the exercise sessions, been increased. As mentioned earlier, the present investigator, after consultation with primary care staff, had decided that to increase the frequency of the exercise sessions would be to the detriment of the adherence of the exercise group. It is acknowledged, however, that it would have been advisable to monitor and record the intensity at which subjects exercised at regular intervals throughout the duration of the study.

FUNCTIONAL STATUS MEASUREMENTS

Exercise subjects showed a trend to improving their scores as a result of exercise training in the majority of functional status measures. However when the average difference for each test in the exercise group was compared with the average difference in the control group for each variable, it was found that the exercisers had failed to improve by a significantly greater margin. It should be noted that several tests showed trends of improvement and neared significant differences in: time to complete the "up & go" test ($p=0.09$); time to place a 1kg bag onto a 1.34 metre high shelf with the right arm ($p=0.09$); and the same test with a 2kg bag with the right arm ($p=0.10$) and left arm ($p=0.06$).

The exercise class was designed to maximise the training potential of certain functional status measures, e.g. squats were included in the muscular strength and endurance section to improve subjects' performance in chair rises and stair climbing. Conversely, controls were instructed not to practise moves similar to the functional variables measured in the present study.

Chair Rise

To maintain an independent lifestyle an individual must be able to complete certain essential tasks, such as rising from a chair or toilet, and climbing stairs. Hence the chair used in this assessment was of height 43cm as this is the British standard height of a toilet, with small amount added on for a seat.

Csuka and McCarty (1985) standardised this test in a large sample of healthy adults ranging in age from 20-85 years, regarding it as a "simple, rapid and reproducible method for quantification of lower extremity strength". They found that weight was related to the time taken to complete the task after adjusting for age, but that this effect, while significant ($p<0.05$), was slight compared with the effect of age alone ($p<0.0001$). The authors found that the mean time to complete ten consecutive chair rises for 60 year old and 65 years old females was 17.6s and 18.4s, respectively. As can be seen in Table 25, the present group of females (mean age 63 years) took considerably longer to complete this task, even after 12 weeks of exercise training (post-intervention times: exercise group 29.1s, control group 32.6s). These times would be considered to be "abnormal" by Csuka and McCarty who stated that the upper 5% times should be taken as the cut-off point differentiating between a normal or abnormal performance. The authors defined an abnormal time for 60 year old females as 22.6s and 23.5s for 65 years old females; times the present female cohort failed to reach even after training.

The raw data presented in table 25 shows that the exercise group were able to perform ten consecutive chair rises over 3 seconds faster after training. The failure of the exercise group to reach significance when compared with the control group is comparable with the only other study to have measured the time taken to complete a similar number of chair rises (Skelton and McLaughlin, 1996). It was not possible to compare the time taken for this task post-intervention as Skelton and McLaughlin presented their data in the form of mean percentage change. However, pre-training times of 27.5s for the exercise group and 33.1s for the control group were comparable only with the control group in the present study. It would be expected that the exercise subjects in Skelton and McLaughlin's study would have improved by a greater margin as their protocol incorporated actual chair rises as part of the exercise class in an effort to maximise the training effect. While the exercise class in the present study incorporated movements designed to simulate functional tasks, this would not be as effective as practising the task itself (Sale and MacDougall, 1985). Additionally, Skelton and McLaughlin, as well as other, similar studies, used resistance training only and, hence, spent more time training muscle strength and endurance in comparison with the present study.

Other studies concentrating on resistance training in a class-based exercise programme have looked at the effect of training on chair to stand time (Binder et al, 1994; Gillies et al, 1999; McMurdo and Rennie, 1993), triple chair rise time (Gillies et al, 1999) and time to complete five consecutive chair rises (Binder et al, 1994). In all cases the exercise group improved their performance.

Although Csuka and McCarty (1985) describe the chair rise test as a method for quantifying lower extremity strength, it could be argued that completing ten consecutive chair rises is a measure of muscular endurance. In addition, the excess body weight of the present subjects would have increased the difficulty of this test.

"Up & Go" Test

The exercise group managed to decrease the time taken to rise from a chair, walk 3 metres, turn and return to a seated position in the chair from test 1 to test 2. However, when compared with the change in the control group, there was no significant difference although the 95% confidence interval only just contained zero, (-0.21, 2.68), showing that there was a trend toward a significant improvement.

Skelton and McLaughlin (1996) also found that their exercise group decreased the time taken to perform the "up & go" test having completed eight weeks of moderate intensity resistance training, three times per week.

20 Metre Walk

Post-intervention, the exercise group was able to complete a 20m walk in a faster time, although the control group failed to record a similar improvement (Table 31). However there was no significant difference between groups at re-testing. This failure to show a significant improvement could possibly be explained by the fact that the exercise class did not incorporate any specific advice or practise of walking this distance. Additionally, due to the low socio-economic status of the area of Glasgow in which the intervention took place, car ownership is low compared to areas of higher SES (GGHB Report, 1985). Therefore, it could be expected that walking would be a common mode of transport in the present cohort. Informal discussion with subjects showed this to be the case.

While other studies have timed walks (Skelton and McLaughlin, 1996; Binder et al, 1994), they have not matched the distance used in the present study. A 6.1m walk has been said to be representative of the distance between rooms in a house (Bassey et al, 1992) and, hence was chosen by Skelton and McLaughlin (1996) as a measure of functional status. However, the authors failed to find an improvement as a result of training. The distance chosen by Binder and colleagues (1994) of 24 feet, is again significantly shorter than was used in the present study. Having participated in a 60 minute exercise class three times per week for eight weeks, exercise subjects decreased the time taken to walk this distance.

It was decided that, if the subjects in the present study walked a similar, short distance to those distances mentioned in the above studies, there would not be sufficient scope for improvement due to the younger mean age of the present cohort of females. While the present population is undoubtedly compromised due to their excess body mass, this was not expected to be sufficient to result in reducing their walking capacity to a large degree since walking was reported to be the only type of physical activity in which subjects occasionally participated.

Lifting 1kg and 2kg bag onto a shelf with a Single Arm

This test was chosen to represent placing groceries on a shelf of British Standard height (1.3m). The exercise group improved the average time required to place 1kg and 2kg weights, equivalent to one and two bags of sugar respectively, onto the shelf with the right arm alone (both weights) and left arm alone (2kg bag only). When compared to the mean changes of the control subjects, the improvements neared significance with p values ranging from 0.06 (2kg lift with the left arm, table 45) to 0.10 (2 kg lift with the right arm, table 42).

Two factors were considered when assessing the possibility of improving the exercise subjects' performance in this measurement of functional status: range of movement in the shoulder joint and upper body muscular strength. Hence, as part of the training programme, the exercise subjects completed regular large arm movements which were designed to mobilise the shoulder joint - in an attempt to improve their ability to reach the shelf - and progressive strengthening exercises were incorporated to improve the intervention subjects' strength to lift the bag. A possible explanation for the failure of the exercise group to improve their performance when compared to the control subjects, could be that there was no rehearsal of the actual movement during the class of lifting a bag from the floor and reaching to place it on a shelf. Hence the neuromuscular pathways involved in the movement were not utilised during the training period resulting in a lack of specificity of the training programme, which is a necessary part of improvement of functional tasks (Fiatarone et al, 1994; Sale and MacDougall, 1981; Skelton et al, 1990).

Although Skelton and McLaughlin (1996) included this test as part of their protocol, the authors decided that, as all subjects were able to perform the test at baseline, they would not re-test subjects post-intervention. It is not clear if the authors felt that the test would not be sensitive to change. In the present study it was also found that all but two subjects were able to complete this test at baseline. However, contrary to Skelton and McLaughlin, the author felt that subjects could improve their score with training, as proved to be the case.

Stair Walk

Most probably due to the younger mean age of the subjects in the present study, to replicate the protocol of previous studies investigating the time to ascend and descend a set of three or four stairs (Gillies et al, 1999; Skelton and McLaughlin, 1996) would be too easy and therefore not sensitive to change. Thus, it was decided that subjects would be tested on a set of 12 stairs, each 16cm high.

The thigh and gluteal muscles were targeted in a series of progressive muscular strength and endurance exercises performed during the exercise sessions, e.g. squats, in an effort to maximise the exercise subjects' improvement in this functional measurement.

The exercise group decreased the total time taken to complete the stair walk as a result of ascending the stairs in a shorter time. Although the exercise subjects descended the stairs an average of 1.4 seconds faster at test 2, verbal reports suggested that subjects were afraid to descend the stairs any faster for fear of falling. Several subjects commented that they would normally hold onto the handrail of the stairs in their home and to not do so, as the protocol dictated, slightly inhibited them.

Although not directly comparable, due to the older age groups, these results show a similar trend as those reported in Gillies et al (1999) and Skelton and McLaughlin (1996). Gillies et al (1999) found that six subjects, of mean age 88 years, improved the time taken to ascend and descend 4 risers, 17cm high after 12 weeks of twice weekly exercise training. Similarly, exercise subjects decreased the time taken to ascend 3 stairs of 20cm and descend 3 stairs of 15 cm with no pause at the top of the stairs (Skelton and McLaughlin, 1996).

Flexibility

There was a slight improvement for both groups in the sit and reach test although neither group recorded a significant improvement from test 1 to test 2 (table 56). Every effort was made during the exercise sessions to progress individuals' flexibility by stretching through their full range of movement. Possibly this measure could have improved further if more time had been devoted to it during the exercise class.

<u>Conclusion</u>

Comparison with other studies revealed that, in general, exercise subjects in the present study demonstrated similar improvements in functional status measures. The assessments measured were chosen to be representative of the daily tasks in which this population of middle-aged obese females have been observed, by their GP, to be compromised as a result of their excess body weight.

Verbal reports suggested that the experimental subjects were able to complete daily tasks more quickly, and with less effort, at the end of the twelve week intervention. Additionally, subjects commented that they felt they had more energy to attempt household chores, DIY and gardening activities.

PSYCHOLOGICAL MEASUREMENT

As presented in Table 58, the exercise group increased their mean score in the Life Satisfaction Index (LSI) from 12.0 at baseline to 15.2 after 12 weeks. In comparison, controls actually decreased their score from 13.5 to 12.8 over the study period. Statistical analysis by 2 sample t-test, revealed that there was a significant difference between exercisers and controls post-intervention (p value 0.004).

This result is comparable to that observed by McMurdo and Burnett (1992) in their 8 month randomised controlled trial of exercise in a group of similar age. Exercise subjects (mean age 66.1 years) improved their LSI score from 13.8 to 15.9 having attended an exercise class 3 times per week for 32 weeks. It is encouraging to note a similar increase in LSI score was found in the present study after only 12 weeks.

The recorded improvement in psychological well-being on completion of the present exercise programme is in keeping with several other studies (Di Lorenzo et al, 1999; Goldwater and Collis, 1985; Heller et al, 1992). While these studies used other instruments to measure mental health, the results of the present study are similar in that they demonstrate an improved psychological profile as a result of participating in an exercise programme.

Although the mechanism through which involvement in an exercise programme improves mental health has not been established (Paluska and Schwenk, 2000), the author noted that the exercise group in the present study evidently enjoyed attending the exercise class, and liked the social nature of the session. Additionally there was a clear sense of mastery over the weeks as the exercise subjects became accustomed to executing the exercises used in the class and improved in their ability to do so.

ADHERENCE

The observed average attendance rate to the exercise class of 67.9% appears to be poor in comparison with other class-based exercise studies: 99.4% (Binder et al 1994); 83% (McMurdo and Burnett, 1992); 91% (McMurdo and Rennie, 1993); a range of 75%-100% (Skelton and McLaughlin, 1996); especially when it is taken into consideration that subjects in these studies completed 3 sessions per week, as opposed to only two sessions per week in the present study. The only favourable comparison is with Gillies et al (1999) who recorded an attendance rate of 60% for an exercise class held twice weekly.

It should be noted that not all of these interventions used community dwelling subjects (Binder et al, 1994; McMurdo and Burnett, 1992; Skelton and McLaughlin, 1996). Additionally, Skelton and McLaughlin (1996) had only one class-based exercise session per week with the two remaining sessions being completed at home. The other class-based training regimens were conducted with institutionalised adults (Gillies et al, 1999; McMurdo and Rennie, 1993) who obviously could not cite travel to the site of the exercise sessions as a barrier, unlike the present subjects. Additionally, the institutionalised subjects had fewer "distractions" and other commitments (e.g. family). O'Brien and Vertinsky (1991) have noted that older females are especially vulnerable to failing to adhere to an exercise programme as they often have many family commitments (e.g. caring for a sick partner) and complain of suffering more frequently of chronic conditions (e.g. osteoarthritis). However, the authors suggest that this group of females tend to think their complaints are worse than they actually are and, as a result, place limitations on themselves. Another characteristic of those more vulnerable to attrition is being overweight or obese (Pacy, 1986). All subjects in the present population had such characteristics.

There was a broad range of adherence rates for exercise subjects: 21%-100%. It should be noted that when the attendance figures of the two subjects who attended only 21% of the exercise sessions are removed, the mean adherence level rises to 76.5%, which is more favourable.

Obviously adherence to the exercise programme will have a direct effect on the improvement of the investigated variables. Thus, it could be expected that there would have been greater improvements observed in the exercise group had there been better adherence.

Another factor relating to adherence is the acceptability of the exercise programme. Obese individuals are likely to have had negative experiences with exercise. On a physical level, obese participants in an exercise programme have to deal with the burden of carrying excess weight and, in the case of the present population, an initial low fitness level. The psychological barriers, however, are liable to be more influential in an overweight person's attempts to exercise. Negative experiences, such as being the last one picked for games when at school, can have a long lasting effect (Grilo et al, 1993). Additionally obese persons regularly report feeling self conscious and embarrassed if they have to exercise in a group setting, or perceive they are being observed. During informal discussion with the exercise group in the present study, these preconceptions were frequently mentioned as acting as barriers during previous attempts to initiate an exercise programme.

In an attempt to ensure that the exercise programme used in this study was suitable psychologically for the present population, participants were of similar BMI. Furthermore, adaptations to all the exercises included in each session were continually offered to facilitate participants' ability to modify the exercises to suit their needs. Another method used to break down a barrier to participation was to make the atmosphere of the exercise sessions very relaxed, to encourage the exercise subjects to feel comfortable with one another.

It has been documented that a drop out rate of 50%-68% in the first eight to twelve weeks of an exercise study is to be expected (cited in Gillet et al, 1988). However, the observed drop out rate in the present study of 43.5%, while poorer than other class-based exercise studies (Binder et al, 1994; McMurdo and Burnett, 1992; McMurdo and Rennie, 1993; Skelton and McLaughlin, 1996), is actually slightly lower than this.

LIMITATIONS OF THE STUDY

There were certain limitations involved in working with the present study population of middle-aged, overweight females from an area of low socio-economic status. The first, and potentially most influential of these, was poor adherence to the exercise programme. Although exercise subjects attended, on average, two thirds of expected exercise sessions, this may not have been a sufficient stimulus to elicit significant improvements in the exercise subjects when compared with the controls for reasons discussed above.

Although systolic and diastolic blood pressure measures improved for the exercise subjects from test 1 to test 2, the standard protocol of taking three blood pressure readings was not followed. Subjects' blood pressure was measured by the Practice Nurse and, as such, was outwith the author's control. However, the Practice Nurse was specifically asked to take the blood pressure measurements because of her experience in taking this measurement and her familiarity with the subjects. It was hoped that this second factor would reduce the likelihood of subjects recording false readings due to anxiety. Additionally, all subjects were familiar with blood pressure measurements.

During the planning stages of this study, the possibility of assessing the acceptability of a home-based exercise programme was discussed. It was rejected due to the expected difficulties in accurately recording the number of sessions completed by subjects. However, it may have been worthwhile to ask subjects to complete one home-based exercise session each week, resulting in subjects completing three sessions per week and meeting the current ACSM recommendations concerning frequency of exercise (Pollock et al, 1998).

As a result of conversation with the exercise subjects, the author felt that they might have had unrealistic expectations regarding the effectiveness of regular exercise in causing significant weight loss. This may have meant that this group of subjects did not restrict their energy intake sufficiently to influence outcomes such as body mass, BMI and blood pressure, as well as the functional measures.

It may have been possible that the study involved changing too many behaviours at the one time in a population which tends to be resistant to change. The Ministry of Agriculture Fisheries and Food report (Gregory et al, 1990) found that persons from lower social classes ate less fresh fruit and vegetables compared with their counterparts from higher social classes. One of the changes all subjects were encouraged to make to their diets during their attendance at the general practice Weight Reduction Clinic was to increase their consumption of fruit and vegetables. Obviously this would require a greater effort in the present population than in a group from a higher social class.

Additionally, the structure of the exercise sessions may have tried to incorporate too many different components of fitness into each forty minute exercise session. It is possible that concentrating either only on increasing the subjects' muscular strength and endurance, or on improving their aerobic endurance would have resulted in more favourable improvements. Alternatively, the duration of the exercise sessions could have been expanded to allow more time to be spent on each component. However, increasing the duration of the sessions would possibly have adversely affected adherence. As noted previously, the intensity of the exercise sessions could have been more tightly controlled by measuring subjects' heart rates during the class.

The subjects in the intervention group had more contact time with the investigator compared with the controls, which could have influenced results. A tighter study design could have resulted from instructing controls to attend twice weekly sessions, of 40 minutes duration and of a sedentary nature, to account for this.

Finally, the small numbers of subjects who presented for re-testing at the end of the twelve week intervention limited the confidence with which conclusions could be drawn. With just over half of the original sample returning for the second battery of tests, the statistical power of the analysis was greatly reduced. Had a larger number returned, it is possible that some of the results which showed positive trends would have reached significance. Every attempt was made to ensure a sufficient number of subjects returned and, as outlined previously, a second round of recruitment was undertaken. However this still did not prevent the a relatively small number of subjects presenting for re-testing.

RECOMMENDATIONS FOR FUTURE RESEARCH

A case has been made for the implementation of an effective intervention to reduce levels of overweight and obesity and the resultant loss of functional status in a population of females aged 55-70 years living in a deprived area in the east end of Glasgow. The results from this small study indicate that this type of intervention has the potential to enhance the health status and functional capability of middle-aged overweight women. These data provide valuable information for power analyses for future studies.

However, as discussed above, there are certain improvements that could be made to the research design that would allow stronger conclusions to be drawn regarding the efficacy of an exercise programme and/or dietary advice in improving a range of physiological, functional and psychological variables for this cohort of females.

The current study design demonstrated the potential to be effective in improving the psychological well-being of overweight, middle-aged females, as evidenced by the significant improvement in Life Satisfaction Index. Extending the duration of the study period may positively influence the other variables to a statistically significant level as well. Alternatively, the frequency and/or intensity of the exercise class could be increased in future work. Intensity should be monitored during the exercise class using heart rate monitors. Additional exercise sessions could take the form of home-based sessions to encourage adherence.

To ensure improvements observed are not the result of familiarisation with the test battery, subjects should complete one or two practise sessions prior to baseline testing.

The adherence of the exercise group showed that the 12 week duration was palatable for some subjects, but not all. Future studies could increase the level of support subjects receive in the form of telephone calls or incentive schemes (e.g. after completing 6 weeks, subjects are presented with a t-shirt). As is reported in the literature, the protective effect of exercise is only afforded to those currently physically active (Paffenbarger et al, 1993), hence it is important that individuals remain active on a long term basis.

It is possible that the present study design tried to change too many lifestyle factors at the one time. As mentioned in the previous section, the literature would suggest that this population would need to make substantial improvements in their diet to meet current dietary recommendations (Gregory et al, 1990). Hence, future studies could introduce lifestyle changes more gradually by having a 12 week foundation period where subjects make alterations to their diet, and could then initiate an exercise programme.

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APPENDIX A

Date as postmark

Dear

We are organising a study at the Health Centre along with researchers from Glasgow University. We invite you to take part. We see from our records that you are overweight and are between the ages of 55-70 years, and so have the characteristics that we require for you to get involved.

The study aims to investigate the effectiveness of exercise and/or weight reduction in improving functional status (ie the ability to complete everyday tasks such as climbing the stairs) and other health measurements such as weight, blood pressure, cholesterol, and body fat.

If you decide to take part in the study you will be invited to the Health Centre within the next few weeks and will be asked to complete a series of assessments of everyday tasks and how you manage with them, and the health measurements mentioned above. This should take no more than 45min-1hour of your time. You will then be randomly assigned to one of two groups:

Group A: Attends the Weight Reduction Clinic held at the Health Centre once a week.

Group B: Attends the Weight Reduction Clinic once a week and an exercise class designed specifically for this age group and held twice per week in Eastbank Health Promotion Centre.

The study only lasts 12 weeks at which point we will reassess you to see if there are any improvements in your functional ability and health measurements.

Please fill out the tear off slip below, even if you do not wish to take part in the study, and return it to the Health Centre in the stamped, addressed envelope provided.
Thank you.

Yours sincerely,

Sister Patricia Kelly

I am/am not* interested in taking part in the study.
Please send/do not send* me more details (ie an assessment date)

Name: ______________________________

Address: ______________________________

____

Phone No.: ______________________________

* Delete as appropriate

APPENDIX B

RELIABILITY STUDY

Rationale

The purpose of this study was to test the reliability of the proposed test battery. All tests (except total blood cholesterol) were tested on 7 subjects, one week apart. Test 1 and test 2 were carried out at the same time of day.

Procedures

All subjects completed the following tests:

1. **Height** (stadiometer) and **weight** (seca scales) measured. Measurements were made without shoes and while wearing light clothing. Weight was taken to the nearest 0.1kg.

2. **Body mass index** (BMI) assessment. The BMI was calculated by dividing the body mass (in kg) by the square of the height (measured in metres).

3. **Skinfold measurement** using Durnin and Womersely (1974) method, ie four skinfold measures (triceps, biceps, subscapular and supra-iliac) are taken from the right side of the body with the subject in a standing position.

4. **Resting blood pressure** Blood pressure was taken by the Practice Nurse. Subjects sat at rest for 5 minutes before the measurement was taken using a mercury sphygmamometer (Trimline Pymah). The subjects were accustomed to regular blood pressure measurement.

5. **Functional Ability Tests.**

   All tests were demonstrated to the subjects by the assessor prior to each measurement. A seated rest of 3 minutes was given before each test.

a) ***Chair rise*** Subjects were required to rise, with their arms folded and as fast as possible, from a chair with a level seat 0.42 metres from the floor (British Standards Institution (BSI) recommended height for a toilet pedestal plus an amount added for a toilet seat). The subjects were asked to rise 10 times consecutively and the time taken was recorded. This protocol was chosen to allow for the range of abilities that the researcher's preliminary work had indicated was present within the subject population.

b) ***Timed 'Up and Go' Test*** The subjects were asked to rise from a chair (without using their arms for support if possible) and walk 3 metres, turn and return to the chair and sit down, as fast as possible (Skelton and McLaughlin, 1996). The whole movement was timed.

c) ***20 Metre Walk*** The subjects were asked to walk 20 metres as fast as possible. The movement was timed and the number of steps taken recorded.

d) ***Lifting a 1kg and 2kg Bag onto a Shelf*** Subjects were asked to lift a bag of sugar (1kg) in a plastic bag lying on the floor, on to a 1.34 metre high shelf (1.3m is the BSI recommended height of the bottom of a wall unit), but standing 0.3 m away from the shelf (BSI recommended width of a base unit in a kitchen). The test was performed once using each arm with the time for each arm recorded. Subjects repeated the same procedure with a bag weighing 2kg (2 bags of sugar).

e) ***Stair Walking*** The subjects were asked to walk up a small flight of stairs (12 stairs, each of height 16cm), turn on the landing and descend the stairs without stopping, as fast as possible, and without using the handrail as support. The task was timed and the assessor recorded if the subjects hesitated or used the handrails.

7. **Sit and Reach Flexibility Test.** Subjects were given three attempts and the best of these scores was recorded to the nearest centimetre (Wells and Dillon, 1952).

8. Subjects completed the **Life Satisfaction Index** (Neugarten et al, 1961) to give a subjective account of their mental well-being.

RESULTS

The mean value for each test was compared from Test 1 to Test 2 via a paired t-test to examine if there was a significant difference. Table B1 gives the mean results (s.d.) for test 1 and test 2, the mean difference (test 2 minus test 1), and 95 % Confidence Intervals

Variable	Test 1	Test 2	Mean Difference (test 2-test 1)	95% Confidence Intervals
BMI (kg/h^2)	30.4 (3.3)	30.4 (3.7)	-0.01	(-0.60, 0.59)
Systolic Blood Pressure (mmHg)	144.9 (10.9)	143.1 (12.3)	-1.71	(-24.51, 21.08)
Diastolic Blood Pressure (mmHg)	86.2 (5.2)	78.9 (4.3)	-7.43	(-11.80, -3.06)
Up & Go (s)	8.8 (1.7)	9.1 (2.8)	-0.29	(-1.76, 1.19)
20M Walk (s)	15.7 (2.4)	15.4 (2.9)	0.71	(-0.77, 2.20)
1kg bag lift				
- left arm (s)	3.1 (0.7)	3.4 (1.1)	-0.24	(-1.02, 0.53)
- right arm (s)	3.8 (1.6)	3.4 (1.4)	0.42	(-0.65, 1.48)
Stair Climb				
- ascent (s)	6.1 (1.4)	6.1 (1.4)	-0.03	(-0.18, 0.12)
- descent (s)	7.6 (2.9)	7.2 (2.9)	0.43	(-0.01. 0.87)
- total (s)	13.7 (4.3)	13.4 (4.2)	0.34	(-0.12, 0.81)
Flexibility (cm)	30.1 (7.3)	29.9 (8.0)	0.29	(-4.72, 5.29)

With the exception of diastolic blood pressure, the mean differences between tests for all variables was small. The 95 % Confidence Intervals contain zero, indicating that there was no systematic bias between the tests.

As can be seen in Table B1, diastolic blood pressure significantly decreased from test 1 to test 2. It was thought that this was due apprehension subjects felt at test 1, causing their blood pressure to increase. It was hypothesised that subjects felt more relaxed at test 2, as they were now familiar with the assessor and the test battery. Verbal reports from subjects confirmed this theory. It was concluded that the observed decrease in diastolic blood pressure at test 2 was largely attributable to this factor.

CONCLUSION

It was concluded that the test battery was reliable and could be used in the main study.

APPENDIX C

Assessment of the Efficacy of Class-Based Exercise Sessions on Physiological variables, Functional Status measurements and Quality Of Life measurements in overweight women.

Information for subjects

You are invited to take part in a study, the details of which are given below.

In the 55-64 year age group, approximately half the British female population can be classed as overweight, with 15% being defined as obese. Obesity is associated with the increased likelihood of illness from certain medical conditions such as high blood pressure, diabetes and heart disease, as well as making joint problems like arthritis worse.

Exercise has been shown to be helpful during dieting as it increases calories burned and fat loss. Exercise has also been shown to help keep the weight off.

A recent nationwide fitness survey found that as we get older, we are less active. Lower activity levels have been found to correspond with higher body weight. Women in their 50s and 60s who take regular exercise have a lower average weight compared to those who don't.

Who can take part in the study?

This study will recruit women between the ages of 55-70 years, who presently attend, or have previously attended, the Weight Reduction Clinic run in Shettleston Health Centre, who are overweight, and who currently do not take part in any form of regular exercise.

What is the aim of the study?

The aim of the study is to assess the effect of an exercise programme on women who fulfil the description above.

If I decide to take part, what is involved?

Prior to the onset of the exercise programmes, all subjects will undergo tests of:

Functional Status - stair ascent and descent (12 stairs), chair rises, 'up & go' test (rise from a chair, walk 3m, turn and return to the chair), placing two bags of sugar onto a shelf, and walking 20m. All tests are timed.

Physiological Measurements - Height, weight, serum lipid profile (i.e. cholesterol), % body fat (calculated by measuring the thickness of skinfolds) and resting blood pressure.

Psychological Measurements - Life Satisfaction questionnaire

We will repeat the above tests after 12 weeks.

You will be asked to attend the Weight Reduction Clinic held in Shettleston Health Centre and will be placed in one of two exercise groups for 12 weeks:

Control group Those in this group will maintain their current exercise behaviour.

Class-based (CB) exercise group The subjects in this group will attend exercise classes of 40 minutes duration, twice weekly. The classes will consist of a 10 minute warm up, 20 minutes aerobic exercise, 5 minutes strength and 5 minutes stretching exercises. The exercises will be done to music and will be taught in such a way that allows all individuals to exercise at their own pace. The classes will be held in Eastbank Health Promotion Centre (formerly Eastbank Academy).

N.B. There is no need for "sporty" clothing. All exercises can be performed in regular, loose clothes.

This study may be of no direct benefit to you

You can withdraw from the study at any time.