PHYSICAL ACTIVITY AND PERCEIVED BENEFITS AND BARRIERS IN ADULTS AGED 55-74

Alan Montgomery

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PHYSICAL ACTIVITY AND PERCEIVED BENEFITS AND BARRIERS IN ADULTS AGED 55-74

BY

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A thesis submitted for the degree of

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ABSTRACT

In order to increase the number of older adults physically active enough to obtain the health benefits of exercise, inactive individuals must firstly be identified, and attention must then be focused on determinants of exercise amenable to change.

This study set out to develop self-complete questionnaires for assessing activity status, and perceived benefits of, and barriers to, physical activity.

Of 1456 questionnaires sent out to a random sample of adults aged 55-74 a usable return rate of 37.6% (n=548) was achieved. A principal components analysis of the benefits of physical activity revealed five factors (physical performance, social, weight control, enjoyment, and psychological), and of the barriers to physical activity, also five factors (opportunities, physical exertion, time, limiting health, and support). Alpha internal consistency coefficients for the 10 factors ranged from 0.64 to 0.92, and test-retest reliability coefficients from 0.56 to 0.87. A series of one-way ANOVAs revealed that, with the exception of the benefit weight control, there was a significant gradation in factor scores between active and inactive subjects as classified by 4-, 9-, and 5-point activity classification methods.

Validity of the activity classifications was assessed in a subsample of 86 subjects against measures of strength, flexibility, aerobic fitness and objectively measured physical activity. Active and inactive subjects classified using the 4- and 9-point questionnaires differed significantly in 1-mile walk time and energy expenditure estimated by a Caltrac accelerometer. The 5-point questionnaire did not appear able to differentiate active and inactive subjects. Test-retest reliability of the questionnaires ranged from 0.62 to 0.73.

The questionnaire developed from this work for measuring perceived benefits and barriers of older adults can be used in either practical or research settings. Further work is required to determine the accuracy of the physical activity questionnaires in identifying low-active individuals in the population.

DECLARATIONS

(i) I, Alan Anderson Montgomery, hereby certify that this thesis, which is approximately 58,000 words in length, has been written by me, that it is the record of work carried out by me and that it has not been submitted in any previous application for a higher degree.

date 2/10/96 signature of candidate [redacted]

(ii) I was admitted as a research student in October 1992 and as a candidate for the degree of Doctor of Philosophy in October 1992; the higher study for which this is a record was carried out in the University of St Andrews between 1992 and 1995.

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(iii) I hereby certify that the candidate has fulfilled the conditions of the Resolution and Regulations appropriate for the degree of Doctor of Philosophy in the University of St Andrews and that the candidate is qualified to submit this thesis in application for that degree.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

Physical activity has a key role in contributing to health, defined not merely as an absence of disease but also the ability to function to one's full potential (Bouchard *et al*, 1990; Bouchard *et al*, 1994; Department of Health, 1991). Epidemiological studies which relate the frequency, intensity, and duration of different activities to incidence of disease provide evidence of both the preventive and rehabilitative benefits of habitual physical activity. Most of the health benefit is obtained by moving from being completely sedentary to participating in moderate levels of physical activity (Blair *et al*, 1995; Pate *et al*, 1995). Evidence is accumulating that only small changes in the behaviour of sedentary adults, enough to accumulate about 30 minutes of moderate activity each day, could substantially improve the health of a nation such as Scotland which has one of the highest mortality rates from coronary heart disease (CHD) in the world (Kazuo & Zbynek, 1988). For elderly people physical activity is particularly important. A wide range of functional abilities, with important consequences for quality of life and with differing relative importance between males and females, can be maintained through an active lifestyle. This can mean continued independence and the delay or avoidance of institutional care, an enormous burden on already limited health care resources.

Although many researchers use *exercise* and *physical activity* interchangeably, the two can be distinctly defined. Physical activity is any bodily movement which results in energy expenditure. Exercise is a subset of physical activity which involves planned, structured and repetitive bodily movement, with the objective of maintaining or improving physical fitness (Caspersen *et al*, 1985). Where necessary in this thesis, attention is drawn to the specific use of the terms physical activity and exercise. However, as most researchers are vague in their own use of these terms, particularly in relation to exercise/physical activity recommendations for the elderly, their interchangeable use in this thesis is at times unavoidable.

It is apparent from the relatively small number of people who are physically active that knowledge of the health benefits of physical activity alone do not ensure participation. The Allied Dunbar National Fitness Survey (ADNFS; Sports Council & Health Education Authority, 1992) set a target level of twelve 20 minute sessions of moderate physical activity over a 4-week period for 55-

74 year old men and women. This was similar to a recommendation made by the American College of Sports Medicine (ACSM, 1990) and was based on earlier exercise and CHD research. The ADNFS reported that only 29% of men and 26% of women aged 55-74 reached this level. The remainder did 1-11 sessions over 4 weeks (35% of men and 43% of women) or did no 20 minute sessions at all (36% of men and 31% of women). This contrasts with over 70% of subjects who said that exercise was important for the improvement or maintenance of health. Although the recommended level of physical activity was more stringent than that made by Pate *et al* (1995), the ADNFS was the first attempt to assess the physical activity status of the population of this country. With well over two thirds of older adults below the recommended level of activity it is clear that inactivity-related disease and loss of function pose a real threat to this age group.

There are two stages involved in attempting to increase participation in physical activity in the population. It is important to identify and target those people who are least active and therefore most at risk, and so a method of assessing physical activity must be employed. Once inactive people are identified, variables suitable for intervention at an individual level must be found. Strategies in the past have targeted all the population using educational campaigns. It may prove more successful and cost-effective to target only the least active sections of the population and to focus on the circumstances of each individual. Different factors are important in determining exercise behaviour in individuals and interventions need to be tailored accordingly. Research in both of these areas has focused on younger, more readily accessible sections of the population such as college or work-site samples, and as a consequence, there is a lack of knowledge relating specifically to older people.

There are several possible ways of measuring physical activity, each varying in complexity, cost, and time and effort required of both researcher and subject. The most commonly used method is the questionnaire, which itself can vary in the amount of detail it seeks to elicit, the time frame of reference, the method of administration, and the summary 'activity score'. Studies of the relationship between physical activity and disease have typically used detailed questionnaires which estimate energy expended in different types of activity. But for the purposes of identifying individuals who are below a certain activity level and may be at risk from inactivity-related disease, a more general type of questionnaire which seeks information about the subject's overall activity pattern may be all that is necessary. If valid and reliable, such a questionnaire

has the advantages of being self-administered, short, and easy to understand, and therefore suitable for use in the general population, at for example, a visit to a health centre. At present, there is no such questionnaire which has proved valid and reliable for use in older adults.

There are many factors which determine whether or not someone will exercise (Dishman *et al*, 1985; King *et al*, 1992), and it is important to focus on those which can be modified when attempting to increase physical activity. Two variables which feature in several psychological theories developed to guide the study of exercise behaviour and are known to be related to exercise are perceived benefits of, and perceived barriers to physical activity. Examples of perceived benefits are physical and mental health, social interaction, and weight control, and of perceived barriers to physical activity, time, physical exertion, and limiting health.

Assessing the importance of these variables has until recently been hampered by a lack of consistent measurement. Findings from large, descriptive studies which used single item questionnaires to assess these variables (Canada Fitness Survey, 1983; Sports Council & Health Education Authority, 1992) showed that perceived benefits and barriers are related to exercise behaviour, and this has been confirmed by the development of psychometric scales for the measurement of exercise benefits and barriers. Again though, a lack of research means there is no questionnaire such as the ones developed with younger samples (Sechrist *et al*, 1987; Steinhardt & Dishman, 1989) to assess elderly peoples' perceived benefits and barriers, and how these affect physical activity behaviour.

1.2 Aim

The aim of this research is to produce valid and reliable questionnaires for adults aged 55-74 years which:

(a) classify individuals according to their physical activity status;

(b) assess perceived benefits of, and barriers to physical activity.

As this research is not experimental in nature, there are no independent and dependent variables. Instead, the validity of the questionnaires will be measured against a series of validation criteria. In the case of the physical

activity questionnaires, these will be measures of fitness, an objective estimate of activity, and a more detailed physical activity questionnaire. For the benefits and barriers questionnaires, the validation criterion will be physical activity status.

1.3 Research Hypotheses

There are five questions which this research will address:

1. Will a principal components analysis of a list of perceived benefits and barriers produce meaningful factors?
2. Will physically active subjects perceive greater benefits and fewer barriers to exercise than inactive subjects?
3. If meaningful benefits and barriers factors are produced, are they reliable?
4. Do subjects identified as active by three different questionnaire methods differ in terms of fitness and physical activity (measured by different means) from those identified as inactive?
5. Can these three physical activity questionnaires reliably classify subjects?

From these five questions, the following null hypotheses will be tested:

1. Meaningful benefits and barriers factors do not exist for adults aged 55-74 years.
2. Perceived benefits and barriers are not related to physical activity status.
3. The three physical activity questionnaires do not accurately classify subjects according to fitness and objectively measured physical activity.
4. Neither the benefits and barriers questionnaires, nor the physical activity questionnaires produce reliable results.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 Introduction

In the first section of this chapter, evidence supporting the positive effects of physical activity on health is reviewed, with emphasis on studies relating specifically to older adults.

It is known that the majority of adults in this country are not physically active enough to obtain these health benefits. Before any attempt can be made at changing behaviour, inactive individuals in the population must firstly be identified. The second section reviews methods of assessing physical activity and their practical utility for population studies.

Once identified, some attempt must be made to increase physical activity in sedentary people. Theories developed to guide the study of exercise behaviour are reviewed in the third section, along with studies aimed at testing parts of these theories. In particular, perceived benefits of physical activity, and perceived barriers to physical activity appear to be important determinants of exercise behaviour, and methods of assessing these theoretically key variables are evaluated.

2.2 Physical Activity and Health

Why should people be encouraged to be physically active? Study of the contribution of exercise to health and to an active, independent and enjoyable life into old age demonstrates that even small increases in physical activity levels could make an enormous difference to individuals' quality of life and to the general health of the nation. It is against this background of health-related physical activity which the research described in this thesis should be viewed.

Britain, like most western countries, is faced with an ageing population. Advances in health care mean that life expectancy is increasing, and the percentage of older people in the population will rise accordingly (Department of Health, 1991). It ought to be stated that there is no threshold at which 'old age' starts. Ageing is a physiological process which begins at the end of the growth phase, and which begins to accelerate in most people in the sixth

decade. For the purposes of this research, the age group of subjects ranges from 55-74 years to facilitate comparison with other research, but could feasibly have ranged from 50 or 60 years upwards. In terms of functional ability, senior citizens form a much less homogeneous group than do, say 20 year-olds (Muir Gray, 1987), and gerontologists sometimes distinguish between the young old, who are not limited in their physical activity; the middle old, who suffer some physical limitations; and the very old, who are almost totally dependent (Shephard, 1994). It may be that classification is better based on functional, rather than calendar age.

The process of ageing is characterised by: (a) a decrease in reserve capacity of various functions of the body; (b) a decline in the ability of the body to adapt to internal and external changes; and (c) a decrease in resistance to invasion of the body (Kuroda, 1988). Examples of reduced function remaining at age 80 compared with age 30 are nerve conduction velocity (85%), resting cardiac output (70%), and maximal voluntary ventilation (40%). Measures of physical fitness show a concurrent decline, with grip strength at 70%, $\dot{V}O_{2max}$ at 50%, and one foot balance at 15% at age 70 compared with age 20 (Kuroda, 1988). These changes inevitably mean that people will have more and more difficulty doing the activities of daily life. Individual differences are important, but only a few years after finding difficulty in performing a relatively simple daily task, many people will become dependent on care (Shephard, 1993).

Can increased physical activity alleviate health problems and the associated loss of functional abilities, and prevent or delay the dependence on care? Although factors such as initial level of functional ability and fitness, and presence of age-related disease mean that the answer can be rather complicated, research suggests that the answer is 'yes'. There is now a very large literature on the benefits of exercise, both physiological and psychological, and Bouchard *et al* (1990) provide an extensive and up to date consensus of knowledge of exercise, fitness, and health.

Much of the research has focused on the role of physical activity in preventing coronary heart disease (CHD). Morris and colleagues initiated the study of exercise and CHD in the 1950's, with their research on London transport workers providing the first evidence that men in physically active occupations experienced a lower incidence of CHD than those in sedentary jobs (Morris *et al*, 1953). Paffenbarger *et al* (1977) showed that dockers who expended less

than 8500 kcal/week at work had a relative risk of 1.80 of fatal CHD attack compared with those who expended more than 8500 kcal/week. As people have become increasingly sedentary in their occupations through mechanisation, automation and the elimination of strenuous work, studies have focused more on the relation between CHD and leisure time physical activity. Paffenbarger *et al's* (1978) study of Harvard alumni reported that although participation in strenuous sports provided a reduced risk of CHD, a total leisure time physical activity index of below 2000 kcal/week resulted in a 64% increased risk of premature death from CHD.

These studies, along with others (Morris *et al*, 1980; Morris *et al*, 1990) have fuelled the debate on the *type* and *intensity* of activity required to give protection from CHD. In their 1989 paper, Blair *et al* examined the relationship between physical *fitness*, rather than physical activity, and all-cause mortality. They argue (Blair *et al*, 1994) that exercise habits are so difficult to measure accurately that fitness is a more easily measured and suitable indicator of habitual activity. In support of this they point to Bouchard *et al's* (1986) study of fitness in monozygotic twins, which concluded that the genetic contribution to aerobic fitness was at most 40%, the remainder being dependent on physical activity habits. Additionally, they argue that the low correlations (r=0.3 to 0.5) often seen between exercise and fitness tests are due to the imprecise assessment of physical activity, and when exercise sessions are recorded accurately on computer, correlations between exercise record and aerobic fitness are typically 0.7 to 0.8 (Blair *et al*, 1994). The 1989 study (Blair *et al*, 1989) found that there was a gradient in all-cause, cardiovascular, and cancer mortality rates across five fitness categories for both men and women, after controlling for independent risk factors. This lent support to the theory that modest increases in physical fitness, which by inference are produced by moderate levels of physical activity, could produce significant health benefit.

Blair *et al* (1995) have also since found that a change in fitness status from unfit to fit category, with five years between tests, leads to a reduction in mortality risk of 44% compared with men who remain unfit. In 1992, Blair *et al* reviewed the subject, and concluded that "moderate levels of activity or fitness are associated with important and clinically significant reductions in risk", and that 30 minutes of moderate activity accumulated throughout the day could have the same effects as one 30-minute bout. This subsequently led to a recommendation from the US Centre for Disease Control and Prevention and the American College of Sports Medicine (Pate *et al*, 1995) that "adults should

try and accumulate 30 minutes or more of moderate-intensity activity on most, preferably all, days of the week". Moderate activity equates to brisk walking at 3 to 4 mph for most adults. The point that activity can be accumulated is very important, as it represents a smaller change in lifestyle and a more easily attainable target for a sedentary individual than attempting to adhere to a more rigorous programme.

The beneficial effects of physical activity on disease go beyond CHD. Exercise can reduce the risk of developing hypertension, and lower elevated systolic and diastolic blood pressures (Hagberg, 1990). Stroke is a common endpoint for hypertension. Paffenbarger *et al* (1984) found the incidence of stroke was inversely related to physical activity index in Harvard alumni, and although evidence is not conclusive, it may be that the observed reduction in stroke rate in more active individuals is mediated by a reduced risk of developing hypertension. Both acute and chronic exercise are known to improve blood lipid profile, increasing high density lipoprotein (HDL)-cholesterol thereby lowering the total cholesterol/HDL ratio (Gordon & Cooper, 1988).

Physical activity increases insulin sensitivity and is recommended, along with careful monitoring of diet and body weight, in the management of non-insulin-dependent diabetes (type II diabetes) (Vranic & Wasserman, 1990). There is also evidence that physical activity can provide protection against development of the disease, with the age-adjusted risk of developing the disease decreasing by 6% for each 500 kcal increase in weekly leisure time energy expenditure (Helmrich *et al*, 1991).

An inverse relation between physical activity and certain types of cancer have been reported. Lee *et al* (1991) found that alumni expending more than 2500 kcal per week in physical activity had approximately half the risk of developing colon cancer as their inactive counterparts. No evidence that this higher level of activity protected against rectal cancer was found. Frisch *et al* (1985) found a relative risk of 2.53 for reproductive-system cancer and 1.86 for breast cancer in women college nonathletes versus athletes. Blair *et al* (1989) reported low-fit men had a cancer mortality risk (all types) of 4.3 and 2.8 of highly fit and moderately fit men respectively. The corresponding relative risks for low-fit women were 16.3 and 1.7. Although there is some evidence here that physical activity can protect against the development of some cancers, the mechanism of this protection is not yet known (Calabrese, 1990).

Osteoporosis, defined as the deterioration of bone architecture to the point of fracture with minimal trauma (Bassey, 1995), is a major public health problem, especially for the elderly. There is a gradual decline in bone mineral density (BMD) detectable from around the age of 35, and this accelerates in women after the menopause (Smith *et al*, 1990). This post-menopausal bone loss due to oestrogen deficit means that women are two to six times more likely to suffer an osteoporotic fracture than men (Devogelaer & Nagant de Deuxchaisnes, 1993). Other known contributing factors to osteoporotic fractures in the elderly are lack of physical activity, inadequate dietary calcium intake, history of smoking and increased risk of falls (Bassey, 1995).

A Danish study has shown that 44% of 70 year old women will have suffered at least one osteoporotic fracture, vertebrae and wrist being the most common sites (Jensen *et al*, 1982). Hip fractures are a particular cause for concern as they require lengthy hospitalisation. Fifteen percent of women will suffer from one hip fracture, but this rises to 33% of those who live into their nineties. For men the figures are 5% and 17% respectively (Devogelaer & Nagant de Deuxchaisnes, 1993). Twenty percent of patients with hip fracture are unable to return home and require nursing home care. Even those patients who are able to return home have difficulty in performing many Activities of Daily Living (ADL) and subsequently experience a loss of independence and a lowering of quality of life (Devogelaer & Nagant de Deuxchaisnes, 1993). Any fracture will result in some degree of loss of function and independence, and rehabilitation must aim for replacement of muscle mass in addition to restoring functional ability as fully as possible.

Physical activity has a role to play in the prevention of osteoporosis. Gutin & Kasper (1992) reviewed a number of both cross-sectional and prospective studies involving elderly people, and drew the following conclusions:

(a) starting or maintaining an exercise programme during the older years can maintain or increase BMD;
(b) weight bearing exercise such as brisk walking, jogging or aerobics is required, and must be of an intensity greater than normal walking to stimulate bone;
(c) strength training has also been shown to be effective but is perhaps best combined with an aerobic programme;
(d) more research is required to determine the site of increases in BMD, as both localised and systemic improvements have been observed;

(e) more research is required to determine the optimal magnitude and rate of strain which will provide most benefit;
(f) exercise in combination with oestrogen replacement therapy is particularly effective.

In addition to maintaining bone mineral density, physical activity maintains muscular strength and proprioception, factors which lessen the risk of falling in the elderly and which may protect against fractures when falls do occur (Nickens, 1985).

One particular type of osteoporotic fracture which is a significant cause of functional impairment in the elderly is the vertebral fracture (Galindo-Ciocon *et al*, 1995). Vertebral fractures are the most common manifestation of osteoporosis, and along with small ruptures of the myotendinous structures, degeneration of disk cartilage, and mechanical problems occuring at the disk-invertebral articulations, constitute a major cause of low back pain (Nachemson, 1990; Borenstein, 1992). It is estimated that 60% to 80% of individuals will experience an episode of back pain during their lifetime with an annual incidence of 5%, but the majority do not seek medical care and will improve without treatment (Borenstein, 1992). The estimated annual cost of low back pain in the elderly in the USA is $20 million (Swezey, 1988).

In a study to assess functional impairment in elderly women with back pain, Galindo-Ciocon *et al* (1995) found that patients with vertebral fractures had a significantly greater pain level and were significantly more dependent in bathing, toileting, dressing, transfers, and continence than those patients with no vertebral fracture. Lyles *et al* (1993) reported that subjects with vertebral fractures suffered reduced strength, flexibility and walking performance in an assessment of functional status. Although there is no absolute evidence that fitness prevents low back pain, the known effects of training on muscle, bone and connective tissue would be expected to extend to the lower back and thus provide some protection from trauma (Nachemson, 1990). Most instances of low back pain can be controlled with simple analgesics, and other forms of treatment include transcutaneous electrical nerve stimulation, cold compression, traction, manipulation, and rest (Swezey, 1988). Exercises effective in the treatment of low back pain include both flexion and extension exercises (abdominal and back strengthening), backstroke swimming, and leg strengthening. Initial exercising should be low level, and progress should be steady and carefully monitored (Nachemson, 1990).

Obesity is a condition affecting a significant number of elderly people in western countries, with resultant consequences on health and functional ability. The Allied Dunbar National Fitness Survey (Sports Council & Health Education Authority, 1992) used Body Mass Index (BMI) as an indicator of body fat. A BMI greater than 25.0 for men and 23.9 for women is classified as overweight, and greater than 30.0 and 28.6 respectively as obese (Royal College of Physicians, 1983). The survey found that 61% of men and 74% of women aged 55-74 were classified as overweight, of which 13% and 31% were obese. Two other measures of body composition were also taken. Skinfolds, from which estimates of percent body fat were calculated, revealed mean values for men and women aged 55-74 of 28% and 37% respectively. Waist to hip girth ratio provided a measure of the distribution of body fat. Thresholds of 1.0 in men and 0.8 in women have been associated with significant increases in stroke and CHD incidence. The percentage of elderly men exceeding the respective threshold was 20% and for women, 68%.

The survey provides evidence that a large number of elderly people in this country are at risk from overweight-related illness. Obesity is associated with hypertension, diabetes mellitus, CHD, and chronic respiratory failure (Royal College of Physicians, 1983). Functionally, excess weight has the greatest effect on the ability to be mobile, essential to performing everyday tasks and enjoying life. Using the data to calculate the effect of a weight loss of 10kg of fat by everyone who was overweight or obese, the ADNFS (Sports Council & Health Education Authority, 1992) concluded that 40% of men and 35% of women who had difficulty in rising unaided from a chair (mainly elderly people) would then be able to do so. The percentage of people who had difficulty walking on level ground would be halved, and those who found a 5% gradient demanding would be reduced by 37% for men and 19% for women.

Energy balance is a simple equation of energy intake and energy expenditure. When intake exceeds expenditure a person will put on weight and almost all of this will be stored as fat. Studies have shown that the most effective way of losing fat is a combination of both reduced energy intake and increased energy expenditure (Bray, 1990; Baumgartner, 1993). Assisting in weight loss is another way by which increased habitual physical activity could improve the functional ability of a large proportion of elderly people (Royal College of Physicians, 1991). Bearing in mind that the overweight elderly may already have mobility problems, any increase in physical activity should be conducted

with care, and a simple walking programme is probably the safest and most easily accessed recommendation.

In addition to physical health, exercise has been linked with mental health anecdotally for centuries, and more recently with experimental evidence (Brown, 1990; Biddle & Mutrie, 1991; Martinsen & Stephens, 1994). Studies of both acute and chronic exercise suggest a benefit for both normal and clinical populations in relieving symptoms of depression (Martinsen, 1990; North *et al*, 1990), anxiety (Morgan, 1987), tension (deVries, 1987), and increasing feelings of self-confidence, vigour and well-being (Stephens, 1988; Moses *et al*, 1989).

The evidence supporting the positive association between physical activity and health is large and increasing. However, health encompasses more than the mere absence of disease, as Bouchard *et al* (1990, p6) point out:

> Health is a human condition with physical, social, and psychological dimensions, each characterized on a continuum with positive and negative poles. Positive health is associated with a capacity to enjoy life and to withstand challenges; it is not merely the absence of disease. Negative health is associated with morbidity and, in the extreme, with mortality.

This definition, which stresses functioning to one's full potential, becomes particularly important for the elderly. As already noted, there is an age-related decline in physiological and functional capabilities, which, if allowed to remain unchecked, may quickly lead to the inability to perform simple tasks and a dependence on care (Shephard, 1993). Physical activity has a central role in allowing an individual to remain active and independent (Buchner *et al*, 1992). Physical fitness (an attribute) is largely dependent on physical activity (a behaviour) and contributes significantly to positive health (Blair *et al*, 1989; Blair *et al*, 1995).

Physical fitness is commonly divided into five components (Skinner *et al*, 1990): aerobic capacity; anaerobic capacity; muscular strength; flexibility; and body composition. Of these, aerobic capacity, strength, and flexibility are the most important in functional ability. deVries (1971) reported a mean increase in estimated aerobic capacity of 16% in 52 men aged 60-79 years following a six week walk-run programme, and calculated that the minimum threshold for

improvement in aerobic capacity was 40% of heart rate reserve (HRR). For a 70 year old man with a resting heart rate of 70bpm, this equates to an exercise heart rate of 102bpm. The Allied Dunbar National Fitness Survey (Sports Council & Health Education Authority, 1992) used two different levels of exertion, walking at 3mph on the level and up a 5% gradient, against which to measure aerobic capacity. It was found that about 30% of men and 45% of women aged 55-74 had a heart rate exceeding 70% of maximum at an oxygen uptake of 13 $mlO_2/kg/min$ (equivalent to walking on the level), indicating that was above their normal level of exertion and would not be sustainable for long. At 21 $mlO_2/kg/min$ (equivalent to walking uphill), this rose to 70% of men and 90% of women. The results show that walking, a task essential for independent functioning for most people, holds real difficulty for a substantial number of elderly adults. Many studies report that older adults can improve their aerobic capacity with fairly moderate intensity aerobic exercise (deVries, 1971; Foster *et al*, 1989; Belman & Gaesser, 1991), thus maintaining their ability to move around and function independently.

A decline in strength, due to the ageing process and the decrease in physical activity which usually accompanies it (McDonagh *et al*, 1984; Bassey *et al*, 1988), means that many elderly people have difficulty walking, climbing stairs, rising unaided from a chair, opening screw-top containers, and holding on to a handrail for support. Studies investigating the effects of strengthening exercises in older adults report gains of anything up to 200% depending on initial level of strength, and the intensity and duration of the programme (Perkins & Kaiser, 1961; Aniansson *et al*, 1984; Frontera *et al*, 1988; Charette *et al*, 1991). Although any improvement in strength is undoubtedly beneficial, expressing gains as a percentage can be misleading as elderly adults are often relatively weak to start with (Buchner *et al*, 1992). The American College of Sports Medicine (ACSM) position stand of 1990 states that exercise programmes should include a resistance training component performed twice per week. Given that very few elderly people will have ever done any strength training, a formal programme such as that recommended by the ACSM is unlikely to appeal. It is better that the elderly continue to perform functional tasks of daily living themselves, rather than letting others do them and be forced in to a passive dependent lifestyle (Muir Gray, 1987). This is likely to go a long way in preventing the downward spiral of inactivity and loss of functional ability (Muir Gray, 1987; Sports Council & Health Education Authority, 1992).

Flexibility can be improved with training (Chapman *et al*, 1972; Voorrips *et al*, 1993) and is another aspect of fitness for which maintenance is very important for performing functional activities such as washing hair, reaching high shelves, and hanging out washing. A threshold level of shoulder flexibility of 120° abduction was identified by the National Fitness Survey (Sports Council & Health Education Authority, 1992) as the flexibility required to perform such tasks, and it was reported that 10% of men and 14% of women aged 55-74 years were below this level.

In addition to these studies of the relation between physical activity and health and fitness, researchers have also studied the relationship between ageing and the capability of individuals to do certain tasks. This can be done with an Activities of Daily Living (ADL) questionnaire which comprises a large number of questions about daily activities and the ease with which they can be performed. Walking certain distances, climbing stairs, lacing shoes, dressing and undressing, reading a newspaper, using public transport, going shopping, and replacing a light bulb are among the many activities assessed to give an ADL score (Spector *et al*, 1987; Kempen & Suurmeijer, 1990). Loss of ability to do these activities would make an individual more dependent on others. An ADL questionnaire could be used in a physical activity intervention study to assess any functional improvements as well as health benefits.

Quality rather than quantity of life, independence, and maintenance of functional ability should be seen as the ultimate goal of any exercise/physical activity programme for the elderly (Barry & Eathorne, 1994). But what specifically must the elderly individual do to achieve this? What are the recommendations regarding physical activity or exercise for this age group? Many authors have quoted exercise guidelines based on the ACSM recommendations for healthy adults (ACSM, 1990), but modified to take account of the elderly individual's reduced maximal capacity (Astrand, 1992; Carroll & Pollock, 1992; Vorhies & Riley, 1993; Barry & Eathorne, 1994). This prescription generally involves a mode of activity which uses large muscle groups (walking, jogging, swimming, cycling) at a moderate intensity (60% of maximum heart rate or a Rate of Perceived Exertion of about 13) for 15-20 minutes at least three times per week. The programme should also incorporate resistance training and flexibility components twice a week. There is little doubt that such a programme, if started at a low level and with slow progression, would produce fitness and health benefits and help maintain an individual's ability to function

independently. But two important practical questions about this recommendation must be addressed:

(1) How feasible is it to expect elderly people to commence such a programme of exercise and incorporate it into their daily life when over 70% are currently sedentary? These recommendations require quite a substantial change in lifestyle at a time when society stereotypes deem that people should be 'taking it easy', not engaging in a strenuous programme of exercise.
(2) Is a programme which specifies *exercise* as opposed to *physical activity* (page 2) necessary? Can functional ability be maintained through activities which are less structured and more easily incorporated into everyday life?

Although more research on the subject of physical activity and maintenance of functional ability in the elderly is required, it seems reasonable to suggest that a programme which is less rigorous than that described above may be sufficient. Indeed, more recent research advocates the accumulation of physical activity throughout the day to lessen the risk of morbidity and mortality (Blair *et al*, 1992; Pate *et al*, 1995). Ebrahim *et al* (1988) found that functional problems such as immobility, incontinence and cognitive impairment were significantly related to physical activity, and concluded that an activity such as regular walking could have an important role in ameliorating symptoms. Astrand (1992), in addition to the ACSM-type programme, also recommends "60 minutes of daily physical activity, not necessarily vigorous, not necessarily continuously. During the daily routine of moving, walking, climbing stairs etc, whether for 1 min 60 times a day, 12 min five times a day, or any combination totalling 60 min may demand 300 kcal." The adage 'use it or lose it' is particularly appropriate for the elderly, and we should be moving away from direct-assistance treatments for older people which do for them what they could learn to do for themselves (Rowe & Kahn, 1987; Vorhies & Riley, 1993).

Perhaps there is a role for direct-assistance treatment during the early stages of recovery from an illness or accident. Functional ability and hence quality of life in the elderly can deteriorate very rapidly following such an acute trauma. This leads to a sudden decrease in physical activity, and deconditioning, weakness, and fatigue soon follow. The individual must be encouraged to undertake active rehabilitation by renewing as far as possible their previous level of activity, otherwise a vicious circle of inactivity and further physical decline is likely to ensue.

All elderly people should aim to maintain participation in activities which challenge their cardiovascular, strength, and flexibility capacities (Vorhies & Riley, 1993). Continued participation in activities such as walking, gardening, using public transport, household chores, lifting and carrying, bending, and social interaction will greatly contribute to the elderly individual's ability to function independently and maintain their quality of life. With only around 9% of people receiving advice on physical activity and exercise from their GP (Fentem, 1992), primary health carers must be educated about the types of activity to recommend to older people, and be able to encourage and monitor progress. Although a carefully planned and individualised programme of *exercise* is undoubtedly beneficial, overall *physical activity* to provide a health benefit, and maintenance of everyday tasks to ensure the ability to function independently, are perhaps more important and more realistic recommendations when *quality of life* is the outcome.

The case for physical activity in providing health and functional benefits is now clearer. Along with diet, smoking, and alcohol consumption, low exercise level is a key cause of morbidity and mortality in western countries. The risk of many of the major causes of ill-health can be reduced by taking more physical activity, and exercise can play a vitally important role in maintaining independence in to old age. With increased knowledge of the benefits of exercise and the generally low level of exercise participation, it is becoming ever more important to dramatically change the physical activity habits of the population of this country.

2.3 Assessment of physical activity

2.3.1 Physical activity participation

Although there is ample evidence of the benefits of exercise, the amount of physical activity which people do as they get older is known to decrease (Canada Fitness Survey, 1983; Scottish Sports Council, 1991; Sports Council & Health Education Authority, 1992). The proportion of people in the population deemed to be active depends on the method used to assess physical activity and on the definition of active. In 1988, Powell (p24) listed a number of studies in which 'active' was defined as "participation in one or more of six listed activities on a regular basis", "1500 kcal/week or 3+ kcal/kg/day

expended on sports and conditioning", and "3+ sessions/week for 20+ min/session at 60%+ maximal capacity". Unsurprisingly, the proportion of active people was inversely related to the strictness of the definition. The Allied Dunbar National Fitness Survey (Sports Council & Health Education Authority, 1992) assessed the number of 20 minute periods of vigorous, moderate, and light activities performed in the previous 4 weeks, and used this as the basis for 5 different activity levels. The target level of activity for men and women aged 55-74 years was level 3, or at least twelve 20 minute occasions of moderate activity in the past 4 weeks. Seventy-one percent of men and 74% of women were below this threshold.

Another important factor in determining physical activity participation is the method of data collection. Physical activity and exercise behaviour can be assessed in a large number of ways, depending on the size of the sample and the type of activity under measurement (for example, total energy expenditure; leisure time physical activity; activity at work; moderate versus vigorous activity etc). LaPorte *et al* (1985) listed seven major categories of physical activity assessment methods: calorimetry; job classification; survey procedures; physiological markers; behavioural observation; mechanical and electronic monitors; and dietary measures. They also stated that no single instrument fulfills the criteria of being valid, reliable, and practical without affecting behaviour. Subjects may be tempted to increase their normal level of activity if being observed or if wearing an electronic monitor.

One of the major problems with physical activity research is the lack of a 'gold standard' measure against which to judge and validate new methods of activity assessment. Unlike measurement of blood pressure or cholesterol level, physical activity has so many facets that there is no accepted standard technique which provides consistency of measurement and definition across studies (LaPorte *et al*, 1985; Washburn & Montoye, 1986). Nevertheless, assessment methods are constantly being refined and improved, as research investigating the relationship between physical activity and health relies on accurate measurement of activity. An apparent lack of relationship may actually be due to an inaccurate estimate of activity, rather than a true absence of a relationship.

2.3.2 Activity Questionnaires

Of the seven categories listed, attention in this research will focus on questionnaire methods. Survey procedures are the most commonly used in

epidemiological research, and there are four key components of questionnaires (LaPorte *et al*, 1985). The first is the time frame the respondents are asked to remember, which can range from 24 hours to a year or more. Although a shorter recall period is less affected by forgetfulness, it may not provide a true representation of physical activity over an entire year. Indeed, Uitenbroek (1993) reported considerable seasonal fluctuations in physical activity participation in a Scottish sample, and this variation was greater in older than in younger adults. The second is the nature and detail of the physical activities. This may require the frequency, duration, and intensity of specific activities, or may be more general, asking simply for participation in groups of activities. Thirdly is the method of data collection. This is usually done by self-administered questionnaire, personal or telephone interview, or a combination of the three, and is determined by the first two components. The remaining component is the 'activity score', usually a summary index based on calculated estimates of kilocalories expended, or an ordinal scale of activity categories which ranks individuals according to their activity level.

Based on these four characteristics, surveys can be grouped into four general types (LaPorte *et al*, 1985). *Diary surveys* are self-administered, with individuals making a detailed record of all activities in a short time period, typically 24 hours (Edholm *et al*, 1955; Acheson, 1980). Cost, time, and acceptability constraints mean that diary surveys are generally not suitable for epidemiological studies. More often, *recall surveys* are used in epidemiology. These obtain information about activity usually over a 1-7 day period by means of a personal or telephone interview or a self-administered mail questionnaire. Time spent in vigorous, moderate, and light intensity activities is recorded and converted to energy expenditure in kilocalories using published values (Paffenbarger *et al*, 1978; Blair, 1984; Sallis *et al*, 1985). *Quantitative history surveys* attempt to obtain similar information as recall surveys but over a longer period, often up to 1 year (Montoye, 1971; Taylor *et al*, 1979). The type of questionnaire which will be used in this research is referred to as a *general survey*. These surveys typically take the least time and are the easiest to complete, often consisting of only a few items. They seek little specific information about the nature and detail of physical activities, and the subject may only be required to provide a subjective impression of his or her overall activity. They attempt to classify individuals in to broad categories rather than describe behaviour in detail. For some studies, it may be sufficient to identify individuals who have a low level of physical activity participation and may therefore be at risk from inactivity-related disease and loss of function, without

eliciting detail of energy expenditure. If proved valid and reliable, general surveys readily lend themselves to this type of study.

The Lipids Research Clinics (LRC) questionnaire in its original form (Haskell *et al*, 1980) was administered by personal interview, consisted of two questions, and placed subjects into one of three activity categories. Subjects were asked if they participated in strenuous exercise or hard physical labour, and if so, how many times per week, and were classified as inactive, moderately active, and highly active, according to their responses. In developing the LRC questionnaire Haskell *et al* (1980) showed that men and women who reported performing strenuous exercise on a regular basis had higher levels of high density lipoprotein (HDL)-cholesterol, lower resting and submaximal exercise heart rates, and longer treadmill exercise test durations than those who reported no such exercise. Gordon *et al* (1983) used the same three-group classification, but found in addition that self-rated physical activity at both work and leisure compared with others of the same age and sex (5 categories ranging from much more active to much less active) showed a positive graded relationship with HDL-cholesterol. This classification was simplified by Siscovick *et al* (1988) who found that very few people reporting strenuous physical activity performed such activity less than three times per week. A two-group classification was employed: those who reported any strenuous activity were classified as active; all others were classified as inactive. The same associations between activity classification and resting heart rate, submaximal exercise heart rate, and treadmill test duration were found as with Haskell *et al* (1980). Significantly though, there was no relationship with body mass index or CHD incidence. This led Ainsworth *et al* (1993a) to conclude that the two-point classification lacked sensitivity in detecting the least active subjects. They suggested that the group classified as inactive may have contained some individuals who were somewhat active, thus reducing the CHD risk estimate for the truly sedentary group. The result of this was a four-point classification (Ainsworth *et al*, 1993a) (very low active, low active, moderately active, and high active) based on leisure-time physical activity relative to others of the same age and sex, and a yes-or-no response to regular participation in strenuous physical activity. The validity and reliability of this classification was tested using a sample of 28 men and 50 women with a mean age of 39.8 $\pm$ 9.1 years. A number of validation measures were used:

1. Physical activity history. A modification of the Minnesota Leisure Time Physical Activity (LTPA) questionnaire (Taylor *et al*, 1979), the Four Week

History (FWH) questionnaire requires subjects to recall duration and frequency of all leisure and household activities over the previous four weeks from a list of over 70 activities. Heavy, moderate, light, household, and total activity scores in kcal/d were calculated.

2. Motion detection. An objective measure of physical activity was obtained using a Caltrac accelerometer which the subjects wore for 48 hours excluding sleep, showering, and water sports. Scores were expressed as kcal/d and activity units/d (AU).

3. Cardiorespiratory fitness. Resting heart rate (HR_{rest}), submaximal exercise heart rate (HR_{submax}), and maximal oxygen uptake ($\dot{V}O_{2max}$).

4. Body composition. Percent body fat and body mass index (BMI).

Using multiple linear regression analysis, the variance explained by the 4-point and 2-point classifications after adjusting for age and gender was statistically significant for $\dot{V}O_{2max}$, HR_{submax}, percent fat, BMI, FWH_{heavy} and FWH_{light} activities, suggesting that the LRC questionnaire reflects habitual vigorous physical activity patterns which contribute to aerobic fitness and body composition. Although the 4-point classification explained very little variance in the FWH_{total} scores, there was a graded increase in FWH_{total} scores with activity classification. This is important as low total leisure physical activity as measured by the LTPA questionnaire is predictive of CHD incidence (Leon *et al*, 1987; Slattery *et al*, 1989). The 4-point classification had a 4-week test-retest correlation of 0.88. Ainsworth *et al* (1993a) concluded that although the LRC questionnaire classified subjects primarily by vigorous activity, the 4-point classification enabled additional discrimination between subjects with very low and low activity habits, and between those with moderate and high activity habits.

2.3.3 Objective Activity Measurement

Although questionnaires are the method of choice for activity assessment in epidemiological research, several techniques attempt to gain an objective measurement of activity. If proved valid and reliable these may become the elusive 'gold standard' against which other methods, including questionnaires, may be validated. Heart rate monitoring (Richardson, 1971; Gretebeck & Montoye, 1992; Haskell *et al*, 1993), pedometers (Washburn *et al*, 1980), and accelerometers (Montoye *et al*, 1983; Meijer *et al*, 1989; Matthews & Freedson, 1995) have all been used to try and quantify physical activity. In terms of cost,

time and effort required by subject and investigator, validity and reliability, and influence on normal physical activity, accelerometers appear to offer the greatest potential for objectively assessing physical activity. The Caltrac, a vertical accelerometer which is commercially available, will be used in this research. It measures acceleration in the vertical plane via a piezoelectric bender element and provides an estimate of energy expenditure in kcal. This is calculated as a function of basal metabolic rate after programming with the subject's age, height, weight, and sex, plus energy expenditure due to body movement.

During early development of the Caltrac (Montoye *et al*, 1983), a correlation of r=0.74 with $\dot{V}O_2$, and a reproducibility of r=0.94 across 14 different activities performed in a laboratory were reported. Washburn and LaPorte (1988) reported a correlation of r=0.85 with walking speed and a reproducibility of r=0.89 while walking outside and at two different speeds. The age of the subjects in these two studies ranged between 20 and 60 years. During bicycle riding outdoors a correlation of r=0.85 between the Caltrac and $\dot{V}O_2$ in subjects aged 15-62 years was found by Hunter *et al* (1989). However in this study, the Caltrac was worn at the ankle and the knee, and not at the hip as in the previous studies, and as recommended in the instructions for the commercially available Caltrac. This is a potential drawback when using the Caltrac. There is actually very little, if any, vertical acceleration of the hips during cycling, and energy expenditure for this activity, along with others such as rowing, weight training, and digging, is likely to be underestimated. The Caltrac does however contain a function which should be used when performing these types of activity, and which allows some correction for this underestimate of energy expenditure.

Three-dimensional accelerometers tested in laboratory and field studies may allow a more accurate assessment of energy expenditure (Meijer *et al*, 1989; Bouten *et al*, 1994; Matthews & Freedson, 1995; Welk & Corbin, 1995). One of this new generation of accelerometers has recently become available. The Tritrac-R3D records movement in all three planes and can record minute by minute activity information continuously for up to two weeks. The data is stored internally and must be downloaded to a computer, and there are no external controls thereby removing the possibility of subject tampering.

In a study of 25 adults (mean age 26.7 years), Matthews & Freedson (1995) reported that the Tritrac significantly underestimated total daily energy expenditure (EE) by about 350 kcals/d compared with a 3 day physical activity

log and a 7 day recall interview. They concluded that this was primarily due to the Tritrac overestimating time spent in sedentary activities and underestimating time spent in light, moderate and hard activities. The authors suggested that the Tritrac may still not sufficiently detect energy-expending activities which do not involve a great deal of movement, or that conversion of movement data to EE data may be inaccurate. In a study of 35 schoolchildren aged 9-11 years, Welk & Corbin (1995) reported that the correlations between movement counts recorded by the Tritrac and heart rate recorded using a Polar heart rate monitor were highest during free play situations (lunch, recess, after school) and lower during sedentary (class time) or structured (physical education class) activities. This was attributed to the standard deviation of activity counts during these periods being relatively small compared with other time periods due to more homogeneous activity levels between the children. The authors concluded that the ability of the Tritrac to parcel activity by time and intensity greatly increases its utility, but that the higher cost may not be justified if only a rough measure of total activity is required. Like the Caltrac, the Tritrac is useful in identifying the least active subjects from all others, and although it may provide a much better estimate of daily EE than the Caltrac, further study is needed to evaluate its utility as an objective measure of physical activity.

Due to availability and cost, the Caltrac rather than the Tritrac will be used in this research. Two studies have used the Caltrac with older adults. Twenty-three men and 22 women with a mean age of 72.9 $\pm$ 5.3 years wore a Caltrac and completed a detailed activity diary for 3 days (Washburn *et al*, 1990). The mean Caltrac activity counts/h for the sample of 99.7 counts/hr (obtained by programming with the same values for height, weight, age, and sex for every subject) was significantly less than that observed in a sample of college students (113.6 counts/hr). Caltrac readings were significantly related to percent time engaged in walking, sport, and recreation ($r=0.28$) and percent time spent standing ($r=0.28$), and there was a nonsignificant trend ($r=-0.20$) with time spent sitting and lying down. Reliability was not tested. Although the correlations were not as high as those observed in other studies, they were in the expected direction. Washburn *et al* (1990) also argued that a larger sample would have allowed more precise activity diary categories (the nine original categories had to be condensed in to three), and may have provided a stronger relationship between the Caltrac and physical activity. Nichols *et al* (1992) compared the validity and reliability of the Caltrac between young (aged 26.1 $\pm$ 1.1 years) and older (64.8 $\pm$ 1.0 years) adults during treadmill walking over 6 different speeds. The criterion measure in this study was energy expenditure

measured by direct gas analysis. In the older adults, the test-retest reliability was r=0.98. The correlation between the Caltrac and oxygen consumption across all walking speeds was r=0.84 for men but only r=0.13 for women. The authors suggested that this may have been due to gait differences between men and women, but without biomechanical analysis, this explanation remains speculative. As Caltrac counts were significantly related to walking speed, the data were further analysed with the influence of speed removed. The correlations decreased to r=0.29 for men and r=-0.05 for women, demonstrating a lack of accuracy of the Caltrac in estimating energy expenditure in older adults. The correlations for younger subjects, whether across all speeds or with the influence of speed removed, were higher than those for older subjects.

The number of days required to give a reasonable estimate of habitual physical activity in older adults has not been determined. Subjects in the Washburn *et al* (1990) study wore the Caltrac for 3 days for about 14 hours per day. Validity of the Caltrac was assessed in a laboratory in the Nichols *et al* (1992) study and subjects were not required to wear the Caltrac during their normal daily activity. In a study with working males (mean age 36.9 years) Gretebeck and Montoye (1992) found that energy expenditure (kcals/d) measured by the Caltrac was significantly greater during weekdays than weekends, and concluded that for a 7-day week, 2 and 3 days were required to give measurements with less than 10% and 5% intra-individual error respectively.

It can be concluded from these studies that the Caltrac gives highly reliable measurements, but may lack accuracy in estimating energy expenditure in older adults. However Washburn *et al* (1990) suggested it may be useful for assessing qualitative differences in levels of physical activity, and as such could be used to detect differences in physical activity between subjects classified into activity levels using the LRC questionnaire. Future studies may be able to utilise the greater detail recorded by the Tritrac-R3D monitor to validate activity questionnaires; however their underestimation of total daily energy expenditure and high cost is likely to render them unsuitable for population use.

2.4 Theories of exercise behaviour

With the growing evidence (Blair *et al*, 1992; Pate *et al*, 1995) of a shift in emphasis from vigorous physical activity to include the health benefits of light and moderate activity, so the task of studying the determinants of physical activity has become considerably more difficult. In 1985, Dishman *et al* described these determinants in three categories: (a) characteristics of the individual and his/her lifestyle habits (for example age, gender, occupation, biomedical status, and knowledge, attitudes, and beliefs about exercise); (b) characteristics of the environment (for example family/friends participation, access to facilities, social reinforcement, cost, and climate); and (c) characteristics of the activity (for example programme complexity and convenience, and activity type, intensity, frequency and location). The determinants were reviewed in relation to both supervised exercise programmes and spontaneous changes in levels of physical activity within a population base. The paper concluded that known determinants still had to be ranked according to priority, there was little knowledge regarding specific determinants for certain populations and settings, and that it was not known how past activity environments and experiences influenced present and future participation. King *et al* reviewed the subject again in 1992, summarising studies which had attempted to address the questions raised in Dishman *et al's* review, but also highlighting a large number of gaps in the literature still remaining. It has been suggested that the poor understanding of exercise adherence was due to early studies lacking reference to theoretical models of human behaviour (Godin, 1994a). A number of psychological theories have been developed and applied to exercise behaviour in an attempt to guide research in the area and gain a better understanding about who will do what type of physical activity, when, and for how long. Of the determinants known to be associated with exercise behaviour, two are repeatedly found in these psychological theories. These are perceived benefits of physical activity (also called outcome expectancies) and perceived barriers to physical activity. Theories which contain these two variables and methods of assessing them will now be reviewed.

The Health Belief Model (HBM; Maiman & Becker, 1974) was originally developed to predict preventive health behaviours other than physical activity. The model postulates that the likelihood of adopting a behaviour depends on the individual's perception of a threat to personal health and a belief that the

recommended action will reduce this threat. This belief in the efficacy of the preventive behaviour must also outweigh any barriers to action. The model was supported by studies of illness and medical care recommendations, with perceived barriers consistently seen as the most powerful predictor of behaviour (Janz & Becker, 1984). Although the HBM has a definite illness-avoidance orientation (Rosenstock, 1974), it has been used to investigate exercise, a positive health behaviour. Lindsay-Reid & Osborn (1980) found in a sample of fire-fighters, contrary to the HBM, that those who adhered to an exercise programme actually had lower perceptions of susceptibility to CHD and general illness. Overall adherence to a walking programme in a sample of heart surgery patients was associated with fewer barriers to exercise and greater perceived efficacy of the programme, but not with beliefs of illness susceptibility and severity (Tirrell & Hart, 1980). Similarly, Slenker *et al* (1984) also reported that perceived susceptibility to health problems was a weak factor in discriminating joggers and non-exercisers, but that barriers to exercise was the single most powerful predictor, accounting for 40% of jogging behaviour. It appears that although isolated variables from the HBM (eg perceived benefits and barriers) are related to exercise behaviour, the model as a whole has been relatively unsuccessful in predicting adoption and maintenance of physical activity.

Expectation of outcome is defined as "the estimate that a given behaviour will lead to certain outcomes", and self-efficacy as "the conviction that one can successfully execute the behaviour required to produce the outcomes" (Bandura, 1977, p193). According to self-efficacy theory (SET; Bandura, 1977), exercise behaviour would be associated with a belief in the benefits of physical activity, and a perceived ability to exercise regularly. The theory has been supported by a number of studies (Dzewaltowski, 1989; Sallis *et al*, 1989; McAuley *et al*, 1991), though self-efficacy shows a consistently greater role in predicting exercise behaviour than outcome expectancies. However it is unlikely that a single variable can fully explain exercise behaviour, and self-efficacy has been incorporated into other theoretical frameworks.

The protection motivation theory (PMT; Rogers, 1975) is similar to the HBM and has more recently proposed that the intention to adopt a particular behaviour depends on perceived self-efficacy and efficacy of the recommended behaviour, in addition to perceived severity of illness and probability that this illness will occur (Rogers, 1983). Studies have generally reported a relation between physical activity and the self-efficacy theory variables (perceived self-efficacy

and efficacy of the recommended behaviour), rather than perceived threat and severity of disease (Stanley & Maddux, 1986; Wurtele & Maddux, 1987; Godin *et al*, 1991). Messages conveying a persuasive threat seem to enhance intention to exercise, but are less effective in inducing and sustaining changes in behaviour. The PMT thus has limited use for the study of exercise behaviour.

The theory of reasoned action (TRA; Fishbein & Ajzen, 1975) proposes that intention is the immediate determinant of behaviour, and that intention, in turn, is predicted from attitude toward the behaviour and perception of social normative factors (a belief that 'significant others' think the individual should adopt the behaviour). The TRA suggests that attitude is a function of beliefs about the behaviour and also the value of the expected outcomes. Fishbein & Ajzen (1975) state that the measurement of such variables should be highly specific to the behaviour in question. The behaviour must be clearly specified, volitional in nature, and performed in a given situation. The TRA has been applied to exercise behaviour by a number of investigators (see Godin & Shephard, 1990; Godin, 1994b), and overall has been useful in clarifying the relationship between intention and behaviour. In contrast with researchers using less specific measures of attitude (Dishman & Gettman, 1980; Dishman *et al*, 1980) who claimed that attitudinal scores do not predict exercise, attitude, when measured within a proper theoretical framework, seems an important predictor of exercise behaviour (Godin & Shephard, 1986). Subjective norm (perception that majority of significant others think one should adopt the behaviour) is less consistently associated with exercise than measures of attitude (Godin, 1994a). External variables, such as past exercise habits (Godin *et al*, 1987) and barriers to exercise (Slenker *et al*, 1984; Godin *et al*, 1991) can also exert a substantial influence on the translation of intention into behaviour. With the model explaining around 30% of the variance in exercise behaviour (Godin, 1994b), a large proportion of variance is left unexplained. This implies that measurement techniques need to be refined, or that external factors additional to those in the basic model are involved, and stresses the need for a theory which will offer a more complete description of exercise behaviour.

The theory of planned behaviour (TPB; Ajzen, 1988) is an extension of the TRA to take into account that most behaviours are not under complete volitional control and are more likely fall somewhere on a continuum from total control to complete lack of control. There is total control if there are no practical constraints to the adoption of a given behaviour, and a lack of control if adoption of the behaviour requires opportunities, resources, or skills that are

lacking (Godin, 1994a). Thus perceived behavioural control (PBC) was added to the original TRA model and defined as "the perceived ease or difficulty of performing the behaviour" (Ajzen, 1988 p132). Further, it is assumed to reflect "past experience as well as anticipated impediments and obstacles". Although not adhering to the strict definition of PBC, perceived barriers to exercise have been used to measure the variable, and have been shown to be related to both intention and behaviour in a range of populations and activities (Slenker *et al*, 1984; Tappe *et al*, 1989; Sallis *et al*, 1989).

A theory which takes a different approach is the transtheoretical model of behaviour change. Originally developed to study the stages and processes involved in quitting smoking (DiClemente & Prochaska, 1982), it has since been applied to exercise behaviour (Marcus & Simkin, 1994). The theory presents six stages which represent the direction in which change occurs, and which can be both stable and dynamic in nature. The stages have been labelled (Prochaska & Marcus, 1994):

- Precontemplation. Individuals in precontemplation do not intend to change their behaviour in the foreseeable future (usually the next 6 months) and view the pros of their risk behaviour as outweighing the cons.
- Contemplation. Individuals seriously intend to change their behaviour within the next 6 months but may stay in this stage for up to 2 years. They view the pros and cons as about equal and are consequently ambivalent about changing.
- Preparation. Individuals have made some behaviour change and typically have a plan of action. The cons of the risk behaviour are evaluated as greater than the pros, and preparation is not a stable stage.
- Action. The individual has actively begun the new behaviour in the past 6 months. Action is also the least stable stage with the highest risk of relapse.
- Maintenance. This is the period from 6 months after beginning the new behaviour until the risk of returning to the old behaviour has terminated.
- Termination. The stage in which there is no temptation to engage in the old behaviour and 100% self-efficacy in all previously tempting situations.

Decisional balance or evaluation of the benefits and costs of performing a behaviour, and self-efficacy are also important parts of the model (Prochaska & Marcus, 1994). A concept central to the model is that interventions aimed at changing behaviour are more likely to be successful if tailored toward a specific stage of change (Marcus *et al*, 1992a; Prochaska *et al*, 1993). For example, it is

thought that the failure of most physical activity interventions is because programmes and media campaigns tend to be action-oriented, whereas the majority of the population are sedentary and therefore either in precontemplation or contemplation (Marcus & Simkin, 1994).

Marcus *et al* (1992b) developed scales to measure stages of change and self-efficacy for exercise. They found that subjects in all stages except contemplation and preparation differed significantly in their exercise self-efficacy. Using a work-site sample of 219 employees, Marcus & Simkin (1993) found evidence of the concurrent validity of the stages of exercise behaviour questionnaire with a 7-day recall activity questionnaire. Subjects in action/maintenance reported significantly more vigorous and moderate physical activity than subjects in preparation, who were in turn significantly more active than those in precontemplation/contemplation. There have been two studies of the transtheoretical model using samples of older adults. Barké & Nicholas (1990) studied 59 adults with a mean age of 64.9 years. Eighteen subjects were participants in a 10-week exercise programme, 21 were on a university-run Elderhostel programme (a residential craft and activity programme), and 20 were a group of matched retirees. A 32-item questionnaire was used to assess four stages of change (preparation was not included). For the group as a whole, action and maintenance subscales were significantly higher than precontemplation, indicating that a large number of subjects did not perceive themselves as sedentary. Between the groups, it was found that the exercise and Elderhostel groups scored significantly higher on the action and maintenance subscales than the retirees, who scored significantly higher on the precontemplation subscale. Thus although the instrument used to determine stage of exercise differed from that used by Marcus and colleagues (Marcus *et al*, 1992b; Marcus & Simkin, 1993), it appears that the stages of change model is able to distinguish groups of older adults who differ in their level of physical activity. In a sample of 583 Australians aged 50-65 years, Gorely & Gordon (1995) reported significantly greater exercise participation by subjects in action and maintenance than those in preparation. Using discriminant analysis, they also found that 8 of 13 predictor variables made significant and independent contributions to the discrimination among stages. Five of the 8 variables were processes of change, the other three were self-efficacy and decisional balance pros and cons. The results of these two studies demonstrate that the transtheoretical model is appropriate for study with older adults, that subjects classified using a stages of exercise behaviour questionnaire differ in their

physical activity status, and that a number of other constructs can successfully discriminate between exercise stages.

Although designed to study the transtheoretical model, the questionnaire developed by Marcus *et al* (1992b) performs a similar function as questionnaires which attempt to classify individuals according to their overall activity status, such as the LRC questionnaire (Ainsworth *et al*, 1993a). The stages of exercise questionnaire refers specifically to exercise behaviour whereas the LRC questionnaire refers to overall physical activity, but both involve only a few items, both can be self-administered in a short time, and both classify subjects in to one of a few activity categories. In this respect, both questionnaires are able to identify individuals for whom intervention may be appropriate. The transtheoretical model has an additional advantage in that it is known that interventions are more successful if specifically tailored toward the individual's present stage (Prochaska *et al*, 1993).

Prochaska & Marcus (1994) have highlighted a number of limitations of present studies of the Transtheoretical Model, two of which will be addressed in this study. Firstly, all studies have relied on self-reports of physical activity to provide evidence of concurrent validity of the model. Studies are required which measure physical activity objectively. Secondly, studies which use more representative and diverse samples are required to investigate the application of the model to all groups in the population. Prochaska & Marcus (1994) also state that there should be more longitudinal studies to investigate the dynamic nature of the model, and that the efficacy of stage-matched interventions requires more study.

Personal Investment Theory (Maehr & Braskamp, 1986) has been developed by Duda and Tappe (Duda & Tappe, 1988; Tappe & Duda, 1988; Tappe, 1992) to investigate physical activity behaviour. The theory proposes that perception of meaning of a situation is the major determinant of behaviour, and focuses on the complex interactions between person and situation characteristics. The meaning of a situation itself is comprised of three interrelated components:

(a) *personal incentives.* This refers to the motivational focus of an activity and can be likened to perceived benefits of physical activity.

(b) *sense of self.* This is comprised of four components:

  (i) sense of competence - an individual's subjective judgement of personal ability to do something successfully.

  (ii) self-reliance - an individual's sense of personal control.

(iii) goal-directedness - the personal tendency to set goals and organise behaviour in accordance with these goals.

(iv) social identity - an individual's perception of association with certain groups and holding of selected others as significant.

(c) *perceived options.* A context-specific component referring to the behavioural alternatives and opportunities available in a particular situation.

Research with elderly subjects has shown the theory to have some use. Duda & Tappe (1988) reported that current physical activity participation by a group of 47 male and female subjects aged 50-81 years was significantly predicted by variables reflecting exercise incentives, the congruency between these incentives and the focus of the programme, and sense of self. The incentive of social recognition (eg 'I exercise to gain the attention of other people') was the best predictor, followed by exercising for fitness reasons and reducing stress by exercising. Each of the three dimensions of meaning also significantly predicted expected physical activity in 6 months time. Exercising for reasons of mastery and self-improvement was the best predictor of future physical activity. Physical activity has also been associated with life satisfaction in older adults (Kelly *et al*, 1987). Tappe & Duda (1988) investigated the degree to which the three dimensions of personal investment theory predicted life satisfaction among a group of elderly exercise programme members. Perceived self-competence in physical ability best predicted life satisfaction. Mastery was also positively related to life satisfaction, whereas exercising to gain support and recognition for one's accomplishments were negatively related. These studies indicate that the theory of personal investment is useful in predicting physical activity and important associated variables in elderly adults. The theory has been expanded in research with adolescents (Tappe, 1992) to include perceived barriers, perceived situational opportunities, and perceived situational climate in addition to the three original dimensions, but this has not yet been extended to older adults.

As this review of some of the theories of exercise behaviour has shown, perceived benefits of physical activity, and perceived barriers to physical activity, appear as either central or peripheral variables in quite a number of these theories. It also apparent that the utility of a particular model depends to a large extent on the accuracy of measurement of the variables contained within the model. Perceived benefits and barriers have been assessed using unvalidated, single item questionnaires in all but two studies. The danger here is that there is no evidence that single items are interpreted the same by

respondents or that responses are reliable (Steinhardt & Dishman, 1989). The fact that benefits and barriers measured in this way do show a relationship with exercise behaviour suggests that a more precise, psychometrically developed method of assessing these variables could clarify this relationship further.

A 25-item questionnaire concerning motivations for exercising was used in a study investigating adherence by elderly subjects to class-based and home-based exercise programmes (Mutrie *et al*, 1993). This questionnaire comprised five major motivations (physical health, mental health, challenge, social, and cues from significant others/media), each with five items. The class-based members were most motivated by improving physical health, followed by mental health, and then social opportunities, the only motivation on which the groups differed significantly. The two most important motivations for the home-based group were the same as those for the class, but the next highest motivation was the challenge involved. However, it is not known whether the items purported to measure a particular motivation actually did so, as the questionnaire was not validated. Similarly, perceived barriers in the study were measured using single items. Most important barriers for the class-based group were lack of nearby facilities, lack of instruction, inconvenient facility opening times, and lack of time. Most important barriers for the home-based group were lack of time, being too tired after work, lack of instruction, and low self-motivation. Total barriers scores were significantly reduced after 12 weeks in both the class-based and home-based programmes, which had adherence rates of 55% and 66% respectively, lending some evidence for the validity of the items.

The Allied Dunbar National Fitness Survey (Sports Council & Health Education Authority, 1992) measured benefits and barriers in men and women aged 16-69 years. Benefits were assessed using twelve single items, and barriers were grouped under five main categories (physical, emotional, motivational, time, and availability) each with three or four items pertaining to that category. For both men and women the top three motivating factors for exercise were to feel in good physical shape, to improve/maintain health, and to feel a sense of achievement. Results of the benefits of physical activity were not given for different age groups. The main barriers for men and women aged 55-69 were 'I'm not the sporty type' (34% of men and 46% of women said this stopped them doing more exercise), 'injury or disability' (32% and 24%), 'I need to relax in my spare time' (26% and 28%), and 'lack of time' (25% and 27%). Assuming that these results are valid, they highlight the importance of

conveying the message that physical activity need not mean structured, strenuous exercise, and that these barriers can be overcome if individuals are given assistance and choices about how to incorporate appropriate types of activity within their lifestyle.

A questionnaire to measure personal incentives for exercise was developed by Duda & Tappe (1989) with a sample of 515 male and female students. A principal components analysis of 85 items produced nine factors. These were labelled Appearance, Competition, Mental Benefits, Affiliation, Mastery, Flexibility/Agility, Social Recognition, Health Benefits, and Weight Management. The questionnaire was used in studies investigating the theory of personal investment as a predictor of physical activity life satisfaction in elderly adults (Duda & Tappe, 1988; Tappe & Duda, 1988). Although components of the questionnaire were successful in predicting the dependent variables, it was developed with a college sample and its validity for use with an elderly sample, through a similar principal components analysis, has not been tested.

Sechrist *et al* (1987) and Steinhardt & Dishman (1989) have both developed psychometric scales for the measurement of exercise benefits and barriers. Sechrist *et al* (1987) used factor analysis on a list of 45 perceived benefit items and 20 perceived barrier items. A sample of 650 adults aged 18-88 years (mean age 38.7 years) responded to the items on a 4-point Likert scale to indicate strength of agreement with the item statements. Five benefits factors consisting of a total of 29 items were obtained from the analysis and these were labelled: life enhancement; physical performance; psychological outlook; social interaction; and preventive health. Four barriers factors containing 14 items were extracted. These were: exercise milieu; time expenditure; physical exertion; and family encouragement. The benefits and barriers scales had an internal consistency (Cronbach's alpha) of 0.95 and 0.87 respectively, and a 2-week test-retest correlation of 0.89 and 0.77 respectively. Despite the lack of evidence of concurrent validity, with for example, individuals' actual activity levels, and the fact that most of the subjects were college educated, middle to upper income, working white adults, the authors claim that the Exercise Benefits/Barriers Scale (EBBS) possesses sufficient reliability and validity to warrant its use in exercise behaviour research.

Steinhardt & Dishman (1989) conducted two similar studies with college students and a work-site sample. Three outcome-expectancy factors (benefits) were identified with the college sample, accounting for 60.7% of the total

variance. These were: psychologic; body image; and health. Three barriers factors were also found, accounting for 48% of the variance, and these were labelled time, effort, and obstacles. In a multiple linear regression analysis it was found that the barriers time and effort measured at the start of term were both significantly inversely related to supervised running (kcal/kg/wk) at the end of term. Seven-day recall estimates of free-living physical activity (kcal/kg/wk) at term end were predicted by the barrier effort and the benefit health. In addition to the three outcome-expectancy factors for the college sample, competition, fun, and social factors were identified with the work-site sample. Limiting health was identified as an additional barrier to exercise. Participation in the company's health and fitness programme was used as one of the criteria for validating the scales. Programme adherents were more likely to value psychologic and body image/health benefits, and less likely to exercise for social reasons than nonadherents. Adherents were also less likely to perceive time or obstacles as barriers to physical activity and more likely to find limiting health a barrier. Cronbach's alpha for the factors over both studies ranged from 0.47 to 0.84, and 8-week test-retest reliability of the factors in the college sample ranged from 0.66 to 0.99. These studies provide precise and stable scales for independent factors which were related to several different measures of physical activity. Further work is required if they are to assess perceived benefits and barriers in samples other than college and work-site. Using the same scales developed with the college sample, Dishman *et al* (1992) found that the variability in physical activity explained by known determinants can be dependent upon the method used to estimate physical activity. A ratio of outcome expectancy values to perceived barriers ($OE_{values}/P_{Barriers}$) had a correlation of r=0.51 with physical activity when measured by a 7-day diary, but only r=0.34 when measured by the Caltrac accelerometer. The correlation between the two estimates of physical activity, although significant, was low at 0.35, suggesting that the two were measuring different components of physical activity. The authors suggest that the accuracy of physical activity estimates might be improved by the combination of several different measures. They concluded that the associations found between self-reported psychological determinants and self-reported physical activity may be confounded by a halo effect of employing the common method of self-report for both assessments.

A criticism which can be levelled at both the Sechrist *et al* (1987) and Steinhardt & Dishman (1989) scales is the lack of an analysis of gender differences in perceived benefits and barriers. Other studies, which used single item type questionnaires, showed that differences do exist between men and women in

their reasons for exercising, and for gender analyses not to be conducted on scales designed to assess these important variables is a serious error. Summers *et al* (1983) reported differing motives for men and women competing in the Melbourne marathon. Men competed for fitness, achievement, and challenge reasons, whereas women ran more for social and affiliation reasons. The Canada Fitness Survey (1983) found that the main reasons for women being active were weight control, relaxation, and social, and for men were to challenge their abilities. In a survey of single-sex exercise classes in England, Biddle & Bailey (1985) reported men exercising for health and fitness reasons, whereas women strongly endorsed cathartic and social factors, although this could partly be a reflection of the types of classes offered which differed between the two groups. In a factor analysis of 15 motives for using a community sports centre, male users were significantly higher on factors of assertive achievment (power, aggression, independence, and achievement) and sports mastery and performance than women (skills, competition, excellence, and learning) (Ashford *et al*, 1993). It was also found that middle and older aged adults scored significantly higher on socio-psychological well-being (aesthetics, relaxation, affiliation, and environment) than subjects aged below 25 years. Markland & Hardy (1991) also found differences in exercise motivations with respect to both age and sex. Young men (mean age 20.35 years) exercised more for social recognition and competitive reasons and less for weight management, recreation, and fitness reasons than young women (mean age 21.22 years). Older women (mean age 35.79 years) exercised more for fitness and illness avoidance reasons and less for stress management, personal development, social recognition, and competition reasons than young women.

Fewer studies have reported gender differences in barriers to exercise. The ADNFS (Sports Council & Health Education Authority, 1992) reported the main barrier for women aged 55-69 as 'I'm not the sporty type' (46%) and for men as 'injury and disability' (32%). In a study which followed up male and female exercise adherence 5 months after a fitness test, Robertson & Mutrie (1989) found that female adherers were much more self-motivated than all other groups, and that self-motivation is not a factor in adherence for men, implying that men have fewer, or at least a different set of external obstacles. Main reasons for reducing or stopping exercise were lack of time, illness/injury, and inconvenience of sessions, and although gender differences were not reported, the authors conclude by saying that women encounter greater barriers to

participation and future studies must consider male and female subjects separately.

2.5 Summary

There is now a large literature supporting the benefits of regular physical activity. These benefits are wide-ranging, and recent evidence suggests that most health benefit can be gained by moving from sedentary to moderately active. An accumulation of around 30 minutes of moderate activity on most days of the week is now recommended as a goal for sedentary individuals. Compared with the previous recommendation of regular bouts of vigorous exercise which had a fitness gain perspective, this would appear to be much more easily attainable by the majority of sedentary individuals.

There is still no consensus as to the best method of assessing physical activity. Objective methods, such as the Caltrac accelerometer are gaining more widespread use, but are impractical for use in population studies. Questionnaire methods remain the most suitable for large studies, but many are cumbersome, seeking to elicit great detail of physical activity, and often requiring a personal interview. If proved valid for identifying sedentary individuals, short questionnaires which aim to gain a picture of global physical activity status readily lend themselves to population use where classification of individuals into an activity category may be sufficient.

A number of theories have been developed to guide the study of exercise behaviour, and the ability of many of the variables proposed by these theories to determine physical activity has been investigated. Perceived benefits of physical activity and perceived barriers to physical activity are two such determinants which are known to be related to activity behaviour. Some studies have assessed perceived benefits and barriers using single item questionnaires. Psychometric questionnaires for assessing these variables have been developed with college and worksite samples, but it is not known whether the perceptions of physical activity benefits and barriers of elderly people differs from these groups. If these theoretically important variables are to be properly assessed in older adults, a similar questionnaire must be developed. The literature also suggests that women are quite different to men in their approach to physical activity and exercise, and separate analyses for male and female benefits and barriers must be conducted to obtain a fuller picture in this area.

CHAPTER THREE

PILOT STUDY

3.1 Introduction

The identification of people who may be at risk from inactivity related disease and loss of function is essential before any intervention attempt can be made at increasing levels of physical activity. With the likely time available to make such an assessment in the population, a questionnaire which is self-complete, short, and easy to understand, and also very importantly, valid and reliable, would be the most practical for large-scale use. Three such methods will be used in this study (Ainsworth *et al*, 1993a; Marcus & Simkin, 1993).

Once inactive individuals are identified, practitioners must find areas which can be targeted for intervention. Two variables which have shown a strong and consistent relationship with physical activity are perceived benefits of physical activity, and perceived barriers to physical activity. It should be possible to offer sedentary people a choice of activities, participation in which will produce the benefits of physical activity they endorse, and which will not be affected by their perceived barriers to activity. Although these variables have been assessed in older adults using single item questionnaires (Mutrie *et al*, 1993; Sports Council & Health Education Authority, 1992), there is no psychometrically developed questionnaire such as those developed with college and worksite samples (Steinhardt & Dishman, 1989).

Before this questionnaire for determining activity status and perceived benefits and barriers in older adults could be tested with a large sample, it was necessary to complete a pilot study. The objectives of the pilot study were to:

1. Identify problem phrases/questions/concepts in the questionnaire which may need to be altered;
2. Assess the return rate and hence estimate the sample size required for a larger study;
3. Assess the utility of the three different activity classification methods;
4. Investigate the relationship between subjects' activity status and perceived benefits and barriers.

3.2 Method

3.2.1 Subjects

A sample of 50 subjects was selected at random from a list of patients aged between 55 and 74 registered with a General Practice in St. Andrews, Scotland. Twenty eight were female and 22 were male.

3.2.2 Instrument

The pilot questionnaire was divided into five sections (Appendix A):

Section 1. Leisure Activity
The aim of this section was to classify subjects according to the amount of activity they do during their leisure time. The questions did not ask details of frequency, duration, intensity or mode of exercise; instead they were more general, requiring subjects to indicate their perception of their activty status. Items were based on the work of Ainsworth *et al* (1993a), Marcus & Simkin (1993), and that of the author.

Section 2. Benefits of Physical Activity
This section contained 25 items, constructed using the stem "I think a major benefit of taking part in physical activity is" followed by, for example, "improved stamina" or "relaxation". Subjects responded on a 7-point Likert scale, ranging from very strongly agree (1) to very strongly disagree (7).

Section 3. Barriers to Physical Activity
This section contained 33 items, formed by the stem "A major reason I do not exercise is" followed by, for example, "facilities cost too much" or "no-one to exercise with". Again response was on a 7-point Likert scale. Both Sections 2 and 3 were based on the work of Sechrist *et al* (1987), Steinhardt & Dishman (1989), Mutrie *et al* (1993), and the Sports Council & Health Education Authority (1992).

Section 4.
This section required the subject to give demographic information.

Section 5.

As this was a pilot study, the final page of the questionnaire asked the subject how easy or difficult they found the questionnaire to complete, how long it took them, and if there were any problem words, phrases, or questions which they felt should be changed to make the questionnaire more understandable. There was also a space to list any benefits/barriers which had not been given in the questionnaire.

3.2.3 Procedure

A questionnaire was mailed to each subject, along with a prepaid reply envelope, and a covering letter explaining the purpose of the study (Appendix F), and urging the subject to complete and return the questionnaire promptly. Postcard reminders were sent out one week after the initial mailing.

After a two week period, 38 questionnaires were accounted for, although 8 of these had been only partially completed or returned blank, the subject stating that he/she did not wish to participate in the study. The mean age of the remaining 30 respondents was 63.8 $\pm$ 5.8 years; 18 were female and 12 were male.

3.2.4 Data Analysis

The aims of the pilot study and the small sample size meant that only descriptive statistics are given. The percentage of subjects in different activity categories are given, and the benefits and barriers sections are examined for any differences in responses between active and inactive subjects. Although this does not offer any statistical evidence as such, it was felt that it would be sufficient to meet the main aims of this study, which were to assess if the questionnaire could be understood, and to decide whether the questionnaire in its present form warranted further development.

3.3 Results

3.3.1 Return rate

Of the 30 questionnaires which had been fully completed, there was some doubt as to whether a further 8 of these had been understood by the subjects. This was due to there being contradictory responses to questions in the activity section of the questionnaire, and/or circling the same response for all items in the benefits and barriers sections respectively. Therefore for the purpose of analysis, these 8 were discounted, and 22 questionnaires were used.

3.3.2 Physical activity classifications

The purpose of the first section of the questionnaire was to categorise subjects according to their activity levels (Appendix E). Combination of responses to items 1 and 2 results in four activity categories. Also shown in Table 3.1 are results from the Ainsworth *et al* (1993a) study (Lipid Research Clinics).

Table 3.1 Subject frequency in 4 activity categories (LRC questionnaire).

Activity Category	Present Study		Ainsworth et al (1993a)	
	n	(%)	n	(%)
1. High Active	1	(4.5)	18	(23)
2. Moderately Active	6	(27.3)	20	(26)
3. Low Active	9	(40.9)	17	(22)
4. Very Low Active	6	(27.3)	23	(29)

Similarly, combination of items 3 and 4 resulted in nine activity categories, depending on frequency of vigorous and moderate physical activity. As these questions were developed for this study, there are no other results for comparison. Table 3.2 shows the number and percentage of subjects in each of the nine categories.

Item 5 of the first section was based on the questionnaire used by Marcus & Simkin (1993) to place subjects in one of five stages of exercise behaviour. This required that all four parts of the question be answered. Unfortunately,

very few of the subjects actually did this, and frequencies were not calculated for this variable.

Table 3.2 Subject frequency in 9 activity categories.

Activity Category	n	(%)
1. Most Active	3	(13.6)
2.	0	(0)
3.	0	(0)
4.	7	(31.8)
5.	5	(22.7)
6.	0	(0)
7.	1	(4.5)
8.	3	(13.6)
9. Least Active	3	(13.6)

Spearman's correlation coefficient between the 4- and 9-point activity classifications was r=0.65.

3.3.3 Benefits and Barriers

The second section of the questionnaire required the subjects to indicate the extent to which they agreed or disagreed with a list of statements relating to the benefits of taking physical activity. The small sample size meant that subjects were grouped in to two activity categories rather than four. Categories 1 and 2 (High Active and Moderately Active, n=7) and categories 3 and 4 (Low Active and Very Low Active, n=15) were grouped together, and named Active and Inactive respectively. Responses on the Likert scale were also banded together to indicate agreement (Likert 1-3), no view (Likert 4), and disagreement (Likert 5-7).

Table 3.3 shows the percentage of subjects averaged over all 25 items who expressed either agreement, no view, or disagreement that the item was a benefit of physical activity. For example, a mean of about 62% of both Active and Inactive subjects indicated agreement to some extent that each statement represented a benefit of physical activity. Note that the results are very similar for both activity categories, and that the percentage of subjects indicating disagreement with the benefits of exercise is small at about 14%.

Table 3.3 Mean percentage of Active and Inactive subjects indicating agreement, no view, or disagreement with Benefits of physical activity.

	Agree	No View	Disagree	Total
Active (n=7)	61.6%	25.1%	13.2%	100%
Inactive (n=15)	62.6%	22.6%	14.8%	100%

The third section of the questionnaire, Barriers to exercise, was analysed the same way. Table 3.4 shows the percentage of subjects averaged over all 33 items who expressed either agreement, no view, or disagreement that the item was a barrier to physical activity. Here the responses by Active and Inactive subjects do differ slightly, an average of 9% more of the Inactive subjects indicating agreement with barriers to physical activity. Although the sample size means that one must be cautious when drawing conclusions from this data, it appears that a closer examination of the individual barrier items would yield more worthwhile detail.

Table 3.4 Mean percentage of Active and Inactive subjects indicating agreement, no view, or disagreement with Barriers to physical activity.

	Agree	No View	Disagree	Total
Active (n=7)	13.1%	15.2%	71.7%	100%
Inactive (n=15)	22.1%	12.4%	65.5%	100%

Table 3.5 shows that there are 24 barriers for which the percentage of Inactive subjects who indicated agreement that this was a barrier to exercise for them (Likert 1-3) exceeded that of Active subjects. The individual items are headed under the broad categories of barriers which they are thought to represent.

Table 3.5 Percentage of subjects indicating item is a barrier to exercise.

Barrier to exercise	% of subjects indicating this is a barrier to exercise for them	
	Inactive	Active
Time		
I am too busy	40	28
Environmental		
Lack of facilities	20	0
Unsuitable weather	40	14
Lack of classes/courses available	33	0
Facilities are too far away	13	0
Classes are at inconvenient times	20	14
Cost		
Proper clothing costs too much	27	14
Equipment costs too much	20	14
Cost of facilities is too much	47	14
Footwear costs too much	20	0
Effort		
I am not the sporty type	47	43
Lack of motivation	47	28
I get too fatigued by exercise	33	14
I have no-one to exercise with	20	0
Lack of support from family	13	0
I am too tired after work	20	0
Lack of support from friends	7	0
I am too shy/embarrassed to exercise	20	0
Physical exertion		
Exercise is too hard work	27	14
I don't like sweating	20	0
I feel sore and stiff after exercise	20	0
Exercise makes me feel uncomfortable	7	0
Limiting health		
I am overweight	14	0
Physical disability	14	0

3.4 Discussion

The Lipid Research Clinics (LRC) questionnaire (Ainsworth *et al*, 1993a) asks subjects how active they perceive themselves to be relative to others of the same age and sex on a 5-point scale ranging from much less active to much more active, and a 'yes-or-no' response to whether they do regular vigorous activity. Results of the present study match those of the LRC study fairly closely on the Very Low and Moderately Active categories, but only 4.5% were classified as High active, and 40.9% were classified as Low Active, compared with 23% and 22% respectively in the LRC study. Subjects in the present study were about 25 years older than those in the Ainsworth *et al* (1993a) study (63.8 $\pm$ 5.7 years vs 39.8 $\pm$ 9.1 years). This may account for some of the observed differences in activity classification. It is well known that participation in physical activity, particularly of more vigorous intensity decreases as people get older (Sports Council & Health Education Authority, 1992).

The 9-point activity classification was developed for this study as a variation to the LRC classifications. The items asked the subjects about their overall participation in vigorous and moderate intensity physical activity. Rather than offer examples of these types of physical activity, vigorous was defined as any activity which made the subject 'perspire and/or out of breath and/or heart beat faster' and moderate was any activity which was 'less strenuous' than the previous description. The small sample size meant that some of the nine activity categories did not contain any subjects. The nine categories can be reduced to three if grouped together in a similar way to the LRC categories. Groups 1-3 (those who often participate in vigorous activity) contained 3 subjects (14%), groups 4-6 (sometimes participate in vigorous activity) 12 subjects (54%), and groups 7-9 (rarely or never participate in vigorous activity) 7 subjects (32%). These categories provide the basis for the calculation of the sample size for the main study described in Chapter 4.

Correlation between the two activity classifications was $r=0.65$. Although significant ($p<0.01$), differences between the two methods can be highlighted. The LRC items resulted in about 68% of subjects saying that they did not do any vigorous physical activity. However, when offered a choice of three responses, as in the 9-point classification, the percentage of subjects who rarely or never did vigorous activity decreased to 32%, with 54% replying that they

sometimes participated in this intensity of activity. If validated, this method may be preferable, in that subjects have a greater degree of response choice, and moderate as well as vigorous activity is assessed.

An important outcome of the pilot study was the fact that the method used to classify subjects into stages of exercise (Marcus & Simkin, 1993) was found to be unsuitable for use with this age group. This method of classifying subjects (into Precontemplation, Contemplation, Preparation, Action, and Maintenance) requires that all four parts are completed and few subjects actually did this. The method developed by Marcus *et al* (1992b) was used successfully by Gorely & Gordon (1995) with older adults, and may prove more suitable here. This requires the subject to tick one of five statements which they feel most applies to him/her. For example 'I currently do not exercise and I do not intend to start exercising in the next 6 months' applies to those in Precontemplation and 'I currently exercise regularly but I have only begun doing so within the last 6 months applies to those in the Action stage. The Transtheoretical model has been shown to apply to older adults (Barké & Nicholas, 1990; Gorely & Gordon, 1995) and may prove useful in identifying inactive individuals if a suitable instrument, such as that developed by Marcus *et al* (1992b), is used.

Active and Inactive subjects did not differ in their perceptions about the benefits of physical activity. As there was no overall difference in perceived benefits (Table 3.3) individual items were not examined. Perhaps it is not surprising that no difference was found, since a major strategy in the past to try and improve participation has been education about the benefits of exercise, particularly those relating to improved health. However knowledge of the benefits of exercise is no guarantee that an individual will participate in physical activity. Steinhardt & Dishman (1989) also found that perceived benefits were unrelated to supervised or free-living physical activity in college students. But in a work-site sample, they did find differences between subjects who did different amounts of exercise in their perceived benefits of physical activity. Members of an on-site health and fitness programme gave significantly more value to psychologic benefits than non-members; adherents to the programme were more likely to value psychologic and body image/health benefits than nonadherents, and less likely to exercise for social outcomes; and employees who joined an outside fitness facility valued competitive and psychologic outcomes more than who were not members of an outside club. These studies used large samples and the authors were able to employ principal components analysis, a statistical technique for reducing a large number of items into groups

or 'factors' of items which measure the same construct. Other studies have assessed perceived benefits and barriers in older adults. In the Allied Dunbar National Fitness Survey (Sports Council & Health Education Authority, 1992) subjects rated the importance of 12 motivating factors for exercise, but there was no attempt to relate results to activity status. Mutrie *et al* (1993) found that following 12 weeks of exercise, subjects in class- and home-based programmes both significantly increased their perception of the importance of meeting a challenge as a motivator for exercise. No cross-sectional studies relating perceived benefits/barriers to activity status in older adults could be located.

The lack of difference in perceived benefits of physical activity between Active and Inactive subjects also raised the question about the clarity of the questionnaire instructions. Some subjects, commenting on the questionnaire, stated that it was not clear enough whether the benefits section sought their opinion on the benefits of physical activity for everyone in general, or for the benefits which applied specifically to them. For example, someone may feel that improved stamina is indeed generally a benefit of physical activity; but if they do not actually perceive this as a major benefit of their own participation in physical activity, then they should not indicate agreement. As one of the hypotheses of this research is that active and inactive subjects differ in their perceived benefits of physical activity, the instructions for this section of the questionnaire must be clarified so that subjects give their own personal perceptions, and not what they think are benefits of activity for everyone in general.

Twenty four of the 33 barriers to exercise had a greater percentage of Inactive than Active subjects stating that the item was a barrier. The subheadings under which the barriers are listed in table 3.5 are theoretical factors, and may not necessarily be the ones which would be produced in a factor analysis. The sample size meant that only limited information was gained from a more detailed examination of the data. For example, five of the barriers (I am too busy; Unsuitable weather; Cost of facilities is too much; I am not the sporty type; Lack of motivation) had 40% or more of the Inactive subjects stating that this was a barrier for them. What it does not tell us, is how strong a barrier it is for these people. The sample size meant that Likert responses 1-3 had to be banded together, thus losing the discrimination of whether a person very strongly agreed, strongly agreed, or merely agreed that this was a barrier to exercise for them.

In their college sample, Steinhardt & Dishman (1989) found that the barriers time and effort were significantly related to activity. In their worksite sample, members of the on-site facility viewed time and limiting health as barriers to exercise, and were less likely to perceive other obstacles to participation; adherents to the programme expressed limiting health as a barrier, and were less likely than non-adherents to view time or obstacles as barriers; employees who were members of an outside club were less likely to perceive time or effort as barriers to exercise. Mutrie *et al* (1993) reported a significant reduction in a total barriers score (obtained by adding together the responses for all 19 barrier items) for both class- and home-based groups after the 12-week exercise programme.

As a pilot study, the four objectives which were set out have, in the main, been met. The results provide some preliminary evidence for the utility of both the activity classification and the Benefits/Barriers sections, and point to areas of the questionnaire which must be altered before use in a larger study. It may be possible to increase the usable return rate of 44% by making changes to the wording of some of the questions, and explaining instructions more carefully to make the questionnaire more understandable. As already noted, a different approach for determining stage of exercise is required, and it must be made clear that the subject is to give personal perceptions of benefits and barriers. Another area which drew comment was the method of responding on the Likert scale. It would probably be easier for subjects to tick a box, rather than circling a number which may have caused some confusion. Reducing the number of response categories to five was suggested by some subjects, although most managed to cope with seven.

With these findings in mind, the questionnaire was ready to be tested on a larger sample.

CHAPTER FOUR

ACTIVITY QUESTIONNAIRES

4.1 Introduction

Questionnaires remain the most commonly used method for assessing habitual physical activity in population surveys. There exists a wide array of questionnaires, and depending on the type, duration, and intensity of the activities, and the time period under consideration, can vary from a few questions to detailed activity inventories.

Validity of these questionnaires is typically assessed by one or more of the following criteria: fitness (usually aerobic capacity); body composition; concurrent physical activity diaries; concurrent caloric intake; and an objective measure of activity (usually by accelerometer).

The validity and reliability of three questionnaires will be investigated in this study. Two are of the type referred to as *general surveys* which take little time and are the easiest to complete, both consisting of only two items. Depending on responses to the items, subjects are placed in one of four or one of nine categories. The third questionnaire requires the subject to tick one of five statements, each corresponding to a Stage of Exercise Behaviour proposed by the Transtheoretical Model. The reason for using these short questionnaires is that they may identify those people who participate in only low levels of activity and may therefore be at risk from inactivity-related disease, without requiring details of energy expenditure. They are easy to understand, are self-complete, and can be administered in the likely short time available to gather such information during, for example, a visit to a GP.

The investigation of these questionnaires will be reported first, although practical constraints required that they be used in the development of the benefits and barriers scales described in Chapter 5 without evidence of their validity in older adults. However, their use was not unreasonable: validity of the 4-point classification has been demonstrated with younger adults (mean age of 40 years) (Ainsworth *et al*, 1993a); the Stages of Change model is able to distinguish between groups of older adults who differ in their physical activity participation (Barké & Nicholas, 1990); and the Stages of Change Instrument to be investigated in this study (Marcus *et al*, 1992b) has recently shown significant relationships with physical activity recall, processes of change, self-efficacy and decisional balance pros and cons (Gorely & Gordon, 1995). The

9-point activity classification was developed for this study and has not been previously tested. Validity of all three questionnaires in older adults using measures of fitness and objective activity monitoring has still to be demonstrated.

The objectives of this study were:

1. To assess preliminary evidence for the validity of each of the three activity classifications against measures of fitness and objective activity monitoring;
2. To assess reliability of each of the three classifications.

4.2 Method

4.2.1 Subjects

Subjects were 41 males and 45 females aged 55-74 years (mean age & SD = 64.3 ± 5.6 years), selected from the 548 subjects described in Chapter 5 who returned the questionnaire shown in Appendix B. Calculation of the sample size, shown in section 5.2.1, is based on the minimum number of subjects required in each of two groups necessary to be 80% certain of detecting any true difference. Half of the subjects (n=43) were in activity categories 1 to 4 of the 9-point classification (those who did vigorous physical activity either often or sometimes). The other 43 subjects were in categories 7 to 9 (those who reported doing vigorous activity rarely or never). Refer to Appendix E for the method of activity classification.

4.2.2 Procedure

(a) Selection

Of the 548 subjects included in the first analysis (Section 5.3), 240 were selected from the appropriate activity categories and sent letters inviting them to take part in the next phase of the study, validation of the physical activity section of the questionnaire. These comprised all 85 subjects in categories 1 to 3, 35 subjects selected at random from category 4, and 120 subjects selected at random from categories 7 to 9 of the 9-point activity classification . It was planned to compare subjects in groups 1-3 with those in groups 7-9 (the most active and least active), but there proved to be insufficient response from the active group. Subjects in group 4 were therefore also included with this group.

A series of criterion measures, including a physical appraisal, a detailed activity questionnaire, and an objective physical activity counter were used to assess the validity of the activity classifications.

(b) Contact

Subjects were sent a letter explaining the purpose of this part of the study and the procedure (Appendix H). Also included was a return slip confirming/refusing willingness to participate, and a medical screening questionnaire (Appendix J). Of the subjects who replied, 43 active and 43

inactive were chosen on a first-come basis and were then contacted by telephone to arrange an appointment for the home visit.

(c) Physical Appraisal

As subjects were selected from all over the region, it was not practical to expect everyone to visit the laboratory for a physical appraisal. The tests therefore had to involve equipment which was easily portable and could be used in the subject's own home. Selection of the measures to be taken was based on those which in this age group are functionally important. A battery of tests was compiled which would measure Body Mass Index (BMI), flexibility, strength, and aerobic conditioning.

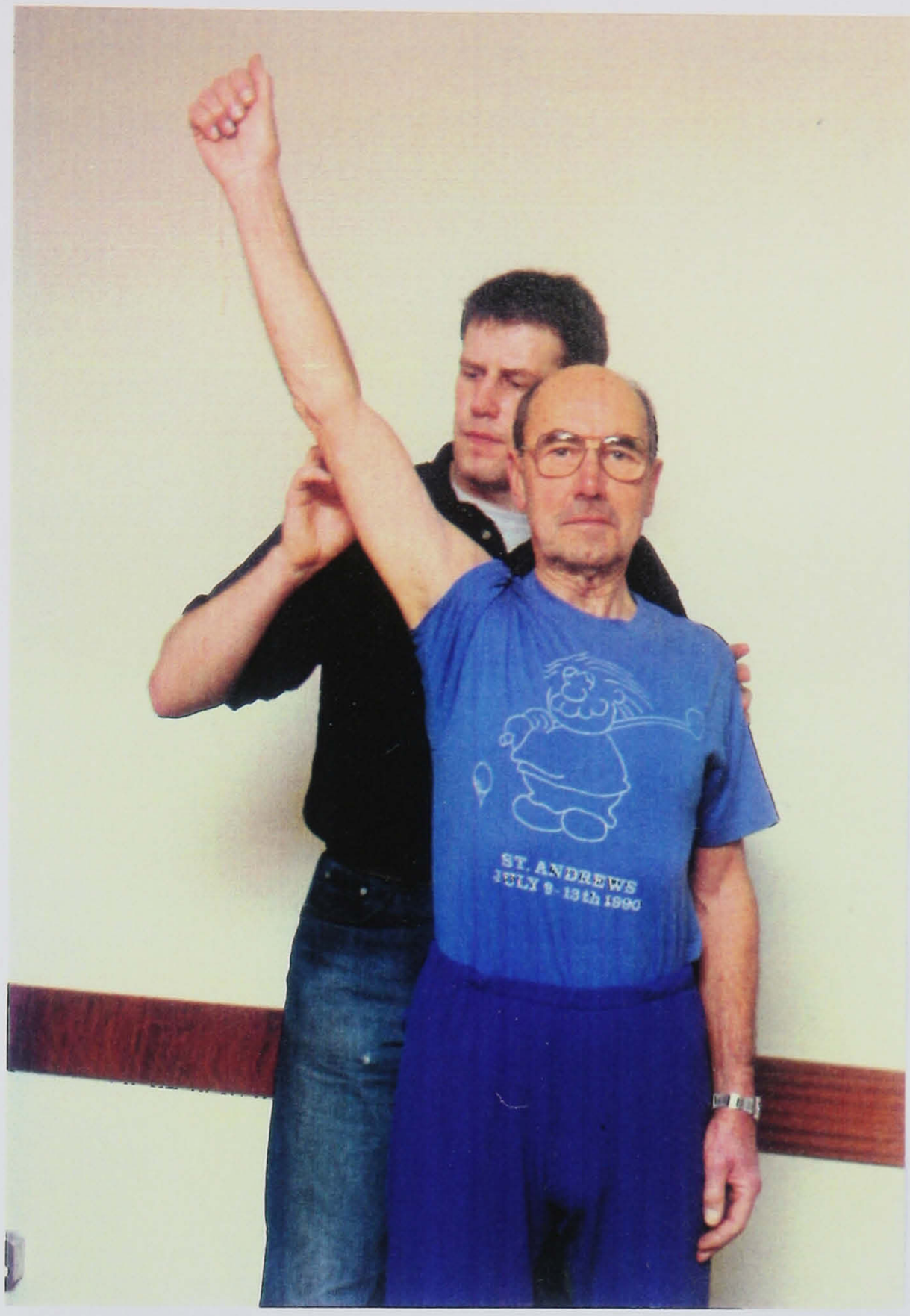
(i) Height (cm) was measured to the nearest 0.5 cm using a portable stadiometer (Holtain Ltd., Crosswell, Wales). Subjects were instructed to stand erect with shoes removed.

(ii) Weight (kg) was measured to the nearest 0.25 kg using calibrated scales (Salter, Birmingham, England) with shoes and loose clothing removed.

(iii) BMI was calculated by dividing Weight (kg) by Height^2 (m^2)

(iv) Shoulder abduction (degrees) was measured using a clinical goniometer (Medical Research Ltd., Leeds, England). With the upper part of the dominant arm bared, a felt-tip mark was made midway between the acromial and olecranon processes. Shoulder abduction was explained to the subject as the maximum range of movement of the arm moving upwards in 45° horizontal flexion from hanging vertically at the side (Figure 4.1). A demonstration was also given. Standing, with the arm hanging freely at the side, the goniometer was held against the upper arm at the mark and set to zero. The subject then abducted the arm in a smooth and controlled manner to the limit of range, keeping the shoulders horizontal, the elbow extended, and without arching the back. With the subject holding this position, the angular range was read from the goniometer dial to the nearest degree. The subject performed three standard trials (nonstandard attempts were not recorded), the highest of these taken as the measure of shoulder flexibility.

Figure 4.1 Measurement of shoulder abduction



(v) Flexibility of the hip was measured to the nearest 0.5 cm by the modified sit and reach test (Hoeger & Hopkins, 1992), with a sit and reach box with sliding metre stick (Figure 4.2). This required the subject to sit on the floor with the head, back, and hips against a wall, the knees extended, and the feet with shoes removed against the sit and reach box. The subject made an initial reach, with the head, back, and hips still against the wall. The sliding metre stick was then moved along the top of the box until zero was level with the tips of the subject's fingers. The subject was then instructed to flex at the hips and reach as far as possible down the top of the box, keeping both hands level, and to hold the position for two seconds. The subject performed three trials, the best score being taken as the measure of hip flexibility.

(vi) Grip strength (N/kg) of the dominant hand was measured using a grip dynamometer (Takei Scientific Instruments Co Ltd, Japan) (Figure 4.3). The dynamometer handle was adjusted so that the second joint of the

fingers was at 90°. In a standing position with the dynamometer at the side, the subject was instructed to squeeze the handle as vigorously as possible for about 3 to 4 seconds, and given verbal encouragement to achieve a maximal contraction. The subject performed three trials with 30 seconds rest between each, the best score being recorded as maximum grip strength.

Figure 4.2 Measurement of hip and spine flexibility

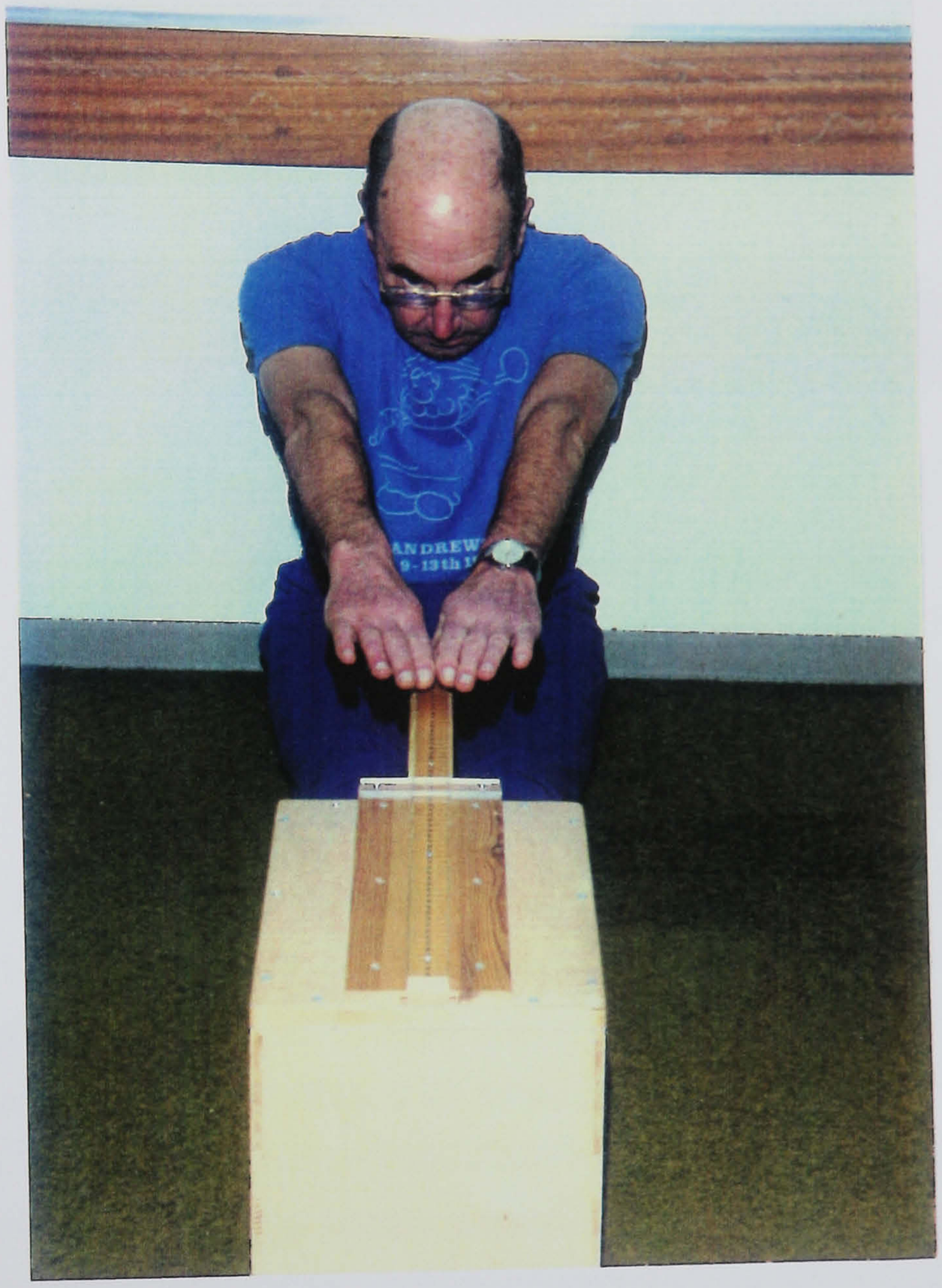
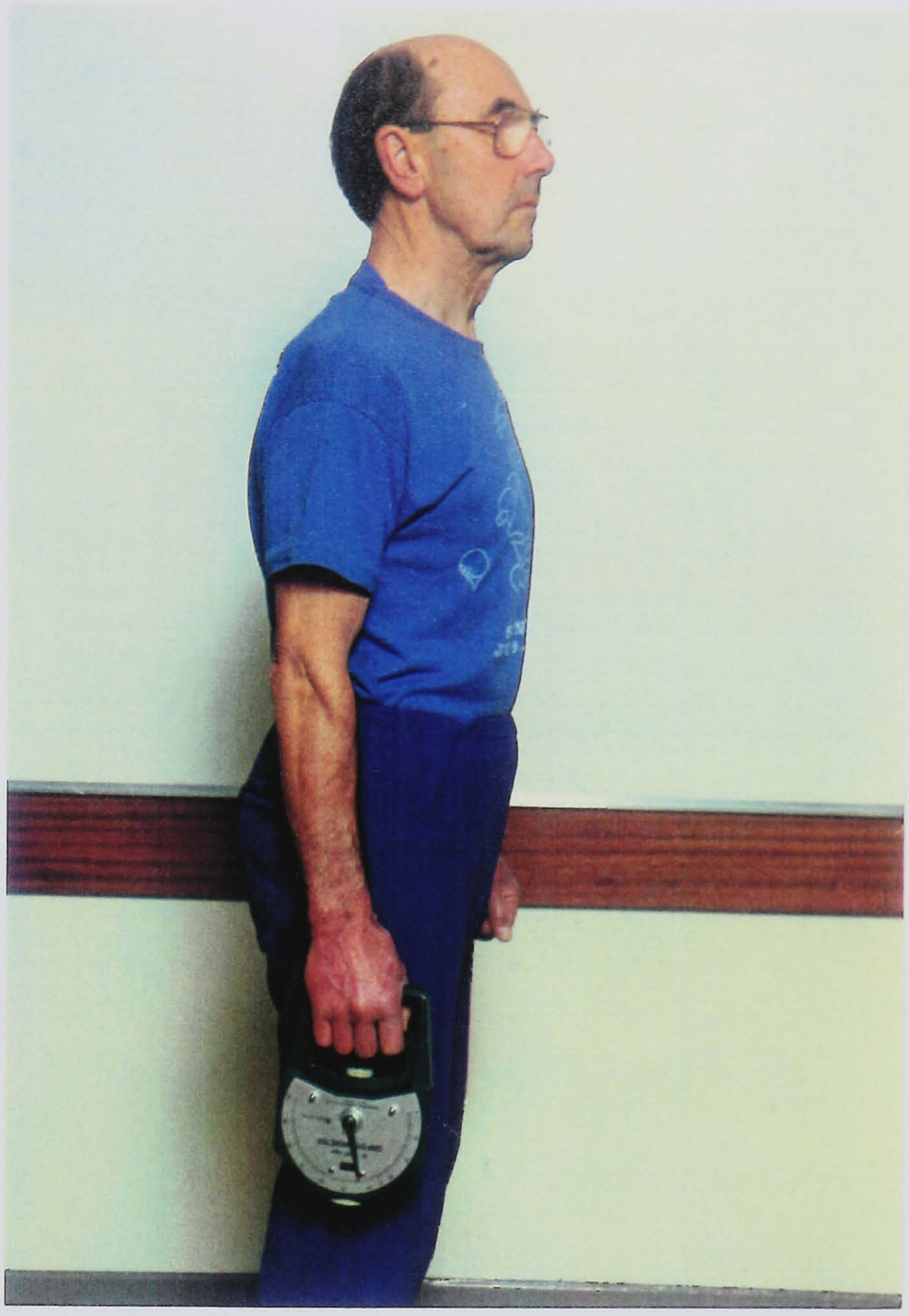


Figure 4.3 Measurement of grip strength



(vii) Isometric knee extensor strength (N/kg) of the dominant leg was measured using a specially constructed chair and a cable tensiometer (Takei Scientific Instruments Co Ltd, Japan) (Figures 4.4 and 4.5). The subject was seated in the chair with arms folded across the chest and strapped around the waist to restrain torso movement. The backs of the knees were on the front edge of the seat and the back of the chair adjusted so as to be firmly against the subject's buttocks. A strap was placed around the ankle and hooked to a cable fixed to an adjustable bar at the rear of the chair. This bar was adjusted so the cable was in the horizontal plane, and on to the cable was placed a strain gauge. The subject was instructed to firstly gently take up the slack, and on the count of three, to kick out as hard and fast as possible, making a maximal effort for 3 to 4 seconds. The subject was given encouragement during the contraction. The subject performed three trials with 30 seconds rest between each, the best score being recorded as maximum knee extensor strength.

Figure 4.4 Measurement of isometric knee extensor strength

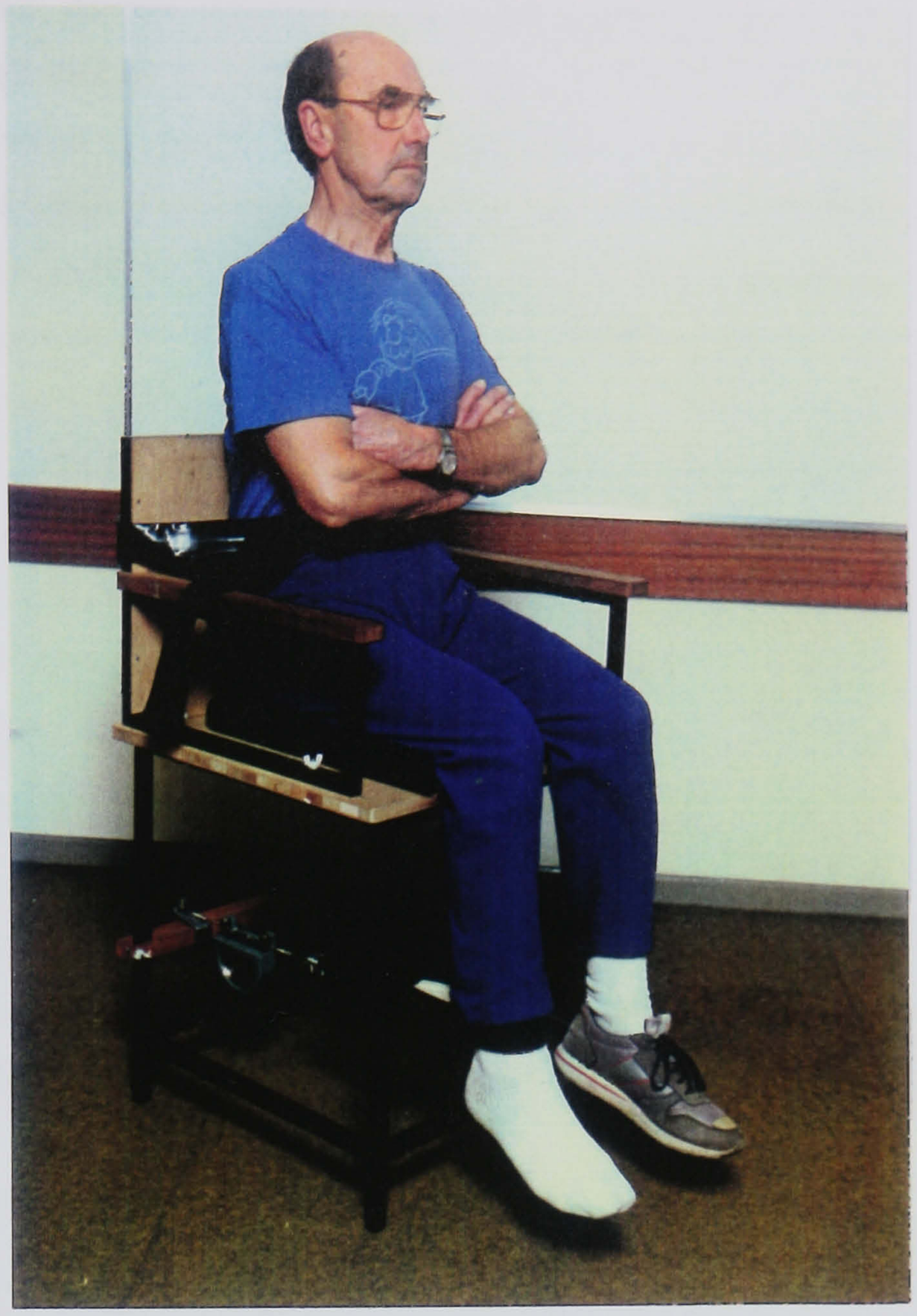
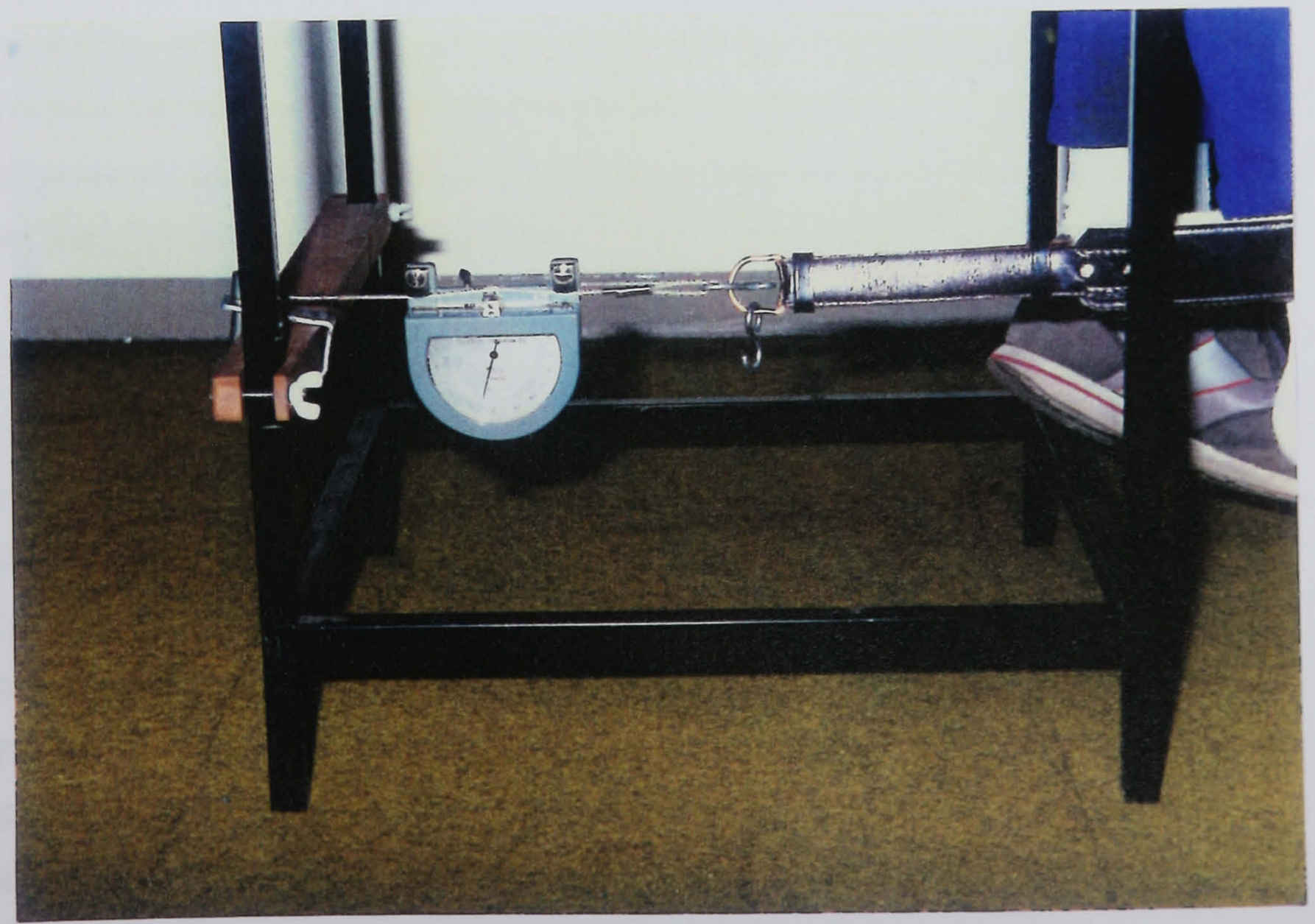


Figure 4.5 Cable tensiometer



(viii) Aerobic fitness ($\dot{V}O_{2max}$ ml/kg/min) was estimated from a one-mile indoor walk, gender, age, and bodyweight (Kline *et al*, 1987). This test was carried out on a separate day from the home visit. A track was marked out in a sports hall and measured, and the number of laps required to walk exactly one mile calculated. The subject was fitted with a Sport Tester PE3000 heart rate monitor (Polar Electronics, Kempele, Finland) and shown how to start/stop the recording mode on the watch. Subjects performed the walk in groups of two or three, and were started at intervals. Subjects were instructed to walk at the fastest pace possible which they would be able to maintain for the entire mile, and to walk near to the inside of the track unless overtaking. Feedback was given on the number of laps completed by each subject. The time taken to complete the walk was recorded on a separate stopwatch for each subject. $\dot{V}O_{2max}$ was then estimated using the following equation:

$\dot{V}O_{2max}$ = 132.853 - 0.0769*weight (lb) - 0.3877*age (yr) + 6.3150*sex (male=1, female=0) - 3.2649*T1 (time to complete walk, min, $^1/_{100}$ min) - 0.1565*heart rate at end of walk (BPM)

(d) Detailed Physical Activity Questionnaire

In addition to the physical measurements, subjects were given a more detailed questionnaire about their activity around the home, about sports and exercises, and about other leisure activities such as walking. This was given in interview form and took about ten minutes. The questionnaire (Voorrips *et al*, 1991) was developed for, and validated with, an elderly sample, and gains particular detail about lower intensity activities, which for many people in this age group forms a large proportion of their entire daily activity. The questionnaire and a sample scoring sheet are shown in Appendix D.

(e) Caltrac Accelerometer

Some of the subjects (n=32) were asked to wear a Caltrac accelerometer (Muscle Dynamics, Torrance, CA, USA) for five days. This is two days more than the estimated number required to obtain a true representation of activity in a week (Gretebeck & Montoye, 1992). The Caltrac (which measures 7.5x7x2 cm and weighs about 90g including batteries) was clipped at the waist during waking hours, except when showering or swimming, and subjects recorded two scores, total kilocalories (kcals) used and kcals used during activity, at the end of the day. The Caltrac was worn for three weekdays and over a weekend.

Subjects were instructed not to alter their normal daily pattern of activity, and not to wear the Caltrac on the day of the one-mile walk test. Sheets with instructions for subjects and for recording data are shown in Appendix L.

4.2.3 Data Analysis

Raw data for each subject were entered and analysed using SPSS for Windows (SPSS Inc., 1993a). As the calculation of sample size was based on differences between only two groups, the three methods of activity classification were recoded by grouping some of the categories together as follows:

(a) 4-point: groups 1 and 2 together (n=26), and groups 3 and 4 together (n=60);
(b) 9-point: groups 1 to 4 together (n=43), and groups 7 to 9 together (n=43);
(c) 5-point: those in precontemplation and contemplation together (n=18), and those in action and maintenance together (n=47).

This enabled comparison of the mean scores of the two groups (active and inactive) on the physical variables, the detailed physical activity questionnaire, and the Caltrac scores, by independent t-test. Although strictly subjects in Action and Maintenance should be referred to as exercisers, and those in Precontemplation and Contemplation as non-exercisers, the terms active and inactive will be used to maintain consistency with the other two classifications. Subjects in Preparation (n=21) were not included in the analysis as this category is defined as 'doing some exercise but not regularly' and therefore does not match either of the other two categories. It should be emphasised that the sample size used here permits only partial validation of the activity questionnaires *ie* it will distinguish between subjects broadly classified as active and inactive, but will not allow a more sensitive classification by accurately identifying subjects in all activity categories.

For the Caltrac data, mean total kcals used and mean kcals used due to activity were calculated for the three weekdays, the two weekend days, and all five days together. A paired samples t-test was used to investigate if there was any significant difference in activity between weekdays and weekends, and thus determine whether the two should be analysed separately when comparing data from active and inactive subjects.

Reliability of the activity classifications was determined using data from the 58 subjects who returned a second identical questionnaire eight weeks after the first. The statistic used was Spearman's correlation coefficient (Spearman's rho).

4.3 Results

4.3.1 Subjects

Demographic data were examined to determine whether the validation sample (n=86) differed in terms of age, work category, income, education, and housing tenure from subjects who only participated in the benefits/barriers part of the study (n=462). Validation sample males (n=41) were significantly older (65.0 $\pm$ 5.2 yrs vs 63.2 $\pm$ 5.2 yrs; t(249)=2.10, p=0.037). There was no difference in females' ages (63.2 $\pm$ 5.8 yrs vs 63.0 $\pm$ 5.1 yrs; t(295)=0.29, p=0.77). Other data are shown in Appendix N. There appeared to be little difference between the two samples, and in summary, slightly more subjects who participated in the validation study:

- were retired or looked after the home/family;
- had a higher household income;
- had progressed to higher education;
- were owner occupiers.

4.3.2 Physical Appraisal

The purpose of the physical appraisal was to obtain a series of measures which, although in part genetically determined, are also reflective of current physical activity status. These results could then be used as criteria against which to assess the validity of the activity classifications.

The 1-mile walk test produced estimates of $\dot{V}O_{2max}$ which for the whole sample were low compared to those obtained by the ADNFS (Sports Council & Health Education Authority, 1992), and which for some subjects were impossibly low or even negative. These results are summarised in Table 4.1.

Table 4.1 Summary of walk test results.

	n	mean ml/kg/min	SD	Min	Max	ADNFS mean
Males	41	26.06	7.13	10.66	46.61	35.0
Females	45	18.35	8.21	-2.92	35.63	27.3
All	86	22.02	8.59	-2.92	46.61	-

Rather than discard the results of subjects below an arbitrary cut-off point for estimated $\dot{V}O_{2max}$, time taken to complete the 1-mile walk will be used as an indicator of cardiorespiratory fitness. In a study to develop a similar walking test over 2km (Oja *et al*, 1991), time taken to complete the 2km walk showed a highly significant correlation with $\dot{V}O_{2max}$ measured using direct gas analysis. The results of this study will be discussed more fully in Section 4.4.

Shown in Table 4.2 are the results of the physical appraisal for the 86 subjects as classified by the recoded 4-point classification (groups 1 and 2 = active; groups 3 and 4 = inactive). Of the six measurements, only 1-mile walk time shows a difference significant at $p<0.05$ between active and inactive subjects, there being no relationship between activity category and BMI, flexibility, or strength.

Table 4.2 Descriptive statistics and independent t-test scores for physical measures by recoded 4-point activity classification.

Variable	Group	n	Mean	SD	df	t-value	p
BMI	Active	26	26.70	2.57	84	0.69	0.494
(kg/m²)	Inactive	60	26.16	3.62			
Shoulder	Active	26	141.62	14.20	84	-0.26	0.797
flexibility (°)	Inactive	60	142.28	9.34			
Sit and	Active	26	25.69	8.66	83	-0.37	0.709
Reach (cm)	Inactive	59	26.42	8.00			
Grip strength	Active	26	4.76	1.04	84	0.48	0.630
(N/kg)	Inactive	60	4.64	1.10			
Leg strength	Active	26	4.53	1.24	84	0.25	0.801
(N/kg)	Inactive	60	4.45	1.38			
Walk time	Active	26	16.87	1.44	84	-2.97	0.004
(min/$^{1}/_{100}$min)	Inactive	60	18.10	1.88			

Table 4.3 shows the results of the physical appraisal for active and inactive subjects as classified by the recoded 9-point activity classification (groups 1 to 4 = active; groups 7 to 9 = inactive). Again, the only variable with a difference significant at $p<0.05$ between the two groups is 1-mile walk time, active subjects taking less time to complete the walk.

Table 4.3 Descriptive statistics and independent t-test scores for physical measures by recoded 9-point activity classification.

Variable	Group	n	Mean	SD	df	t-value	p
BMI	Active	43	26.19	2.87	84	-0.36	0.723
(kg/m^2)	Inactive	43	26.45	3.77			
Shoulder	Active	43	143.21	12.29	84	0.95	0.343
flexibility (°)	Inactive	43	140.95	9.45			
Sit and	Active	43	25.90	8.03	83	-0.34	0.735
Reach (cm)	Inactive	43	26.50	8.39			
Grip strength	Active	43	4.75	1.08	84	0.66	0.511
(N/kg)	Inactive	43	4.60	1.09			
Leg strength	Active	43	4.72	1.44	84	1.71	0.091
(N/kg)	Inactive	43	4.23	1.18			
Walk time	Active	43	17.06	1.59	84	-3.61	0.001
(min/$^1/_{100}$min)	Inactive	43	18.40	1.85			

Recoding of the 5-point Stage of Exercise Change classification meant that subjects in Preparation (doing some exercise but not regularly, n=21) were not included in the analysis. The dichotomy was between those who reported exercising regularly (Action and Maintenance, n=47) and those who reported not exercising at all (Precontemplation and Contemplation, n=18). Table 4.4 shows that the only variable with a difference significant at $p<0.05$ between the two groups was BMI, active subjects having a lower mean BMI. The difference between the two groups on 1-mile walk time was in the expected direction but marginally non-significant ($p=0.075$).

Table 4.4 Descriptive statistics and independent t-test scores for physical measures by recoded 5-point activity classification.

Variable	Group	n	Mean	SD	df	t-value	p
BMI	Active	47	26.04	3.10	63	2.43	0.018
(kg/m²)	Inactive	18	28.18	3.36			
Shoulder	Active	47	141.49	11.53	63	-0.19	0.852
flexibility (°)	Inactive	18	140.89	11.79			
Sit and	Active	47	25.54	6.95	62	0.28	0.780
Reach (cm)	Inactive	17	26.15	9.22			
Grip strength	Active	47	4.54	0.89	63	0.74	0.461
(N/kg)	Inactive	18	4.75	1.26			
Leg strength	Active	47	4.40	1.22	63	0.38	0.706
(N/kg)	Inactive	18	4.53	1.31			
Walk time	Active	47	17.41	1.58	63	1.81	0.075
(min/$^{1}/_{100}$min)	Inactive	18	18.24	1.83			

4.3.3 Detailed Activity Questionnaire

As well as using the physical appraisal measures with which to validate the activity classifications, a detailed activity questionnaire for the elderly (Voorrips *et al*, 1991) was also used. The aim was to establish whether the simple, self-complete methods of activity classification would reflect scores on a more detailed questionnaire, which required an interview and obtained information about household as well as exercise and other leisure activities.

The mean activity questionnaire score for all 86 subjects was 11.69 (SD=5.87), with a minimum of 1.40 and a maximum of 26.18. These values are similar to those for the group used for development of the questionnaire (Voorrips *et al*, 1991), which had a mean score of 13.6 $\pm$ 6.8 with a range of 1.2 to 31.4, and tertile cut-off points of 9.4 and 16.5. Table 4.5 shows that mean questionnaire scores were significantly different at $p<0.05$ for active and inactive subjects as classified by the 9-point and 5-point classifications, but not by the 4-point.

Table 4.5 Descriptive statistics and independent t-test scores for detailed activity questionnaire by recoded 4-, 9-, and 5-point activity classification.

Activity Q.	Group	n	Mean score	SD	df	t-value	p
4-point	Active	26	13.28	5.20	84	1.66	0.100
	Inactive	60	11.01	6.05			
9-point	Active	43	13.70	5.33	84	3.35	0.001
	Inactive	43	9.69	5.75			
5-point	Active	47	14.30	4.88	63	-7.25	0.000
	Inactive	18	5.40	2.87			

4.3.4 Caltrac accelerometer

Of the 32 subjects for whom Caltrac data were obtained, each wore the Caltrac secured at the waist during waking hours for three weekdays and a weekend. It was firstly necessary to determine whether estimated energy expenditure on weekdays and weekends differed significantly and would therefore require to be analysed separately. Tables 4.6 and 4.7 show that mean weekday scores, both kcals/hr used during activity and total kcals/hr, were significantly greater than weekend scores. The two were subsequently analysed separately.

Table 4.6 Descriptive statistics and paired samples t-test scores for Caltrac scores (kcals/hr used during activity).

Variable	n pairs	Mean (kcals/hr)	SD	df	t-value	p
Activity kcals/hr weekdays		40.34	18.84			
	32			31	2.07	0.047
Activity kcals/hr weekend		34.58	19.54			

Table 4.7 Descriptive statistics and paired samples t-test scores for Caltrac scores (total kcals/hr).

Variable	n pairs	Mean (kcals/hr)	SD	df	t-value	p
Total kcals/hr weekdays		106.85	27.97			
	32			31	2.40	0.023
Total kcals/hr weekend		99.91	28.11			

Table 4.8 shows that energy expenditure (activity and total) as measured by the Caltrac is significantly greater ($p<0.05$) for subjects classified as active by the 4-point activity classification. This is true for both weekdays and weekends.

Table 4.8 Descriptive statistics and independent t-test scores for Caltrac variables by recoded 4-point activity classification.

Variable	Group	n	Mean (kcals/hr)	SD	df	t-value	p
Activity kcals/hr weekdays	Active	13	48.58	17.32	30	2.17	0.038
	Inactive	19	34.69	18.13			
Activity kcals/hr weekend	Active	13	46.09	23.64	15.7	2.75	0.014
	Inactive	19	26.70	11.14			
Total kcals/hr weekdays	Active	13	120.26	25.80	30	2.41	0.022
	Inactive	19	97.67	26.16			
Total kcals/hr weekend	Active	13	116.42	31.09	18.5	2.86	0.010
	Inactive	19	88.62	19.61			

Subjects classified as active by the 9-point activity classification also had significantly greater ($p<0.05$) energy expenditure than those who were inactive. This was true for both activity and total energy expenditure, and for weekdays and weekends, as shown in Table 4.9.

Table 4.9 Descriptive statistics and independent t-test scores for Caltrac variables by recoded 9-point activity classification.

Variable	Group	n	Mean (kcals/hr)	SD	df	t-value	p
Activity kcals/hr weekdays	Active	17	47.30	19.22	30	2.39	0.023
	Inactive	15	32.44	15.43			
Activity kcals/hr weekend	Active	17	41.61	22.73	24	2.40	0.024
	Inactive	15	26.61	11.28			
Total kcals/hr weekdays	Active	17	118.55	28.16	30	2.78	0.009
	Inactive	15	93.58	21.70			
Total kcals/hr weekend	Active	17	110.96	30.65	27.1	2.65	0.013
	Inactive	15	87.40	18.97			

Subjects classified as active by the 5-point Stages of Exercise Change questionnaire (those in Action and Maintenance) showed no significant difference in energy expenditure from subjects classified as inactive (Precontemplation and Contemplation), as shown in Table 4.10.

Table 4.10 Descriptive statistics and independent t-test scores for Caltrac variables by recoded 5-point activity classification.

Variable	Group	n	Mean (kcals/hr)	SD	df	t-value	p
Activity kcals/hr weekdays	Active	19	42.32	18.82	23	-1.26	0.219
	Inactive	6	32.05	10.56			
Activity kcals/hr weekend	Active	19	37.39	17.96	23	-1.04	0.309
	Inactive	6	29.16	12.17			
Total kcals/hr weekdays	Active	19	110.64	29.84	21.7	-1.85	0.078
	Inactive	6	95.34	11.41			
Total kcals/hr weekend	Active	19	103.83	27.42	14.3	-1.27	0.224
	Inactive	6	92.07	16.65			

4.3.5 Summary of validity

Table 4.11 summarises the results of the validation of the three different methods of activity classification. This table provides, at a glance, which activity classification methods successfully differentiated between active and inactive subjects in terms of their physical measures, scores on a detailed activity questionnaire, and energy expenditure as measured by an objective activity counter.

Table 4.11 Summary of validity.

Validity Criterion	4-Point classification Active(n=26) vs Inactive(n=60)	9-Point classification Active(n=43) vs Inactive(n=43)	5-Point classification Active(n=47) vs Inactive(n=18)
Physical tests:			
BMI (kg/m^2)			✓
Shoulder flexibility (°)			
Sit and Reach (cm)			
Grip strength (N/kg)			
Leg strength (N/kg)		?	
Walk time (min/$^1/_{100}$ min)	✓	✓	?
Detailed activity questionnaire	?	✓	✓
Caltrac:			
Activity kcals/hr weekdays	✓	✓	
Activity kcals/hr weekend	✓	✓	
Total kcals/hr weekdays	✓	✓	?
Total kcals/hr weekend	✓	✓	

✓ Difference between groups significant at least at $p<0.05$

? Difference between groups borderline significant $0.05<p<0.10$

4.3.6 Correlation between activity classifications

All three activity classification methods are based on simple, global estimations of activity rather than detailed information about type, frequency, duration, and intensity of activity. The 4- and 9-point methods specifically ask about **physical activity**, whereas the 5-point refers specifically to **exercise**.

Spearman's correlation coefficient was used to examine any relationships between the categories into which subjects were placed using the three different methods. Cells in table 4.12 show Spearman's rho and p-value.

Table 4.12 Correlations between activity classifications.

	4-Point	9-Point	5-Point
4-Point	1.00		
9-Point	0.60 (.000)	1.00	
5-Point	0.45 (.000)	0.51 (.000)	1.00

4.3.7 Reliability

Reliability of the three methods of activity classification was determined using a random subsample (n=58) selected from the 548 subjects who returned the original questionnaire. The time period between completing the two questionnaires was eight weeks. The statistic used was Spearman's correlation coefficient. Table 4.13 shows Spearman correlations and p-values for the 4-point LRC, 9-point, and 5-point Stage of Exercise Change activity classifications.

Table 4.13 Reliability of the 4-, 9-, and 5-point activity classifications.

Activity Classification	Spearman's ρ	p
4-point	0.73	<.001
9-point	0.62	<.001
5-point	0.63	<.001

4.4 Discussion

At present there is no questionnaire method of assessing physical activity status in over 55 year olds which is self-administered, simple, and short. The aim of this study was to evaluate the validity and reliability of three different methods of activity classification for identifying inactive individuals. These methods were:

(a) The Lipid Research Clinics (LRC) 4-point classification (Ainsworth *et al*, 1993a);

(b) The 5-point Stages of Exercise Change classification (Marcus *et al*, 1992b);

(c) A 9-point activity classification based on frequency of participation in vigorous and moderate physical activity developed for this study.

The LRC questionnaire has been used with a younger sample, but validity with an older age group has yet to be demonstrated. The Stages of Exercise Change model shows evidence of validity with older subjects, although the method of classifying subjects in this study has not been validated against actual activity status.

The subjects (n=86) were a sub-sample of a larger group who completed the study described in Chapter 5. In terms of demographic data, there was little difference between the validation sample and main group. The results reported here should therefore be fairly generalizable to the population of 55-74 year olds, as the original sample were selected at random and appeared representative of this age group.

When developing an activity questionnaire there are several features which must be considered (Washburn & Montoye, 1986). These include the method of administration, the time frame over which activity is assessed, the type of activity assessed, and the measurement scale used. The user must decide whether a simple classification of activity status is sufficient, or if a more detailed description, such as energy expended in different types of activities, is required. Also important are the criteria used for validation. Methods include measures of physical fitness, percent body fat, heart rate telemetry, objective movement counters, energy expenditure estimated from dietary records or detailed activity questionnaires, and presence of inactivity-related disease (Jacobs *et al*, 1993). Although many different criteria for validation have been used, there is no real consensus of a 'gold standard'. Maximum oxygen

uptake, whether estimated or measured directly, is frequently used (Washburn & Montoye, 1986; Dipietro *et al*, 1993; Ainsworth *et al*, 1993(a); Ainsworth *et al*, 1993(b); Jacobs *et al*, 1993), but is known to contain a genetic component of about 40% (Bouchard *et al*, 1986). Recent studies have also used the Caltrac accelerometer (Ainsworth *et al*, 1993(b); Jacobs *et al*, 1993; Washburn *et al*, 1993; Richardson *et al*, 1994) which measures body acceleration and estimates energy expenditure based on age, sex, weight and height, and acceleration and deceleration of a piezoelectric element. The validity and reliability of this instrument for measuring activity have been demonstrated (LaPorte *et al*, 1983; Washburn *et al*, 1990), but has shown only a moderate correlation with a variety of activity questionnaires (Jacobs *et al*, 1993).

Before going on to discuss the results in detail, it is worth taking a closer look at what type of activity the questionnaires are actually aiming to assess. The 4-point LRC questionnaire (Ainsworth *et al*, 1993a) asks if during leisure time the subject regularly takes vigorous physical activity, and how active the subject perceives he/she is compared to others of the same age and sex. The active/inactive two-point scoring method used in this study has previously shown significant differences between groups in $\dot{V}O_{2max}$, submaximal exercise heart rate, percent body fat, BMI, and 4-week physical activity history scores (kcals/d) on light, heavy, and total activities (Ainsworth *et al*, 1993a). The 9-point classification is also based mainly on frequency of vigorous physical activity, with subdivisions based on frequency of moderate activity. The 5-point Stage of Exercise Change classification asks subjects specifically about their exercise habits, rather than overall activity. Exercise is a subset of physical activity, and has been defined as planned, structured and repetitive bodily movement, with the objective of maintaining or improving physical fitness (Caspersen *et al*, 1985). The Stage of Exercise model has been shown to be valid against known exercise status (Barké & Nicholas, 1990), 7-day physical activity recall (Marcus & Simkin, 1993), self-reported exercise participation (Gorely & Gordon, 1995), and self-efficacy and costs and benefits of exercise (Marcus & Owen, 1992).

The percentage of subjects in the main sample (n=548) reporting regular exercise (Action and Maintenance) was 40%. This compared with 28% and 16% reporting regular vigorous activity in the 4- and 9-point classifications respectively, indicating that this sample did not view exercise and vigorous physical activity as synonymous. This is evident in the correlations between the

5-point and the 4- and 9-point classifications, which although at 0.45 and 0.51 respectively were significant, there still remained a large amount of variance unexplained. Activities popular with this age group which are likely to be regarded as exercise but which are moderate in intensity include walking, golf and bowls (Scottish Sports Council, 1991). When reviewing the results it should be kept in mind that the three questionnaires are not measuring exactly the same aspects of activity.

It should also be remembered that the results can provide at best only partial validation of these activity questionnaires. The sample size required to detect any difference between two groups was calculated as 43 subjects in each group. Practical considerations meant that subjects in different activity categories had to be grouped together into either active or inactive groups. So for example for the 9-point classification, the results do not allow conclusions about the sensitivity of the questionnaire in discriminating between high, moderately, and low active subjects. Instead, it will allow differentiation between subjects in categories 1-4 (high active) and those in 7-9 (low active).

Selection of the criteria used to validate the three activity questionnaires was based on acceptability to subjects in terms of time and effort required, practicality of using the tests in the field, and previous evidence that the measures are related to activity status. A summary of results of each of the tests is given in Appendix Q. The test protocol for estimating $\dot{V}O_{2max}$ used in the present study (Kline *et al*, 1987) was chosen because it can be set up in any indoor hall, it involves a submaximal activity with which all subjects are familiar (walking), it requires little specialised equipment, and as up to three subjects can be tested at the same time, it lends itself to testing large samples. The mean age of the sample used to develop the test was 47 years, 17 years less than the present sample. However, the correlations between laboratory determined $\dot{V}O_{2max}$ and $\dot{V}O_{2max}$ estimated from the regression equation were still high at 0.81 for 50-59 year olds and 0.74 for 60-69 year-olds (Kline *et al*, 1987), suggesting that the test should be valid for use with this age group. As shown in the results section, the test produced mean scores for estimated $\dot{V}O_{2max}$ which were about 9 ml/kg/min (30%) lower than the means obtained by direct gas analysis during a submaximal treadmill test on the ADNFS (Sports Council & Health Education Authority, 1992), and 6 ml/kg/min lower than the estimated value for 60-69 year-olds in the Kline *et al* (1987) study. Even allowing for the fact that the ADNFS sample may have been biased (only 23%

of women and 31% of men aged 55-74 who completed the activity interview also completed the treadmill test), this does not explain the very low and even negative estimates of $\dot{V}O_{2max}$ obtained in the present study. These estimates were probably caused by a high T1 (time taken for walk) coupled with a high heart rate at the end of the walk - subjects with low scores tended to be overweight and walk more slowly than other subjects.

As the data for estimated $\dot{V}O_{2max}$ appeared unreliable, a suitable alternative indicator of cardiorespiratory fitness was required. In a 2km walking test developed in Finland for assessing the cardiorespiratory fitness of adults aged 20-65 years (Oja *et al*, 1991), it was found that of the measures included in the prediction equation, 2km walking time had the highest correlation with $\dot{V}O_{2max}$ (ml/kg/min) when measured by direct gas analysis. The correlations for men and women were -0.58 and -0.74 respectively, both significant at $p<0.001$. Although the walk distance differed from that in the test used in the present study (Kline *et al*, 1987), subjects in both tests were instructed to walk as fast as possible using an even pace. The guide for administering the Finnish test (Laukkanen & Hynninen, 1993) recommends that subjects should achieve at least 70% of maximal heart rate and ideally 80% or more. Subjects in the present study achieved a mean heart rate of 76% of predicted maximum, suggesting that effort was sufficient to enable walk time to be used as an indicator of cardiorespiratory fitness. Although there may be some doubt as to the validity of this, under present circumstances it offers the best opportunity to make use of the data collected during the test.

Despite this setback, 1-mile walk time was able to differentiate between active and inactive subjects on both the 4- and 9-point activity classifications, inactive subjects taking significantly longer to complete the walk. This suggests that if walk time is accepted as an indicator of aerobic fitness, and fitness is accepted as an indicator of participation in physical activity, these two questionnaires can successfully identify inactive individuals. The 5-point classification showed a trend in 1-mile walk time in the expected direction although the difference was not significant. This could be due to subjects classifying themselves as exercisers (Action or Maintenance) without participating in the type of more vigorous activity which would improve aerobic fitness and therefore produce a faster walk time. In addition, the sample size was smaller for the 5-point classification (n=65), 21 subjects in Preparation (those who do some exercise but not regularly) being excluded from the analyses.

The measures of flexibility and strength did not show any difference between active and inactive subjects as classified by any of the three questionnaires. This suggests that the classifications are not sensitive to the types of activity which would improve or maintain flexibility and strength, or that the subjects did not consider these activities when assessing their global activity status. The measures taken in the physical appraisal were chosen to represent functionally important abilities, and 'thresholds' have been suggested by the ADNFS (Sports Council & Health Education Authority, 1992 p36) below which functional ability may be impaired. Although not an objective of the present study, it is worthwhile examining the values obtained in relation to these thresholds (Appendix Q). An absolute grip strength of 150 Newtons for tasks such as opening screw-top jars, and a relative grip strength equal to 20% of bodyweight for using a handrail to raise or lower the body were suggested as thresholds. There were no subjects in the present study below these values. If the peak isometric quadriceps strength of one leg is below 50% of bodyweight then it is suggested that the individual will find it difficult to rise unaided from a sitting position. About half of the men and 80% of the women in the present study were below this level. This compares with about one-fifth of men and half of the women in the ADNFS. This apparent discrepancy in leg strength between the two samples is difficult to explain. The equipment used in the present study, although less sophisticated, was calibrated regularly and appeared to function well throughout the study. It is possible that the ADNFS sample may have been biased, as leg strength was measured in only 45% of women and 52% of men who completed the activity interview. It is also possible that subjects with low strength were over-represented in the present sample, which was much smaller than that in the ADNFS, that some subjects did not perform the contractions maximally, or that the results do in fact reflect a true difference from results obtained by the ADNFS. The flexibility and strength scores for active and inactive subjects as classified by all three activity classifications were generally very similar, and although a wide distribution of scores was obtained for all the measures, it seems that the activity questionnaires are not sensitive to these types of activities.

The detailed activity questionnaire for the elderly (Voorrips *et al*, 1991) was adapted from a questionnaire validated in young adults (Baecke *et al*, 1982). Respondents are asked about habitual physical activities of the last year. There are ten items related to household activities, with four to five possible responses corresponding to very active to inactive. Sports and other leisure activities are coded based on net energetic cost, hours per week spent on it, and number of

months in which the activity is normally performed. The total questionnaire score is an index obtained by adding the household, sport, and other leisure activities section scores. The questionnaire was validated against repeated 24-hour activity recall, and pedometer counts per day, and had a Spearman test-retest correlation coefficient of 0.89. Although the Voorrips *et al* (1991) questionnaire does not provide an estimate of energy expenditure in kcals or METS spent on different types of activity, it is valid and reliable, and does assess activities over a range of intensities. It was suitable as a validation criteria in this study as it assesses habitual activity over a year and therefore does not rely on short-term memory which may deteriorate with age (Shephard, 1987), and it takes only 10-15 minutes to complete. It was anticipated that scores on this questionnaire would show a strong relationship with the three methods of activity classification as it assesses the range of activities likely to be considered by subjects when estimating their global activity status. Active subjects on the 9- and 5-point classifications had significantly higher questionnaire scores than inactive subjects. Mean questionnaire score for active subjects on the 4-point classification was higher than for inactive subjects, but the difference was not significant.

The Caltrac accelerometer was developed to give an objective measure of physical activity by estimating energy expenditure (Montoye *et al*, 1983). The model used in the present study was an off-the-shelf model, designed for personal use in a weight loss programme. This particular model did not allow estimated activity to be expressed in 'activity counts' as in Washburn *et al* (1990) and Nichols *et al* (1992), but was programmed with the subject's age, gender, height and weight and expressed activity as estimated energy expenditure (kilocalories). The subject's personal details are used by the Caltrac to estimate basal energy expenditure, and energy expenditure due to activity is calculated from the vertical acceleration and deceleration of a piezoelectric element. Total energy expenditure is the sum of these two values. Subjects also recorded the length of time the Caltrac was worn each day which allowed calculation of energy expenditure per hour.

The Caltrac has been validated with older adults (Washburn *et al*, 1990; Nichols *et al*, 1992), but Nichols *et al* (1992) concluded that although the Caltrac was highly reliable, it may lack accuracy in quantifying energy expenditure and is more useful for assessing qualitative differences in physical activity level. This is sufficient for the purposes of the current study, which is to estimate the mean energy expenditure of subjects in different activity categories. The number of

days required to give a reasonable estimate of habitual physical activity in older adults has not been determined. Energy expenditure on weekdays and weekends in the present study were found to be significantly different, but even when analysed separately should still be long enough periods to sufficiently represent normal physical activity.

Active subjects on the 4- and 9-point classifications had a significantly higher mean energy expenditure than inactive subjects. This was true for activity kcal/hr and total kcal/hr, and for both weekdays and weekends. Jacobs *et al* (1993) reported a correlation of -0.20 between total energy expenditure in kcal/d and the 4-point classification, and a correlation of 0.21 between a Caltrac motion score expressed in MET-min/d and obtained by dividing the total energy expenditure score by estimated resting metabolic rate (Ainsworth *et al*, 1993a) and the 4-point classification. In the study in which development of the LRC questionnaire is reported (Ainsworth *et al*, 1993a), there was no significant difference between active and inactive subjects on total energy expenditure (kcal/d) or activity units per day. The absence of a relationship between Caltrac scores and the 4-point classification reported in these two studies was not borne out in the present study. The Caltrac data offer evidence that the LRC questionnaire, at least in its 2-point form, can detect differences in both activity and total energy expenditure. In addition to the significant results of the t-tests, Spearman correlations between Caltrac scores (activity and total energy expenditure for both weekdays and weekends) and the 4-point classification ranged from -0.33 to -0.47, and between the 2-point classification (active and inactive) from -0.41 to -.048. All correlations except one were significant at least at $p<0.05$, and all were higher than those reported by Jacobs *et al* (1993).

As the 9-point classification was only developed during this study, there are no comparable data for Caltrac scores for subjects of varying activity levels. Again, active subjects had significantly greater energy expenditure than their inactive counterparts. This was true for activity and total energy expenditure, and for weekdays and weekends. This was expected as the 9-point questionnaire classifies subjects primarily according to their frequency of vigorous physical activity. Spearman rank order correlations between energy expenditure and the 9-point classification ranged from -0.33 to -.039, and between the simplified 2-point classification (active and inactive) from -0.41 to -0.47. All correlations between energy expenditure and the 2-point classification were significant at least at $p<0.05$. The results of both the t-tests and the correlations provide further evidence for the concurrent validity of the 4-

and 9-point classifications, albeit when simplified into an active/inactive dichotomy.

Although trends in the expected direction were apparent, there was no significant relationship between energy expenditure and the 5-point Stage of Exercise Change classification. Validation of this questionnaire with the Caltrac has not previously been attempted. Instead, previous studies have focused on known exercise status (Barké & Nicholas, 1990), 7-day physical activity recall (Marcus & Simkin, 1993), and self-efficacy and costs and benefits of exercise (Marcus & Owen, 1992). Conceptually, exercise is defined as a subset of physical activity which is planned, structured and repetitive, with the objective of maintaining or improving physical fitness (Caspersen *et al*, 1985). It would therefore be reasonable to expect subjects who report regular exercise (Action or Maintenance) to have a higher energy expenditure than those in Precontemplation or Contemplation. Ainsworth *et al* (1993a) suggested a possible reason for this lack of relationship may be differences in activity patterns. Although their study referred to the 4-point LRC questionnaire, the explanation may also be applicable to the Stage of Exercise model. For example, subjects reporting themselves as exercisers may engage in heavy physical activity for a short period and then spend the remainder of the day expending little energy; while some subjects may classify themselves as non-exercisers but be physically active in other, lower intensity activities for a larger portion of the day. If using the Caltrac, this could be investigated by instructing subjects to record scores more frequently throughout the day and analysing different periods of the day separately. It is also known that activities such as cycling, weight-lifting, and gardening, which may involve large amounts of energy expenditure but do not involve whole-body movement, are not measured accurately by the Caltrac when worn at the waist (Montoye *et al*, 1983). The new Tritrac accelerometer allows minute by minute recording of activity and intensity of activity, and would therefore provide much more detail than was possible here.

Test-retest correlation coefficients of the activity classifications ranged from 0.62 to 0.73. The correlations were not increased by grouping some of the activity categories together. Although these correlations were significant, it is apparent that a number of subjects changed their self-reported activity status. It may be that the time period between administering the two questionnaires allowed a real change in activity status by a significant number of individuals. The 8 week period, June to August, coincided with a time when physical

activity is known to peak in this age group (Uitenbroek, 1993). Thus the correlations may be reflective of a true shift in activity status rather than poor reliability. Ainsworth *et al* (1993a) found Pearson correlations of 0.85 and 0.88 for the 2- and 4-point classifications respectively, and Jacobs *et al* (1993) reported a test-retest correlation coefficient of 0.93 for the 4-point classification. The period between administration of the questionnaires was 4 weeks in each of these studies. Reliability of the 5-point Stage of Exercise classification has been reported as 0.78 over a 2 week period (Marcus *et al*, 1992b). The 8-week period between mailing of the two questionnaires in the present study was necessitated by the larger number of subjects involved than the studies cited above. Enough time had to be allowed for return of the first questionnaire, data entry, and selection of the reliability sample. As well as there being evidence for a seasonal increase in physical activity at this time (Uitenbroek, 1993), the first questionnaire may have provided a cue for some subjects to increase their activity level (Dishman, 1990; King *et al*, 1992). It should be remembered that test-retest correlations for all three activity questionnaires were still highly significant over 8 weeks, and a shorter time period between questionnaire administrations may provide correlations closer to those reported elsewhere.

In summary, the results appear to provide preliminary evidence for the validity of the 4- and 9-point activity classifications for identifying inactive individuals over the age of 55, and for the reliability of all three activity questionnaires. This must be qualified by stating that the 4 and 9 groups had to be condensed to two groups for practical reasons, and differences in 1-mile walk time, Caltrac scores, and scores on a detailed activity questionnaire for the elderly, were between subjects classified simply as active or inactive. The results presented here suggest that further validation of these questionnaires with this age group would be worthwhile. If proved valid and reliable, these short, easily administered questionnaires would be invaluable for use in the population for identifying those who are least active and therefore most at risk from inactivity-related disease.

The sample size did not allow differentiation between for example, low, moderate, and high active subjects. This would require a larger sample, and statistical analysis by ANOVA and follow-up tests to determine which activity groups, if any, differ in terms of physical appraisal results and Caltrac energy expenditure. This would then allow identification of a range of activity levels, and determine the type of intervention most appropriate for the individual.

It is important to place the type of activity being assessed by these global activity questionnaires in the context of various physical activity recommendations. Until recently, exercise recommendations have been based on dose-response improvements in performance capacity (American College of Sports Medicine, 1990) and were more than adequate in providing concurrent health benefits. The recommendation involved 20 to 60 minutes of continuous moderate to high intensity activity (60-90% of age-related maximum heart rate) performed at least three times per week. However, a new recommendation (Pate *et al*, 1995) states that the accumulation of 30 minutes of moderate intensity activity on most days of the week will provide substantial health benefit. This has implications for the activity questionnaire literature, in that researchers must now decide whether to assess physical activity and exercise which is equal to the new recommendation for health benefit, or whether more frequent and intense activity for performance capacity gain should be the focus. Obviously the questionnaire used will depend on the objectives of the study, but for health promotion purposes, and given the current low level of participation in any kind of activity by the majority of adults, it is likely that activity questionnaires will focus more on the former.

Identification of the least active individuals and providing encouragement and knowledge of how to incorporate this 30 minutes of moderate activity into their everyday lifestyle would make a significant contribution to improving the health of the nation (Department of Health, 1995). The 4- and 9-point classifications used here fall somewhere between the two types of questionnaire described above. Activity category is based mainly on perception of frequency of vigorous activity, but these questionnaires have the advantage of being short and easy to understand, and look promising at identifying the least active individuals in the population. Although new questionnaires may seek a detailed breakdown of activity in a 24-hour or 1 week period, perhaps based on the 7-day recall (Blair, 1984), the 4- and 9-point classifications may have the same desired result of identifying inactive individuals, achieved by different means. In terms of the new activity message, it is unlikely that the 5-point Stage of Exercise classification will have much use. The 30 minutes of physical activity can be incorporated into daily life by means such as walking up stairs, walking or cycling instead of using motorised transport, and garden and house work. This can be achieved cumulatively, and need not involve any structured exercise of the type assessed by the Stage of Exercise classification. However this classification may still prove useful with this age group if trying to measure exercise habits and fitness gain, although further validation is certainly required.

The findings of this study should be borne in mind when reading the next chapter, development of the benefits/barriers questionnaires. As already stated, it was necessary to use the activity questionnaires as criterion variables for the benefits/barriers scales before evidence of their own validity was established. As this study has now provided at least preliminary evidence of the validity of the 4- and 9-point activity classifications, their use in the benefits/barriers scale development can be viewed with some measure of confidence.

CHAPTER FIVE

BENEFITS AND BARRIERS

5.1 Introduction

The importance of perceived benefits and barriers to physical activity in determining exercise behaviour is highlighted in a number of theories, and several studies have provided evidence in support of this. Although these variables have been accurately assessed in college and worksite samples (Steinhardt & Dishman, 1989) and in adults with a mean age of 38 years (Sechrist *et al*, 1987), it is not known whether these scales would be suitable for use with an elderly sample, and there remains a lack of research of older adults' perceived benefits of, and barriers to, physical activity.

Evidence from single item questionnaires, such as those used by the Sports Council & Health Education Authority (1992), Mutrie *et al* (1993), and the pilot study (Chapter 3) suggests that perceived benefits and barriers in older adults do vary according to the individual's activity level. However, researchers cannot be certain that these questionnaires will give valid and reliable results because no attempt was made to validate the items. Both Steinhardt & Dishman (1989) and Sechrist *et al* (1987) used a statistical technique called principal components analysis (similar to factor analysis; see Appendix R) which is often used in psychology for scale development. Briefly, the purpose of factor analysis is to identify a relatively small number of factors or underlying constructs which characterize responses to related groups of items and can be used to represent relationships among sets of interrelated variables. For example many people cite the social benefits of exercise, but to measure this using a single item would be very difficult, and could not measure different dimensions of social benefits such as meeting new people, being part of a team, regular contact with friends, competition, and so on. Thus factor analysis identifies related items measuring the same construct, and allows these items to be grouped under one heading, in the above example 'social benefits'. Once the factors have been identified, the validity of the questionnaire can then be assessed by examining the relationship of perceived benefits and barriers with physical activity.

The development of valid and reliable scales would provide important measures for the dependent variables in intervention studies and for the independent variables in tests of theories of exercise behaviour. In addition, the scales could be used in a practical setting, whereby inactive people can be guided into

appropriate types of physical activity which are likely to maximise perceptions of benefit and to which there are few perceived barriers.

The objectives of this study were:

1. To assess self-reported physical activity status using three different methods;
2. To develop scales for measuring perceived benefits of, and perceived barriers to, physical activity using principal components analysis;
3. To assess the reliability and validity of these scales.

5.2 Method

5.2.1 Subjects

Subjects were males and females aged 55-74 years, obtained by random sampling of the local Health Board's patient list. The size of the sample who received a questionnaire (n =1456) was calculated as follows (Sokal & Rohlf, 1981, p766):

Given the significance level α (0.05), it is desired to estimate the sample size, n, needed in order to be $1 - \beta = 0.80$ certain of detecting a true difference between two proportions p_1 and p_2 ($p_1 > p_2$)

Let $$\bar{p} = \frac{p_1 + p_2}{2}$$ Equation 4.1

and $$A = [t_{\alpha[\infty]}\sqrt{2\bar{p}(1-\bar{p})} + t_{2\beta[\infty]}\sqrt{p_1(1-p_1) + p_2(1-p_2)}]^2$$ Equation 4.2

where $t_{\alpha[\infty]}$ and $t_{2\beta[\infty]}$ are critical values from a two-tailed students t-table.

$$t_{\alpha[\infty]} = t_{.05[\infty]} = 1.960$$

$$2\beta = 2(1-0.80) = 0.40 \qquad t_{2\beta[\infty]} = t_{.40[\infty]} = 0.842$$

Then $$n = \frac{A[1 + \sqrt{1 + 4(p_1 - p_2)/A}]^2}{4(p_1 - p_2)^2}$$ Equation 4.3

p_1 = proportion 1
p_2 = proportion 2
$\bar{p}$ = mean proportion
n = number of subjects required in each sample

The sample size for this study was dependent on the sample required for validation of the activity questionnaires. Using data from the ADNFS (Sports Council & Health Education Authority, 1992), Voorrips *et al* (1993) and Washburn *et al* (1990) sample sizes for each variable were calculated. Of the tests to be used in this further study (flexibility; strength; aerobic fitness; physical activity interview; objective physical activity counter) estimated $\dot{V}O_{2max}$ requires

the largest sample size to be certain of detecting any difference between two sub-groups. For this variable, *n* was calculated to equal 43 subjects in each of the two samples.

A usable return rate of 44% was achieved in the pilot study (Chapter 3). The smallest activity group, those who regularly do vigorous physical activity, contained 14% of subjects. The following calculations are based on this figure of 14%.

total sample size required to result in 43 subjects (14%) in smallest cell	=	43 x 100/14
	=	307

But from the pilot study, the return rate was expected to be 44%.

total sample size required to result in 43 subjects (14%) in smallest cell with a 44% return rate	=	307 x 100/44
	=	700

If questionnaires were mailed to 700 subjects, theoretically <u>all</u> the subjects in the smallest cell who responded would need to be tested in the validation study. As this is unrealistic, this figure of 700 was doubled to allow for a smaller percentage than 14% in the smallest cell, an overall return rate of less than 44%, and subjects unwilling or unable to take part in the validation study. A further 4% was added to allow for subjects in hospitals or residential nursing homes who may have been on the subject list but would not be included in the study. This gave a final sample size of 1456 subjects.

5.2.2 Instrument

The questionnaire (Appendix B) was altered according to the findings of the pilot study, and was divided into four sections:

Section 1. Leisure Activity

The aim of this section was to classify subjects according to the amount of activity they do during their leisure time. The questions did not ask details of frequency, duration, intensity or mode of exercise; instead they were more general, requiring subjects to indicate their perception of their activity status. Items were based on the work of Ainsworth *et al* (1993a), Marcus *et al* (1992b), and that of the author.

Section 2. Benefits of Physical Activity

This section contained 25 items, constructed using the stem "For me, a major benefit of taking part in physical activity is" followed by, for example, "improved stamina" or "relaxation". Subjects responded by ticking a box on a 7-point Likert scale, ranging from very strongly agree (1) to very strongly disagree (7).

Section 3. Barriers to Physical Activity

This section contained 33 items, formed by the stem "When I do not exercise, a major reason is" followed by, for example, "the cost of using facilities is too much" or "I have no-one to exercise with". Again, response was on a 7-point Likert scale. Items in both Sections 2 and 3 were based on the work of Sechrist *et al*, (1987), Steinhardt & Dishman (1989), Mutrie et *al*, (1993), and the Sports Council & Health Education Authority (1992). The open ended section in the pilot study did not reveal any benefits or barriers which were not already listed.

Section 4. Demographic information

This section required the subject to give information on current or most recent occupation, household income, education level and housing tenure.

5.2.3 Procedure

Subjects received an initial mailing containing the self-complete questionnaire, a prepaid reply envelope, and a covering letter explaining the purpose of the study, ensuring confidentiality, and encouraging a prompt response (Appendix G). Postcard reminders were sent out one week after the first mailing. Of the subjects who returned a usable questionnaire, a sub-sample of 120 were sent a second identical questionnaire 8 weeks after the first, to test reliability.

5.2.4 Data Analysis

The data were analysed using the Statistical Package for Social Sciences (SPSS) for Windows (SPSS Inc, 1993a, 1993b). Subjects were categorised into different activity levels according to their responses in Section 1 (Appendix E). These activity levels then formed the basis for subsequent analyses. For certain analyses, some of the activity categories were grouped together.

A principal components analysis with oblimin rotation was used to determine whether the perceived benefits of activity and perceived barriers to activity could be reduced into meaningful subsets. See Appendix R for a fuller explanation of both principal components analysis and discriminant function analysis. The factors were found to be correlated and so were not rotated orthogonally. The criteria for extraction was those factors with eigenvalues greater than 1.0. All factor loadings are reported, but the criteria for inclusion of an item on a given subscale was an absolute value of 0.45 or higher, with absolute loadings on other factors lower by at least 0.10. Internal consistency was measured using Cronbach's alpha coefficient, and reliability of the scales was evaluated using test-retest Pearson correlations.

Once the scales were established, subjects' scores on a given factor were calculated by summing the products of the Likert score and the loading on that factor for every item (SPSS Inc., 1990, p336-337).

Gender differences in Benefits and Barriers scores were investigated using an independent t-test.

One-way ANOVA with Student-Newman-Keuls post-hoc comparisons was used to investigate differences in Benefits and Barriers factor scores between subjects in different activity categories.

Discriminant function analysis was then used to determine the validity of the scales for predicting activity category. Demographic variables were also used in these analyses. The variables were entered in a stepwise manner, the maximum significance of F to enter a variable being 0.05, and the minimum to remove a variable being 0.10.

5.3 Results

5.3.1 Return rate

Of the 1456 questionnaires mailed out, 845 (58.0%) were accounted for. As well as usable questionnaires, these included blank returns, partially completed returns, deceased subjects, and those subjects who had been advised against exercising by their doctor, or who felt they had a medical condition which prevented their exercising. The total number of usable questionnaires included in the analysis was 548, a return rate of 37.6%. Of these, 45.8% were male and 54.2% were female. Ages ranged from 55-74 years, the mean age being 63.2 $\pm$ 5.2 years. Of the 120 questionnaires sent to a random sub-sample 8 weeks after the first, 58 (47.5%) were returned.

5.3.2 Demographic information

Demographic information is given in Appendix M and can be summarised as follows:

- Half the sample are retired and around 30% are in employment (either full, part, or self). The remainder are unemployed, unable to work, or look after the home/family.
- Annual income in over 65% of households is less than £15, 000.
- About 29% have no educational qualifications, 34% have secondary school certificates, and about a quarter of the sample possess qualifications beyond secondary school.
- Over 70% of subjects own their own home.

5.3.3 Activity classifications

The purpose of section 1 of the questionnaire was to categorise subjects according to their self-reported activity level. Combining responses to items 1 and 2 (perceived activity level compared to others of a similar age and sex, and participation/non-participation in vigorous activity) led to four categories (Appendix E). Also shown in Table 5.1 are results from the pilot study and from Ainsworth *et al* (1993a) (Lipid Research Clinics).

Table 5.1 Activity classification using LRC 4-point method (Percent of subjects. n=548)

Activity Category	Present study	Pilot study	Ainsworth *et al* (1993a)
1. High Active	6.9	4.5	23.0
2. Moderately Active	21.7	27.3	26.0
3. Low Active	57.9	40.9	22.0
4. Very Low Active	13.5	27.3	29.0

Similarly, combination of items 3 and 4 ('how often do you take vigorous/non-vigorous activity') led to nine categories (Appendix E). These items were written specifically for this study as they fulfil the criteria of being easy to understand and quick to complete, as well as offering a greater degree of response choice than the LRC items. Also shown in Table 5.2 are results from the pilot study.

Table 5.2 Activity classification using 9-point method (Percent of subjects. n=548)

Activity category	Present study	Pilot study
1. Most Active	7.3	13.6
2.	7.3	0
3.	1.3	0
4.	17.5	31.8
5.	21.5	22.7
6.	3.8	0
7.	8.9	4.5
8.	13.5	13.6
9. Least Active	18.8	13.6

The third method of activity classification was the 'Stages of Exercise Change' questionnaire (Marcus *et al*, 1992b). Subjects were required to tick one item which they felt was closest to their current exercise status. These five items related to the proposed exercise stages of Precontemplation, Contemplation, Preparation, Action and Maintenance (Appendix E). Table 5.3 shows results of the present study, and

for comparison, results of Marcus *et al's* sample (1992b), and Gorely & Gordon (1995).

Table 5.3 Stage of exercise classification.(Percent of subjects. n=548)

Stage	Present study	Gorely & Gordon (1995)	Marcus *et al* (1992b)
1.Precontemplation	17.7	14.6	7.3
2.Contemplation	5.5	9.6	23.1
3.Preparation	35.3	29.0	30.4
4.Action	2.0	9.4	16.6
5.Maintenance	39.5	37.4	22.6

5.3.4 Principal Components Analysis

5.3.4(i) Perceived benefits of exercise

The principal components analysis with oblimin rotation for perceived benefits of exercise yielded five factors with eigenvalues greater then 1.0, accounting for 64.7% of the total variance. The factors were labelled physical performance, social, weight control, enjoyment, and psychological, and contained 7, 4, 2, 4 and 4 items respectively. A further four items did not meet the criteria for inclusion on any factor. These data are shown in Table 5.4. Correlations between the factors, shown in Table 5.6 ranged from 0.19 to 0.40 and so an orthogonal rotation was not performed. Cronbach's alpha for the five factors ranged from 0.78 to 0.88 and Pearson test-retest correlations ranged between 0.62 and 0.79. These data are also shown in Table 5.4.

Scores on a given factor were calculated by summing the products of the Likert score and the loading on that factor for every item (SPSS Inc, 1990, p336-337). Likert scores ranged from 1 (very strong agreement) to 7 (very strong disagreement). So for example, the factor score for physical performance was calculated by 0.79(Likert score) + 0.62(Likert score) + 0.83(Likert score) ..... + 0.40(Likert score). Mean scores, standard deviations and ranges for the sample for each of the five factors are as follows: physical performance (24.10 $\pm$ 6.78, 7.02 to 51.34); social (17.17 $\pm$ 4.85, 4.59 to 32.90); weight control (11.79 $\pm$ 3.45, 3.57 to 24.98); enjoyment (13.00 $\pm$ 3.91, 4.17 to 31.23); and psychological (10.01 $\pm$ 3.15, 2.97 to 22.47).

Table 5.4 Principal Components Analysis with Oblimin rotation of perceived benefits of physical activity (n=548)

For me, a major benefit of taking part in physical activity is:	I	II	III	IV	V
I. Physical Performance					
Improved muscle tone	**.79**	-.12	-.05	.19	.01
Improved co-ordination/balance	**.62**	.18	-.02	.05	.17
Increased muscle endurance	**.83**	.04	-.12	.00	.09
Increased strength	**.79**	.08	-.04	-.10	.00
Improved flexibility	**.56**	-.08	.21	.21	.03
Increased self-image and confidence	**.55**	.33	.08	-.08	.05
Improved stamina	**.66**	-.15	.07	.17	.07
II. Social					
Contact with friends	-.13	**.66**	.00	.38	.08
Sense of belonging to a team	.11	**.81**	-.04	.07	.03
Meet new people	-.06	**.72**	.05	.08	.21
Competition with others	.06	**.78**	.09	-.01	-.07
III. Weight Control					
To lose weight	-.16	.05	**.96**	-.06	-.05
To control body weight	-.02	-.06	**.91**	.05	.04
IV. Enjoyment					
Feelings of well-being	.22	-.09	.15	**.58**	.15
Relaxation	-.07	.05	.06	**.67**	.30
Enjoy exercise	.15	.04	.00	**.78**	-.09
Fun	-.07	.23	-.08	**.78**	-.01
V. Psychological					
Cope better with life's pressures	.33	-.04	.10	.10	**.59**
Improved mental health	.28	.09	.19	.08	**.46**
Decrease stress and tension	.24	.01	.01	.19	**.58**
Chance to get out of the house	-.05	.39	-.03	.06	**.55**
Items not meeting inclusion criteria:					
Personal challenge	.43	.42	.20	.11	-.32
Easier to carry out every day tasks	.44	-.12	.23	.09	.24
Sense of accomplishment	.41	.15	.30	.28	-.15
Improved appearance	.40	.23	.33	-.20	.26
Eigenvalue	9.89	2.38	1.65	1.24	1.04
Percent of common variance	39.6	9.5	6.6	5.0	4.1
Cronbach's alpha	.88	.85	.80	.81	.78
Pearson test-retest correlation	.73	.79	.73	.62	.71

Summated scores for perceived benefits of exercise ranged from 23.14 to 162.01, with a mean and SD of 76.08 ± 18.86.

A small factor score indicates a greater perception of the benefits of exercise. It was hypothesised that a subject who was more active would have a greater perception of the benefits of exercise and therefore a lower benefits score than a subject who was less active.

5.3.4(ii) Perceived barriers to exercise

The principal components analysis with oblimin rotation for perceived barriers to exercise yielded five factors with eigenvalues greater than 1.0, accounting for 60.4% of the total variance. The factors were labelled opportunities, physical exertion, time, limiting health, and support, and contained 9, 12, 4, 2 and 3 items respectively. Three items did not meet the criteria for inclusion on any factor. These data are shown in Table 5.5. Correlations between the factors, shown in Table 5.6, ranged from 0.00 to -0.49 and so an orthogonal rotation was not performed. Cronbach's alpha for the five factors ranged from 0.64 to 0.91 and Pearson test-retest correlations ranged between 0.56 and 0.87. These data are also shown in Table 5.5.

Factor scores were calculated using the same method as for the benefits of exercise. Mean scores, standard deviations and ranges for the sample for each of the five factors are as follows: opportunities (40.65 ± 8.49, 11.21 to 59.12), physical exertion (-47.57 ± 9.56, -16.77 to -70.17), time (20.56 ± 3.87, 7.28 to 32.64), limiting health (9.66 ± 2.74, 1.28 to 17.50), and support (-18.51 ± 3.42, -3.88 to -28.01). Summated scores for perceived barriers to exercise were calculated by adding together absolute scores of the five factors regardless of sign, and ranged from 44.57 to 199.26, with a mean and SD of 136.96 ± 22.87.

A high factor score, regardless of sign, indicates a lower perception of the barriers to exercise. It was hypothesised that a subject who was more active would have a lower perception of the barriers to exercise and therefore a higher factor score than a subject who was less active.

Table 5.5 Principal Components Analysis with Oblimin rotation of perceived barriers to physical activity (n=548)

When I do not exercise, a major reason is:	I	II	III	IV	V
I. Opportunities					
Equipment costs too much	**.87**	-.08	-.08	.01	.14
Cost of using facilities is too much	**.88**	-.03	.03	-.01	.06
Lack of classes/courses available	**.46**	-.10	.03	-.10	-.35
Facilities are too far away	**.54**	.00	.10	.00	-.37
Classes are at inconvenient times	**.45**	-.16	.25	-.04	-.12
Footwear costs too much	**.88**	-.01	-.08	.01	.02
Travel to facilities costs too much	**.71**	.03	.04	-.02	-.21
Lack of facilities	**.62**	.01	.05	.07	-.08
Proper clothing costs too much	**.87**	-.03	-.05	.08	.12
II. Physical Exertion					
I am overweight	.14	**-.56**	-.10	.03	.00
I get too fatigued by exercise	-.02	**-.82**	-.05	.10	-.07
I don't like sweating	.16	**-.61**	-.01	.15	-.07
I don't enjoy physical activity	.00	**-.81**	.01	-.09	-.01
Exercise is too hard work	.08	**-.75**	.13	-.02	.26
My muscles feel stiff after exercise	.11	**-.66**	-.03	.09	-.09
I don't like getting out of breath	.01	**-.69**	-.10	.13	-.21
Exercise makes me feel uncomfortable	.00	**-.72**	-.11	.04	-.26
I am too shy/embarrassed to exercise	.31	**-.49**	.05	-.15	-.09
I am not the sporty type	.31	**-.73**	.20	-.14	.22
Lack of motivation	-.02	**-.66**	.19	-.12	.11
Exercise makes me feel sick	.06	**-.51**	.04	.18	-.23
III. Time					
I am too busy	-.02	.18	**.79**	.04	-.02
Exercise takes up too much time	.08	-.26	**.57**	-.13	-.18
I am too tired after work	-.13	-.28	**.54**	-.05	-.34
Exercise interferes with work	-.02	-.08	**.76**	.11	.12
IV. Limiting Health					
Illness	-.01	-.12	-.01	**.82**	-.07
Injury	.09	.13	.26	**.79**	.19
V. Support					
Lack of support from family	.22	-.15	.05	.01	**-.62**
Family obligations	.21	.10	.38	.06	**-.46**
Lack of support from friends	.36	-.12	.12	-.14	**-.50**

Table 5.5 continued

	I	II	III	IV	V
Items not meeting inclusion criteria:					
I have no-one to exercise with	.34	-.31	.22	-.20	-.16
Unsuitable weather	.19	-.12	.43	.18	.02
Physical disability	-.04	-.41	-.18	.44	-.38
Eigenvalue	12.39	2.55	1.97	1.78	1.24
Percent of common variance	37.6	7.7	6.0	5.4	3.8
Cronbach's alpha	.91	.92	.73	.64	.74
Pearson test-retest correlation	.74	.80	.76	.87	.56

Table 5.6 Factor correlation matrix for perceived benefits of physical activity and perceived barriers to physical activity (n=548)

		I	II	III	IV	V
Perceived Benefits						
I.	Physical Performance	1.000				
II.	Social	.252	1.000			
III.	Weight Control	.400	.255	1.000		
IV.	Enjoyment	.374	.329	.230	1.000	
V.	Psychological	.339	.201	.188	.299	1.000
Perceived Barriers						
I.	Opportunities	1.000				
II.	Physical Exertion	-.488	1.000			
III.	Time	.301	-.234	1.000		
IV.	Limiting Health	.072	-.074	.004	1.000	
V.	Support	-.340	.327	-.122	-.089	1.000

5.3.5 Gender differences in Benefits and Barriers factor scores

Table 5.7 shows the results of the independent t-tests investigating differences between males and females on each of the factors.

Women endorsed the social, weight control, and psychological benefits of physical activity to a significantly greater extent than men (at least $p<0.05$). On the barriers to physical activity, women reported opportunities, physical exertion, time, and support as being significantly greater barriers to physical activity than men.

Table 5.7 Gender differences in Benefits and Barriers factor scores

Variable	Group	n	Mean	SD	df	t-value	p
Benefits:							
Physical	Male	234	24.38	7.10	495	0.85	0.396
Performance	Female	263	23.88	6.48			
Social	M	234	17.76	5.01	495	2.59	0.010
	F	263	16.64	4.65			
Weight Control	M	234	12.26	3.51	495	2.89	0.004
	F	263	11.37	3.34			
Enjoyment	M	234	13.03	3.93	495	0.18	0.858
	F	263	12.97	3.90			
Psychological	M	234	10.32	3.24	495	2.04	0.042
	F	263	9.74	3.05			
Total Benefits	M	234	77.75	19.08	495	1.87	0.062
	F	263	74.59	18.57			
Barriers							
Opportunities	M	228	41.78	8.68	490	2.74	0.006
	F	264	39.69	8.21			
Physical Exertion	M	228	-49.87	9.29	490	-5.09	<0.001
	F	264	-45.58	9.36			
Time	M	228	21.07	3.93	490	2.72	0.007
	F	264	20.12	3.77			
Limiting Health	M	228	9.64	2.84	490	-0.13	0.894
	F	264	9.68	2.65			
Support	M	228	-19.16	3.45	490	-3.96	<0.001
	F	264	-17.95	3.29			
Total Barriers	M	228	141.52	23.15	490	4.18	<0.001
	F	264	133.02	21.92			
Benefits/	M	217	0.56	0.16	451	-1.04	0.299
Barriers Ratio	F	236	0.58	0.16			

5.3.6 Analysis of variance

A series of one-way ANOVAs were performed to investigate whether differences existed in benefits and barriers factor scores between subjects who differed in their

reported activity level. Post-hoc analyses were done using the Student-Newman-Keuls test, which indicated differences between groups significant at the $p<.05$ level.

Tables 5.8 to 5.10 show *F* and *p* values and also which groups, if any, were significantly different from each other, for each of the three activity classification methods. Detailed ANOVA tables are shown in Appendix P.

Mean scores and standard deviations for each of the factors for the various activity groups are shown in Appendix O.

4-point activity classification

Only three factors show no relationship with activity level, and these are the benefit weight control and the barriers time and limiting health. The benefits tend to distinguish the most active subjects from all others, whereas the barriers factors and the benefits/barriers ratio show more discrimination between all 4 groups.

Table 5.8 One-way ANOVA: Benefits and Barriers factors by 4-point activity classification (< mean score of group is less than; > mean score of group is greater than)

Variable	*F*	*p*	Groups significantly different at $p<.05$
Benefits:			
Physical performance	6.64	<.001	1<2,3,4
Social	2.81	.039	1<2,3,4
Weight control	1.26	.288	
Enjoyment	11.71	<.001	1<2,3<4
Psychological	4.11	.007	1<3,4; 2<3
Total Benefits	6.32	<.001	1<2,3,4
Barriers:			
Opportunities	9.23	<.001	1,2>3,4
Physical exertion	23.94	<.001	1>2>3>4
Time	2.10	.099	
Limiting health	2.12	.096	
Support	12.30	<.001	1,2>3>4
Total Barriers	13.95	<.001	1,2>3>4
Benefits/Barriers Ratio	13.79	<.001	1<2<3<4

9-point activity classification

Three benefits (social, weight control and psychological) and the barrier limiting health showed no relationship with activity level. The factors which did show a relationship tended to discriminate the least active subjects from the others.

Table 5.9 One-way ANOVA: Benefits and Barriers factors by 9-point activity classification

Variable	*F*	*p*	Groups significantly different at *p*<.05
Benefits:			
Physical performance	2.97	.003	1<8,9
Social	1.32	.231	
Weight control	1.33	.226	
Enjoyment	6.33	<.001	1<4,5,8,9; 2<5,8,9; 4,5,7<9
Psychological	1.29	.247	
Total Benefits	2.72	.006	1<8,9
Barriers:			
Opportunities	7.23	<.001	1,2,4,7>9; 1,2,4>5; 1>8; 2>6,8
Physical exertion	16.17	<.001	1,2>3,4,5,7,8,9; 1>6; 4,5,6,7>9; 4>5; 4,7>8
Time	1.80	.074	1>5
Limiting health	1.41	.190	
Support	6.68	<.001	1>4,5,7,8,9; 2>5,8,9; 4>9
Total Barriers	9.55	<.001	1,2>4,5,7,8,9; 4>5,9; 7>9
Benefits/Barriers Ratio	5.84	<.001	1,2,4,5,7<9; 1,2<8; 1<5

5-point Stages of Change classification

On the 5-point Stages of Change classification, Precontemplators were distinguished from other groups on the benefits factors, with the exception of weight control, which showed no relationship. Preparers were significantly

different from Maintainers on three of the benefits. The barriers tended to distinguish Maintainers from the other groups, with the differences in the expected direction *i.e.* Maintainers perceived fewer barriers to exercise. The exception to this was the barrier limiting health, where regular exercisers appear to perceive injury and illness as greater barriers to exercise than subjects who exercise infrequently or not at all.

Table 5.10 One-way ANOVA: Benefits and Barriers factors by 5-way activity classification

Variable	*F*	*p*	Groups significantly different at *p*<.05
Benefits:			
Physical performance	7.40	<.001	5,3,2<1; 5<3
Social	2.48	.043	5<1
Weight control	1.24	.293	
Enjoyment	18.31	<.001	5,4,3,2<1; 5<3
Psychological	7.78	<.001	5,3,2<1; 5<3
Total Benefits	8.10	<.001	5,3,2<1; 5<3
Barriers:			
Opportunities	12.55	<.001	5>1,2,3
Physical exertion	35.47	<.001	5>1,2,3; 4,3>1
Time	7.98	<.001	5>1,3
Limiting health	6.08	<.001	1,2,3>5
Support	13.85	<.001	5>1,2,3
Total Barriers	18.88	<.001	5>1,2,3
Benefits/Barriers Ratio	21.16	<.001	5,3,2<1; 5<3

5.3.6 Discriminant analysis

For the discriminant analysis, only those subjects who completed all items in all sections of the questionnaire were included. This ensured that there would be no subjects who could not be classified as a result of one or more missing predictor variables, and gave a sample size of 408. An explanation of discriminant analysis is given in Appendix R.

5.3.6(i) Relationship to 4-point activity classification (LRC)

Results of the discriminant analysis revealed 3 discriminant functions, 2 of which were significant, accounting for 79.9% and 19.0% of the total variance respectively. The following variables were significant in predicting activity category (shown in brackets is the largest absolute canonical correlation between each variable and any discriminant function): physical exertion (0.85 Func 1); age (-0.52 Func 2); physical performance (0.51 Func 2); time (-0.66 Func 3). The percentage of subjects placed in the same category using these four predictor variables as according to their responses to items 1 and 2 of the physical activity section of the questionnaire was 58.58%. The classification table is shown in Appendix Q Table 1.

In a further analysis, the four activity categories were reduced to two. This was done by grouping together categories High Active and Moderately Active (those who regularly did vigorous activity), and categories Low Active and Very Low Active (those who did not do any regular vigorous activity). As the maximum possible number of discriminant functions is always one less than the number of groups in the independent variable, there was only 1 discriminant function. The following variables were significant in predicting activity category: physical exertion (0.83); psychological (0.40); limiting health (0.17). The percentage of subjects placed in the same category using these three predictor variables as according to their responses to items 1 and 2 of the physical activity section of the questionnaire was 74.26%. The classification table is shown in Appendix Q Table 2.

5.3.6(ii) Relationship to 9-point activity classification

Results of the discriminant analysis revealed 4 discriminant functions, 1 of which was significant, accounting for 84.7% of the total variance. The following variables were significant in predicting activity category: physical exertion (0.83 Func 1); total barriers score (0.72 Func 2); household income (0.75 Func 4); limiting health (0.74 Func 4). The percentage of subjects placed in the same category using these four predictor variables as according to their responses to items 3 and 4 of the physical activity section of the questionnaire was 31.13%. The classification table is shown in Appendix Q Table 3.

In a further analysis, the nine activity categories were reduced to three. This was done by grouping together categories 1 to 3 (those who often did vigorous activity), groups 4 to 6 (those who sometimes did vigorous activity) and groups 7 to 9 (those who never did vigorous activity). The discriminant analysis revealed 2 discriminant functions, 1 of which was significant, accounting for 90.6% of the total variance. The following variables were significant in predicting activity category: physical exertion (0.90 Func 1); physical performance (0.43 Func 1); time (0.91 Func 2). The percentage of subjects placed in the same category using these four predictor variables as according to their responses to items 3 and 4 of the physical activity section of the questionnaire was 52.94%. The classification table is shown in Appendix Q Table 4.

5.3.6(iii) Relationship to 5-point classification (Stage of Exercise)

Results of the discriminant analysis revealed 4 discriminant functions, 2 of which were significant, accounting for 82.8% and 12.0% of the total variance respectively. The following variables were significant in predicting activity category: physical exertion (0.71 Func 1); total barriers score (-0.50 Func 1); limiting health (0.65 Func 3); psychological (-0.57 Func 3); educational level (-0.74 Func 4). The percentage of subjects placed in the same category using these five predictor variables as according to their responses to item 5 of the physical activity section of the questionnaire was 58.33%. The classification table is shown in Appendix Q Table 5.

These five categories were then reduced to three for a further discriminant analysis. Precontemplation and contemplation were grouped together (those who currently do not exercise), as were action and maintenance (those who currently exercise regularly), with preparation remaining (those who currently exercise a little but not regularly). The discriminant analysis revealed 2 discriminant functions, both of which were significant, accounting for 90.0% and 10.0% of the total variance respectively. The following variables were significant in predicting activity category: physical exertion (0.71 Func 1); total barriers score (-0.50 Func 1); enjoyment (0.49 Func 1); limiting health (0.28 Func 1). The percentage of subjects placed in the same category using these four predictor variables as according to their responses to item 5 of the physical activity section of the questionnaire was 60.78%. The classification table is shown in Appendix Q Table 6.

5.4 Discussion

This study set out to develop a valid and reliable questionnaire for assessing perceived benefits of, and barriers to, participation in physical activity by older adults. The items were taken from a number of sources (Sechrist *et al*, 1987; Steinhardt & Dishman, 1989; Sports Council and Health Education Authority, 1992; Mutrie *et al*, 1993) and were selected to represent a comprehensive range of perceived benefits and barriers. The principal components analysis produced five factors on both the benefits and barriers scales. These scales showed high internal consistency (Cronbach's alpha) and significant stability over an 8-week period (Pearson test-retest correlations).

Three different methods of assessing physical activity were used for validation of the benefits and barriers scales. It was decided to use these questionnaires even though they had not been validated specifically with an older sample. Practical constraints meant that it was not possible to randomly select and test a sample to validate the activity questionnaires before going on to develop the benefits and barriers scales. There was enough evidence for the utility of the questionnaires for asessing overall activity status, even in older adults, to recommend their use in this study. Thus the large sample required for development of the benefits and barriers scales was selected first, from which a sub-sample was later selected for validation of the activity questionnaires. Although the purpose of this study was to develop the benefits/barriers scales, a short discussion of the activity classifications, the criteria used for validation, is warranted here.

Compared with Ainsworth *et al's* (1993a) sample, this study contained a higher proportion of low active subjects, and fewer very low and high active subjects. Although the age range of the 1993 sample had an upper limit of 59 years, the mean age was about 40 years, whereas in the present study the mean age is 63 years. The majority of subjects (about 80%) in the current study are in either the 'moderately active' or 'low active' categories. This can be interpreted in two ways: either the classification gives a true reflection of the physical activity status of the sample and these subjects are genuinely less active than those in Ainsworth *et al's*; or there is a wide range of physical activity participation but the questionnaire is too insensitive to the range of lower intensity activities in which

the majority of elderly adults participate and thus most of the subjects are grouped together in two categories. When condensed into two categories, 28.6% of subjects reported regular vigorous physical activity, while 71.4% reported none, figures which are similar to those of the pilot study. The results of the 9-point activity classification method reflect the greater degree of response choice. The percentage of subjects reporting 'often' and 'never' participating in vigorous physical activity (categories 1-3 and 7-9 respectively) are 15.9% and 41.2% respectively, both lower than the roughly corresponding LRC categories. With 42.8% of subjects reporting 'sometimes' participating in this intensity of activity, a graded choice of responses may be more favourable than a forced choice of 'yes' or 'no'. Spearman's correlation coefficient between these two methods was r=0.60, slightly lower than that found in the pilot study (r=0.65).

The 5-point Stage of Exercise Change classification showed a different profile to Marcus *et al's* (1992b) sample, with the majority of subjects reporting 'some but not regular' exercise (Preparation) or 'regular exercise for longer than 6 months' (Maintenance). The profile is very similar to Gorely & Gordon's (1995) sample of 583 elderly Australians. They also used the same Stage of Exercise Change instrument as in the present study, and showed a relationship between the stages of change and self-efficacy, processes of change, and decisional balance. The validity of the Stages of Change model has also been tested with an elderly sample using a different classification instrument (Barké & Nicholas, 1990). Although direct comparison with the present results is not possible, this study did show a relation between the stages of exercise and actual activity status. It is interesting to note that correlations between the 4- and 9-point classifications, which are based primarily on vigorous physical activity, and the 5-point Stages of Change classification, which is based specifically on exercise, were slightly lower, at r=0.45 and r=0.51 respectively, indicating that this sample of over 55-year olds did not view vigorous activity and exercise as synonymous.

So in summary, although the activity profiles of the sample in this study are different from those in which the activity classifications were developed, these three methods appear to give an adequate spread of subjects in all 4, 9, or 5 categories. The subjects are not all clustered into one group, suggesting that the classifications are reflective of the activity or exercise status of the sample.

Only one of the ten benefits/barriers factors consistently showed no relationship with activity status, and this was the benefit 'weight control'. All activity groups valued this factor equally as a benefit of physical activity. The barrier 'physical exertion' showed the strongest relationship with activity status as determined by all three methods. Less active subjects found this to be a greater barrier to participating in activity than subjects who were more active. This suggests that when encouraging this age group to become more active there should be emphasis on the benefits to be gained from activity whatever the intensity (Blair *et al*, 1992). Active and inactive subjects on the 4- and 9-point classifications did not differ in their scores on the barrier 'limiting health'. However, on the 5-point Stage of Exercise classification, maintainers found this to be significantly more of a barrier than either precontemplators, contemplators or preparers. This means that among those who exercise regularly, illness and injury are important reasons which prevent participation. Limiting health may also still be an important reason preventing inactive people from exercising - these results merely show that it is a significantly smaller barrier for inactive than active subjects.

Through this series of ANOVAs, summarised in Tables 4.7 to 4.9 and detailed in Appendix P, there is good overall evidence for the concurrent validity of the scales. Active subjects tended to perceive greater benefits and fewer barriers to physical activity and exercise than less active subjects. Although some theories (Maiman & Becker, 1974; Noland & Feldman, 1984; Ajzen, 1988) suggest that an individual weighs up perceived benefits (or outcome expectancies) and barriers when considering exercise participation, a ratio of perceived benefits to barriers ($OE_{Values}/P_{Barriers}$) has only been investigated in one study. Using scales validated previously (Steinhardt & Dishman, 1989), Dishman *et al* (1992) reported that this ratio was significantly correlated with physical activity when measured both by self-reported 7-day diary and an objective activity counter. Relationships between the separate components of perceived benefits and barriers and physical activity were not reported. The current study revealed that the benefits/barriers ratio was merely reflective of those individual benefits and barriers factors which showed the strongest relationship with physical activity, as evident in Tables 4.7 to 4.9. The results of the ANOVAs for the benefit/barrier ratio were very similar to those for the factors enjoyment and physical exertion. Although a benefits/barriers ratio has theoretical appeal, it does not provide the same detail as a close examination of the individual factors.

The analysis of gender differences in perceived benefits and barriers revealed that women scored significantly higher than men on three benefit factors and four barrier factors. Women significantly endorsed the social, weight control, and psychological benefits of physical activity, indicating that activities offered to women should seek to maximise these benefits. The findings also confirm previous research, which showed that class activities such as aerobics and 'keep fit' which would provide such benefits, are much more popular with women than men (Scottish Sports Council, 1991).

This sample of women also reported greater barriers to physical activity than men, scoring significantly higher on opportunities, physical exertion, time, and support. So although women perceive greater benefits of physical activity when they do take part, they also perceive greater barriers to their participation. This is borne out in a breakdown of the activity classifications by sex. Men were significantly more active according to both the 4-point (Chi-square=13.6 (3), p=0.003) and the 9-point (Chi-square=24.7 (8), p=0.002) activity classifications. These findings are similar to those of previous studies which found differences between men and women in their reasons for participation/stopping physical activity (Canada Fitness Survey, 1983; Biddle & Bailey, 1985; Robertson & Mutrie, 1989; Markland & Hardy, 1991; Sports Council & Health Education Authority, 1992; Ashford & Biddle, 1993). These gender differences must be taken into account when formulating physical activity recommendations.

The results of the discriminant analysis show that depending on the method of classification, between 31% and 74% of subjects could be placed in the same activity category using the benefits and barriers factors and demographic variables as their self-reported activity status in the physical activity section of the questionnaire. Six of the ten factors were significant in predicting activity category. Again this provides evidence for the validity of the scales. The variable which had the largest influence on predicting activity category in all of the discriminant analyses was the barrier physical exertion. This both confirms the findings of the ANOVAs and highlights the fact that this barrier must be considered very carefully when prescribing physical activity to this age group.

The scales also possess validity by appearance, and the factors are similar to those found by Steinhardt & Dishman (1989) and Sechrist *et al*, (1987). Naming of the

factors was made easy as there were no items which appeared incongruent with others loading highly on the same factor. The scales should be externally valid, or applicable to other samples of this age group. The sample was chosen at random from the population of 55-74 year olds in the region, and should thus be representative in terms of demographic details and activity status. The item pool was large to cover a wide range of perceived benefits and barriers cited in the literature, and only 4 benefit and 3 barrier items were discarded for not meeting the criteria for inclusion on any factor.

As stated previously, factor scores were calculated by summing the products of the Likert score and the loading on that factor for every item (SPSS Inc, 1990, p336-337). This method gives precise factor scores, but is inconvenient for practical use. Both Steinhardt & Dishman (1989) and Sechrist *et al*, (1987) calculated factor scores by simply summing the Likert scores for the items which meet the loading criteria for a particular factor. This method is acceptable for practical use, and can be used with the scales developed here (Appendix C). These scales should be employed once inactive individuals have been identified using established activity assessment methods. The scales can then be used to highlight important benefits and barriers, and should assist in the prescription of exercise for the individual. Although total benefits and barriers scores are related to activity level (Tables 4.7 to 4.9), it is likely that attention to specific factor scores will be more meaningful.

CHAPTER SIX

SUMMARY AND RECOMMENDATIONS

6.1 Summary

This research has attempted to develop questionnaires in two very different but equally important areas, both of which are central to increasing participation in physical activity in the population. The age range of the chosen sample was 55-74 years for the reasons that this is one of the least active groups in the population, this age group has a significant effect on health care provision, much of which could be redirected, and there is an obvious lack of research with older adults regarding physical activity assessment and determinants of exercise behaviour. Although the response rate of 37% to the questionnaire was slightly lower than expected, it does not appear that this significantly altered the findings. The sample was selected at random and respondents appeared representative of the population, so the results should be applicable to the general population of 55-74 year olds in this country.

The first null hypothesis of the study stated that meaningful benefits and barriers factors do not exist for adults aged 55-74 years. Having established in the pilot study that active and inactive individuals differed at least in their perceived barriers to physical activity, the study described in Chapter 5 demonstrated that lists of benefits and barriers could be reduced to a smaller number of meaningful factors using principal components analysis. These factors, five each on both the benefits and the barriers scales, have face validity in that there were no items loading highly on a given factor which were incongruent with other items included in the same factor. The null hypothesis can therefore be rejected.

The technique used to develop these benefits and barriers scales was similar to that used in two other studies (Sechrist *et al*, 1987; Steinhardt & Dishman, 1989). Items were taken from these studies and also from the Allied Dunbar National Fitness Survey (Sports Council & Health Education Authority, 1992) and Mutrie *et al* (1993), and covered a wide range of possible benefits and barriers. As similar items were used it was expected that the analysis would produce similar factors to those found by Sechrist *et al* (1987) and Steinhardt & Dishman (1989). Although the exact number of factors found in the present study differed, this proved to be the case.

The second null hypothesis stated that the benefits and barriers factors would not be related to activity status. Due to practical constraints, it was necessary to investigate this null hypothesis using physical activity questionnaires, which at the time of use, had been validated only with younger samples. This is not unreasonable, as the pilot study had shown that the questionnaires could place subjects over a range of activity categories (from very high to very low active). Had these questionnaires proved unsuitable for use with this age group in the later study, their use as validation criteria for the benefits and barriers scales would have had to be reviewed accordingly. However this proved unnecessary. As the results in Chapter 5 demonstrate, all of the ten benefits and barriers factors, with the exception of the benefit weight control, showed some relationship with activity status, providing evidence of the concurrent validity of the scales. This is to be expected, as several theories of exercise behaviour state that physically active people perceive greater benefits and fewer barriers to exercise. In addition, women, who were significantly less active than men, scored significantly higher than men on four of the five barriers. The null hypothesis can therefore be rejected.

The third null hypothesis stated that the three physical activity questionnaires do not accurately classify subjects according to fitness and objectively measured activity. Due to the large sample size required to test the validity of the activity questionnaires, subjects from only the most active and least active groups were compared. As any conclusions can only take into account differences between these two groups, it is not possible to say whether the questionnaires will be able to discriminate between high, moderately, and low active subjects. The validation measures were selected for their practicality for field use, to represent functionally important abilities in this age group, and to assess the types of activities likely to be considered by subjects when estimating their overall activity status. The three questionnaires will be discussed individually.

There were significant differences between subjects classified as active and inactive by the 4-point LRC questionnaire (Ainsworth *et al*, 1993a) in 1-mile walk time and Caltrac energy expenditure. Although the 4-point classification asks subjects to rate their overall physical activity in relation to their peers, the 2-point method used here is based on a yes-or-no response to regular participation in physical activity which induces perspiration, breathlessness, or increased heart rate. As 1-mile walk time and energy expenditure are indicative of participation in this level of physical activity, the null hypothesis can be rejected for the simplified 2-point classification, but further work is required

before it is possible to state that the 4-point classification is valid for this age group.

The 9-point activity classification is based on the frequency of strenuous (defined as inducing perspiration, breathlessness, or increased heart rate) and less strenuous activity, although any differences described are only between the most active (groups 1-4) and least active (groups 7-9) subjects. Again, subjects differed in 1-mile walk time and energy expenditure, and also physical activity as assessed by a more detailed questionnaire. There was also a nonsignificant trend in isometric leg strength. Based on these findings, it is not possible to reject the null hypothesis, but instead to state that the questionnaire can successfully discriminate between the most and least active subjects, and that further work is required to demonstrate the validity of the 9-point classification.

The 5-point Stages of Change classification did not differentiate between exercisers and non-exercisers in terms of either 1-mile walk time or energy expenditure. Exercisers did have a significantly lower mean BMI and higher mean score on the detailed activity questionnaire. In this questionnaire, as in the other two, 'regular' activity was not defined, and subjects were asked to consider 'exercise' rather than physical activity participation. Although the Stages of Change model has been used with older adults, the validity of these items against measures of fitness or energy expenditure has not been demonstrated. As participation in exercise would be expected to produce differences in these validation criteria, it is not possible to reject the null hypothesis for the Stages of Change classification.

The fourth null hypothesis stated that neither the benefits and barriers scales, nor the physical activity questionnaires would be reliable. Pearson test-retest correlations for the ten benefits and barriers factors ranged from 0.56 to 0.87 with a mean of 0.73, which compare favourably with the reliability of the scales developed by Sechrist *et al* (1987) and Steinhardt & Dishman (1989). The null hypothesis can be rejected for the benefits and barriers questionnaires. Spearman test-retest correlation coefficients were 0.73, 0.62, and 0.63 for the 4-, 9-, and 5-point activity classifications respectively. The correlations were lower than those found in other studies (4-point r=0.88, Ainsworth *et al*, 1993a; 5-point r=0.78, Marcus *et al*, 1992b) but this may be due to the period of eight weeks between tests which may have allowed a true change in behaviour. However the correlations were still highly significant, and the null hypothesis can therefore be rejected for all three activity questionnaires.

6.2 Recommendations

The benefits and barriers scales developed in this study show evidence of validity and reliability. The scales can be used by researchers wishing to evaluate the effects of perceived benefits and barriers on exercise behaviour, or for assessing the results of interventions aimed at modifying perceptions of exercise. Longitudinal studies which follow exercise behaviour over a longer period of time could make use of the scales to investigate changes in perceived benefits and barriers with adherence to an exercise programme, and with any subsequent alterations in activity patterns during a follow-up period.

The scales are also ready for use in a practical setting, whereby inactive people in this age group can be guided into appropriate types of activity and exercise. An exercise counselling session with a health or exercise professional should involve an individual profile of perceived benefits and barriers, taking into account the gender differences observed in this study. Following analysis of an individual's questionnaire responses, activities should be recommended in which a person's perceived barriers are minimised and which are likely to maximise their perceptions of benefit.

A revised questionnaire with guidance for use is provided in Appendix C. Items not meeting the loading criteria are removed and the scoring system is simplified. The Likert scale has been reversed (very strongly disagree=1 and very strongly agree=7) and factor scores are obtained by simply adding together the Likert scores of the items on that factor. A high factor score now indicates agreement that the factor is benefit or barrier. This revised questionnaire is suitable for research and practical use.

Use of the physical activity questionnaires is less clear cut. Due to their short length, method of administration, and ease of completion, these questionnaires could be of enormous use in being able to quickly identify inactive people in the population. While there certainly seems to be some preliminary evidence for the 4- and 9-point questionnaires' ability to distinguish between the most and least active subjects, further work is required before they can be used to successfully identify moderately active people. As the latest evidence suggests that most health benefits are obtained by moving from being sedentary to moderately active, these questionnaires must be able to identify the least active individuals

in the population separate from all others to be of use in a public health context. This would require a study similar to the one reported here but with a much larger sample to enable comparison on the validation criteria of fitness and energy expenditure between all the activity classifications and not just those at the extremes. If the purpose of the questionnaires is to detect those people at risk from inactivity-related disease, they should ideally be tested in a longitudinal epidemiological setting alongside an established physical activity questionnaire, where incidence of disease is the validation criterion.

The 5-point Stages of Change questionnaire did not accurately classify subjects according to their exercise behaviour using the validation criteria employed here. It is possible that some of the terms in the questionnaire such as 'regular' and 'exercise' must be explicitly defined for it to be of any use with this age group. However as it focuses specifically on exercise behaviour and not overall activity, it is likely to be of less use than the other two questionnaires when attempting to identify the least active individuals in the population, a purpose for which the model was not developed.

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APPENDIX A Pilot study questionnaire

UNIVERSITY OF ST ANDREWS

EXERCISE BEHAVIOUR SURVEY

St. Andrews University is carrying out a survey of exercise behviour in the population and peoples' attitudes and beliefs about exercise. This Questionnaire is part of a more extensive project, and all comments which you have about the Questionnaire will be very helpful.

Please try to be as honest and accurate as possible with your responses, and make sure that you answer all the questions.

Once completed, please return the Questionnaire as soon as possible in the reply envelope provided.

ALL INFORMATION YOU GIVE IS CONFIDENTIAL

THANK YOU FOR TAKING PART IN THIS STUDY

Section 1. Leisure Activity

This section asks you about activity and exercise which you do during your leisure time.

1. During your leisure time (*ie* outside work), how active are you compared with others of your own age and sex ?

(*tick one*)

- much more active
- somewhat more active
- about the same
- somewhat less active
- much less active

2. Do you regularly engage in exercise which makes you sweaty and/or out of breath and/or your heart beat faster ?

(*tick one*)

- yes
- no

3. How often do you take part in physical activity during your leisure time which makes you sweaty and/or out of breath and/or your heart beat faster ?

(*tick one*)

- rarely or never
- sometimes
- often

4. How often do you take part in physical activity during your leisure time which is less strenuous than that described in qestion 3 ?

(*tick one*)

- rarely or never
- sometimes
- often

For question 5, tick either true or false for each of the four statements, (a) - (d).

5.	(a) I currently do not exercise.	true	false
	(b) I intend to exercise in the next 6 months	true	false
	(c) I currently exercise regularly	true	false
	(d) I have exercised regularly for the past 6 months	true	false

6. Do you feel that you have a medical condition which prevents you from taking even light exercise such as walking ?

(*tick one*)

yes

no

7. In the past 6 months, has your doctor ever advised you not to do any exercise ?

(*tick one*)

yes

no

8. How much activity does your work generally involve, if applicable ?

mainly sitting down

mainly standing up

mainly walking around

mainly walking and carrying objects

more vigorous activity

do not work

NOW GO TO SECTION 2

SECTION 2. Benefits of Physical Activity

This section is concerned with what you believe to be the major benefits of taking part in physical activity.

For each statement, please circle one of the numbers 1-7 which corresponds most closely with what you think.
Please make sure that you circle a number for every statement.

Very Strongly Agree						Very Strongly disagree
1	2	3	4	5	6	7

I think a major benefit of taking part in physical activity is :

	very strongly agree						very strongly disagree
1. To lose weight	1	2	3	4	5	6	7
2. To increase strength	1	2	3	4	5	6	7
3. Personal challenge	1	2	3	4	5	6	7
4. Increase self-image and confidence	1	2	3	4	5	6	7
5. Fun and enjoyment	1	2	3	4	5	6	7
6. Improved stamina	1	2	3	4	5	6	7
7. Decrease stress and tension	1	2	3	4	5	6	7
8. Chance to get out of the house	1	2	3	4	5	6	7
9. Easier to carry out everyday tasks	1	2	3	4	5	6	7
10. Sense of accomplishment	1	2	3	4	5	6	7
11. Improved muscle tone	1	2	3	4	5	6	7
12. Contact with friends	1	2	3	4	5	6	7
13. Feelings of well-being	1	2	3	4	5	6	7
14. Improved co-ordination/balance	1	2	3	4	5	6	7

	very strongly agree						very strongly disagree
15. Relaxation	1	2	3	4	5	6	7
16. Sense of belonging to a team	1	2	3	4	5	6	7
17. Meet new people	1	2	3	4	5	6	7
18. Improved appearance	1	2	3	4	5	6	7
19. Increased muscle endurance	1	2	3	4	5	6	7
20. Cope better with life's pressures	1	2	3	4	5	6	7
21. Enjoy exercise in itself	1	2	3	4	5	6	7
22. Maintain proper body weight	1	2	3	4	5	6	7
23. Improved flexibility	1	2	3	4	5	6	7
24. Competition with others	1	2	3	4	5	6	7
25. Improved mental health	1	2	3	4	5	6	7

Do you think that there are any other benefits of taking part in exercise?
If yes, could you please write them in the space below.

.....	1	2	3	4	5	6	7
.....	1	2	3	4	5	6	7
.....	1	2	3	4	5	6	7

Please check that you have answered all 25 statements in this section.

NOW GO TO SECTION 3

SECTION 3. Reasons for not Exercising

This section is concerned with the major reasons which may prevent you from taking physical activity.

Considering each statement carefully, please circle one of the numbers 1-7, depending on the extent to which each applies to you when you do not take part in physical activity.
Please make sure that you circle a number for every statement.

Very Strongly Agree						Very Strongly disagree
1	2	3	4	5	6	7

A major reason I do not exercise is :

	very strongly agree					very strongly disagree
1. I am too busy	1	2	3	4	5	6	7
2. Exercise is too hard work	1	2	3	4	5	6	7
3. Injury	1	2	3	4	5	6	7
4. Exercise interferes with work/study	1	2	3	4	5	6	7
5. Lack of facilities	1	2	3	4	5	6	7
6. Proper clothing costs too much	1	2	3	4	5	6	7
7. I am not the sporty type	1	2	3	4	5	6	7
8. Lack of motivation	1	2	3	4	5	6	7
9. Exercise makes me feel sick	1	2	3	4	5	6	7
10. Because I am overweight	1	2	3	4	5	6	7
11. Equipment costs too much	1	2	3	4	5	6	7
12. I get too fatigued by exercise	1	2	3	4	5	6	7
13. I don't like sweating	1	2	3	4	5	6	7
14. Exercise takes up too much time	1	2	3	4	5	6	7
15. I have no-one to exercise with	1	2	3	4	5	6	7

	very strongly agree						very strongly disagree
16. Unsuitable weather	1	2	3	4	5	6	7
17. Cost of using facilities is too much	1	2	3	4	5	6	7
18. Lack of classes/courses available	1	2	3	4	5	6	7
19. I don't enjoy physical activity	1	2	3	4	5	6	7
20. Illness	1	2	3	4	5	6	7
21. Lack of support from family	1	2	3	4	5	6	7
22. Facilities are too far away	1	2	3	4	5	6	7
23. My muscles feel sore and stiff after exercise	1	2	3	4	5	6	7
24. Classes are at inconvenient times for me	1	2	3	4	5	6	7
25. I don't like getting out of breath	1	2	3	4	5	6	7
26. Footwear costs too much	1	2	3	4	5	6	7
27. Family obligations	1	2	3	4	5	6	7
28. Physical disability	1	2	3	4	5	6	7
29. I am too tired after work/study	1	2	3	4	5	6	7
30. Exercise makes me feel uncomfortable	1	2	3	4	5	6	7
31. Lack of support from friends	1	2	3	4	5	6	7
32. Cost of travel to facilities is too much	1	2	3	4	5	6	7
33. I am too shy/embarrassed to exercise	1	2	3	4	5	6	7

Do you have any other reasons which sometimes prevent you from exercising? If you do, please write them in the space below.

.....	1	2	3	4	5	6	7
.....	1	2	3	4	5	6	7
.....	1	2	3	4	5	6	7

Please make sure that you have answered all 33 statements in this section.

NOW GO TO SECTION 4

Section 4. Personal details

1. Which of these things were you doing last week ?
   (if on holiday please tick the category that normally applies)

   (*tick one box only*)

   Working for an employer full-time
   (more than 30 hours per week)

   Working for an employer part-time
   (less than 30 hours per week)

   Self-employed, employing other people

   Self-employed, not employing other people

   On a Government employment or training scheme

   Waiting to start a job you have already accepted

   Unemployed and looking for a job

   In full time education

   Unable to work because of long term sickness or disability

   Retired from paid work

   Looking after the home or family

   Other (please specify)

   .....

2. What is your current or most recent occupation or job title (if applicable) ?

   .....

3. What is the current or most recent occupation or job title of your spouse or partner (if applicable) ?

   .....

4. Please indicate the approximate total income per year of the household.

   Less than £5,000

   £5,000 - £9,999

   £10,000 - £14,999

   £15,000 - £19,999

   £20,000 - £24,999

   Over £25,000

5. Please indicate the stage at which you finished your full-time education.

No qualifications
Secondary School Certificates
Further education (HNC, City & Guilds *etc* or equivalent)
Higher education (Degree *eg* BSc, MA, PhD *etc*)
Still in full-time education
Don't know/Can't remember

6. Do you

Own your home
Rent from the Council
Rent privately
Other (please state)..... ?

NOW GO TO SECTION 5

IMPORTANT ! **Please fill this section in.**

Section 5. Comments

We would like to ask you for a few comments about the questionnaire which you have just completed.

1. About how long did it take you to complete?.....

2. Were there any words/ phrases/ questions/ instructions which were not clear or you did not fully understand?
(Either write these directly on the questionnaire at the appropriate place, or in the space provided below)

.....

.....

.....

.....

.....

3. How clear and easy to follow was the questionnaire?

	Very clear				Very unclear
(please circle)	1	2	3	4	5

Is there any part which wasn't clear and you would change?

.....

.....

If there are any other comments you would like to make please write them below and continue overleaf if necessary.

Thank you for your co-operation in completing this questionnaire
All information you provide is confidential
Please return the questionnaire in the return envelope as soon as possible

University of St Andrews

Department of Physical Education

SURVEY OF PHYSICAL ACTIVITY

St. Andrews University is carrying out a survey of people in Fife's physical activity, and their attitudes and beliefs about exercise.

When filling in this Questionnaire, please try to be as honest and accurate as possible with your responses, and make sure that you answer all the questions.

Once completed, please return the Questionnaire as soon as possible in the reply envelope provided.

If you have any queries, please telephone Mr. Alan Montgomery on St Andrews 4 62180.

ALL INFORMATION YOU GIVE IS CONFIDENTIAL

THANK YOU FOR TAKING PART IN THIS STUDY

Code

Section 1. **Leisure Activity**

This section asks you about physical activity which you do during your leisure time. i.e outside paid work.

1. During your leisure time, how active are you compared with others of your own age and sex ?

   (tick one)

   - much more active
   - somewhat more active
   - about the same
   - somewhat less active
   - much less active

2. Do you regularly engage in physical activity which makes you perspire and/or out of breath and/or your heart beat faster ?

   (tick one)

   - yes
   - no

3. How often do you take part in physical activity during your leisure time which makes you perspire and/or out of breath and/or your heart beat faster ?

   (tick one)

   - rarely or never
   - sometimes
   - often

4. How often do you take part in physical activity during your leisure time which is **less** strenuous than that described in question 3 ?

   (tick one)

   - rarely or never
   - sometimes
   - often

5. Please tick **one** of the following statements which you feel applies most to you.
Tick only one box

I currently do not exercise and I do not intend to start exercising in the next 6 months.

I currently do not exercise, but I am thinking about starting to exercise in the next 6 months.

I currently exercise a little, but not regularly.

I currently exercise regularly but I have only began doing so within the last 6 months.

I currently exercise regularly and have done so for longer than 6 months.

6. Do you feel that you have a medical condition which prevents you from taking even light exercise such as walking ?

(tick one) yes

no

7. In the past 6 months, has your doctor ever advised you not to do any exercise ?

(tick one) yes

no

8. If you have a paid job, how much activity does your work generally involve ?

(tick one) mainly sitting down

mainly standing up

mainly walking around

mainly walking and carrying objects

mainly more vigorous activity

do not have a paid job

NOW GO TO *Section 2*

Section 2. **Benefits of Physical Activity**

This section is concerned with what **you** believe to be the MAJOR benefits for yourself of taking part in physical activity. Please tell us what **you** feel are benefits of exercise for **YOU** rather than for everyone in general.

For each statement, please tick one of the boxes which corresponds most closely with what **you** think.

PLEASE MAKE SURE THAT YOU TICK A BOX FOR **EVERY** STATEMENT.

For example:

Everyone should use their vote in a General Election	Very strongly agree	Agree	Disagree	Very strongly disagree

For me, a major benefit of taking part in physical activity is :	Very strongly agree	Agree	Disagree	Very strongly disagree
1. To lose weight				
2. To increase strength				
3. Personal challenge				
4. Increase self-image and confidence				
5. Fun and enjoyment				
6. Improved stamina				
7. Decrease stress and tension				
8. Chance to get out of the house				

*Remember we want to know what you think the major benefits of physical activity are for **you.***

9. Easier to carry out everyday tasks				
10. Sense of accomplishment				
11. Improved muscle tone				
12. Contact with friends				
13. Feelings of well-being				
14. Improved co-ordination/balance				

Remember we want to know what you think the major benefits of physical activity are for you.	Very strongly agree	Agree	Disagree	Very strongly disagree
15. Relaxation				
16. Sense of belonging to a team				
17. Meet new people				
18. Improved appearance				
19. Increased muscle endurance				
20. Cope better with life's pressures				
21. Enjoy exercise in itself				
22. To control body weight				
23. Improved flexibility				
24. Competition with others				
25. Imroved mental health				

Do you think that there are any other benefits of taking part in exercise?
If yes, please write them in the space below and show how you feel about them.

.....

.....

.....

Please check that you have answered all 25 statements in this section.

NOW GO TO *Section 3*

Section 2. Reasons for not Exercising

Whether we do little or no exercise, or are regularly active, there are times for all of us when we don't exercise. This section is concerned with the MAJOR reasons which may prevent **YOU** from taking physical activity.

Considering each statement carefully, please tick **one** of the boxes, depending on the extent to which each applies to you **when you do not take part in physical activity**.

PLEASE MAKE SURE THAT YOU TICK ONE BOX FOR **EVERY** STATEMENT.

For example:

Everyone should use their vote in a General Election	Very strongly agree	Agree	Disagree	Very strongly disagree

When I do not exercise a major reason is :	Very strongly agree	Agree	Disagree	Very strongly disagree

1. I am too busy
2. Exercise is too hard work
3. Injury
4. Exercise interferes with work/study
5. Lack of facilities
6. Proper clothing costs too much
7. I am not the sporty type
8. Lack of motivation
9. Exercise makes me feel sick
10. Because I am overweight
11. Equipment costs too much
12. I get too fatigued by exercise
13. I don't like sweating
14. Exercise takes up too much time
15. I have no-one to exercise with
16. Unsuitable weather

Remember we want to know about major reasons why you don't exercise.	Very strongly agree	Agree	Disagree	Very strongly disagree
17. Cost of using facilities is too much				
18. Lack of classes/courses available				
19. I don't enjoy physical activity				
20. Illness				
21. Lack of support from family				
22. Facilities are too far away				
23. My muscles feel sore and stiff after exercise				
24. Classes are at inconvenient times for me				
25. I don't like getting out of breath				
Remember we want to know about major reasons why you don't exercise				
26. Footwear costs too much				
27. Family obligations				
28. Physical disability				
29. I am too tired after work/study				
30. Exercise makes me feel uncomfortable				
31. Lack of support from friends				
32. Cost of travel to facilities is too much				
33. I am too shy/embarrassed to exercise				

Do you have any other reasons which sometimes prevent you from exercising?
If you do, please write them in the space below and show how you feel about them.

.....

.....

.....

Please check that you have answered all 33 statements in this section.

NOW GO TO *Section 4*

Section 4. **Personal details**

1. Which of these things were you doing last week ?
(if on holiday please tick the category that normally applies)

(tick one box only)

Working for an employer full-time
(more than 30 hours per week)

Working for an employer part-time
(less than 30 hours per week)

Self-employed, employing other people

Self-employed, not employing other people

On a Government employment or training scheme

Waiting to start a job you have already accepted

Unemployed and looking for a job

In full time education

Unable to work because of long term sickness or disability

Retired from paid work

Looking after the home or family

Other (please specify).....

2. What is your current or most recent occupation or job title (if applicable) ?

.....

3. What is the current or most recent occupation or job title of your spouse or partner (if applicable) ?

.....

4. Please indicate the approximate total income per year of the household.

Less than £5,000

£5,000 - £9,999

£10,000 - £14,999

£15,000 - £19,999

£20,000 - £24,999

Over £25,000

5. Please indicate the stage at which you finished your full-time education.

No qualifications

Secondary School Certificates

Further education (HNC, City & Guilds etc or equivalent)

Higher education (Degree eg BSc, MA, PhD etc)

Still in full-time education

Don't know/Can't remember

6. Do you

Own your home

Rent from the Council

Rent privately

Other (please state).....

Thank you for your co-operation in completing this questionnaire

All information you provide is confidential

Please return the questionnaire in the return envelope as soon as possible to:

Department of Physical Education, The Sports Centre,
St Leonard's Road, St Andrews KY16 9DY.

EXERCISE:

PERCEIVED BENEFITS AND BARRIERS

Alan Montgomery & Martin Farrally
Department of Physical Education
University of St. Andrews

The purpose of this questionnaire is to find out about some of your attitudes towards physical activity and exercise.

Try to be honest and accurate with your responses, and remember that there are no right or wrong answers. You should answer each question in a way which applies to **you**, not how you think the population in general feel.

Please make sure that you answer **every** question.

Section 1. Benefits of Physical Activity

This section is concerned with what **you** believe to be the MAJOR benefits for yourself of taking part in physical activity. Please tell us what **you** feel are benefits of exercise for **YOU** rather than for everyone in general.

For each statement, please tick **one** of the boxes which corresponds most closely with what **you** think.

PLEASE MAKE SURE THAT YOU TICK A BOX FOR **EVERY** STATEMENT.

For me, a major benefit of taking part in physical activity is:	Very strongly disagree	Disagree	Agree	Very strongly agree
1. To lose weight				
2. To increase strength				
3. Increase self-image and confidence				
4. Fun and enjoyment				
5. Improved stamina				
6. Decrease stress and tension				
7. Chance to get out of the house				

*Remember we want to know what you think the major benefits of physical activity are for **you.***

8. Improved muscle tone				
9. Contact with friends				
10. Feelings of well-being				
11. Improved co-ordination/balance				
12. Relaxation				
13. Sense of belonging to a team				
14. Meet new people				

Remember we want to know what you think the major benefits of physical activity are for you.	Very strongly disagree	Disagree	Agree	Very strongly agree
15. Increased muscle endurance				
16. Cope better with life's pressures				
17. Enjoy exercise in itself				
18. To control body weight				
19. Improved flexibility				
20. Competition with others				
21. Improved mental health				

Please make sure that you have answered all 21 statements in this section.

NOW GO TO *SECTION* 2.

Section 2. Reasons for not exercising

Whether we do little or no exercise, or are regularly active, there are times for all of us when we don't exercise. This section is concerned with the MAJOR reasons which may prevent **YOU** from taking physical activity.

Considering each statement carefully, please tick **one** of the boxes, depending on the extent to which each applies to you **when you do not take part in physical activity**.

PLEASE MAKE SURE THAT YOU TICK A BOX FOR **EVERY** STATEMENT.

When I do not exercise a major reason is:	Very strongly disagree	Disagree	Agree	Very strongly agree
1. I am too busy				
2. Exercise is too hard work				
3. Injury				
4. Exercise interferes with work				
5. Lack of facilities				
6. Proper clothing costs too much				
7. I am not the sporty type				

Remember we want to know about major reasons why you don't exercise.

8. Lack of motivation				
9. Exercise makes me feel sick				
10. Because I am overweight				
11. Equipment costs too much				
12. I get too fatigued by exercise				
13. I don't like sweating				
14. Exercise takes up too much time				
15. Cost of using facilities is too much				
16. Lack of classes/courses available				

Remember we want to know about major reasons why you don't exercise.	Very strongly disagree	Disagree	Agree	Very strongly agree
17. I don't enjoy physical activity				
18. Illness				
19. Lack of support from family				
20. Facilities are too far away				
21. I feel sore and stiff after exercise				
22. Classes are at inconvenient times				
23. I don't like getting out of breath				

Remember we want to know about major reasons why you don't exercise.

24. Footwear costs too much
25. Family obligations
26. I am too tired after work
27. Exercise makes me feel uncomfortable
28. Lack of support from friends
29. Cost of travel to facilities is too much
30. I am too shy/embarrassed to exercise

Please make sure that you have answered all 30 statements in this section.

NOTES OF GUIDANCE FOR ADMINISTERING THE QUESTIONNAIRE

1. Subjects should tick one box for **each** of the 51 items.

2. The scoring system has been reversed from that used in the study. 'Very strongly agree' is now scored as 7, and 'Very strongly disagree' as 1. A high score on a particular factor now indicates strong agreement with that factor as a benefit or barrier.

3. Scoring the questionnaire

   Factor scores are calculated by simply adding together the Likert scores for the items which load on that factor. These are:

   Benefits
   (a) Physical Performance: Items 2, 3, 5, 8, 11, 15, 19.
   (b) Social: Items 9, 13, 14, 20.
   (c) Weight Control: Items 1, 18.
   (d) Enjoyment: Items 4, 10, 12, 17.
   (e) Psychological: Items 6, 7, 16, 21.

   Barriers
   (a) Opportunities: Items 5, 6, 11, 15, 16, 20, 22, 24, 29.
   (b) Physical Exertion: Items 2, 7, 8, 9, 10, 12, 13, 17, 21, 23, 27, 30.
   (c) Time: Items 1, 4, 14, 26.
   (d) Limiting Health: Items 3, 18.
   (e) Support: Items 19, 25, 28.

4. Interpreting the scores

   (a) The following ranges of scores give an idea of low, moderate and high scores for the various factors.

Factor	Low	Moderate	High
Physical Performance	7-28	29-37	38-49
Social	4-16	17-22	23-28
Weight Control	2-6	7-11	12-14
Enjoyment	4-15	16-21	22-28
Psychological	4-15	16-22	23-28
Total benefits	21-82	83-113	114-147
Opportunities	9-23	24-36	37-63
Physical exertion	12-29	30-48	49-84
Time	4-9	10-18	19-28
Limiting Health	2-4	5-9	10-14
Support	3-7	8-14	15-21
Total barriers	30-74	75-120	121-210

(b) It is likely that individuals with a high total barriers and/or low total benefits score will be doing insufficient physical activity to benefit health. This can be confirmed with a questionnaire assessment of physical activity.

When prescribing exercise to this, or any other group, close attention should be paid to the scores on the individual factors. Practitioners should recommend activities which will enhance those benefits which the individual endorses, and which will not conflict with those barriers which the individual feels limit their participation in physical activity.

Remember that the purpose of this questionnaire is not to find out if a person is sufficiently active to obtain health benefits. That should be done by other means. This questionnaire is designed to highlight appropriate areas for intervention once inactive individuals have been identified.

APPENDIX D Voorrips *et al* (1991) questionnaire and score sheet

HOUSEHOLD ACTIVITIES

1. Do you do the light household work? (dusting, washing-up, repair clothes, etc)
   0. Never (<once a month)
   1. Sometimes (only when partner or help is not available)
   2. Mostly (sometimes assissted by partner or help)
   3. Always (alone or together with partner)

2. Do you do the heavy housework? (washing floors and windows, carrying rubbish bags, etc)
   0. Never (<once a month)
   1. Sometimes (only when partner or help is not available)
   2. Mostly (sometimes assissted by partner or help)
   3. Always (alone or together with partner)

3. For how many persons do you keep house?
(including yourself; fill in '0' if answered 'never' in Q1 and Q2)

4. How many rooms do you keep clean, including kitchen, bedroom, garage, cellar, bathroom, ceiling, etc? (fill in '0' if answered 'never' in Q1 and Q2)
   0. Never do housekeeping
   1. 1-6 rooms
   2. 7-9 rooms
   3. 10 or more rooms

5. If any rooms, on how many floors? (fill in '0' if answered 'never' in Q4)

6. Do you prepare warm meals yourself, or assist in preparing?
   0. Never
   1. Sometimes (once or twice a week)
   2. Mostly (3-5 times a week)
   3. Always (more than 5 times a week)

7. How many flights of stairs do you walk up per day? (one flight is 10 steps)
   0. I never walk up stairs
   1. 1-5
   2. 6-10
   3. More than 10

8. If you go out somewhere in your hometown, what kind of transportation do you use?
   0. I never go out
   1. Car
   2. Public transport
   3. Bicycle
   4. Walking

9. How often do you go out for shopping?
   0. Never or less than once a week
   1. Once a week
   2. Two to four times a week
   3. Every day

10. If you go out shopping, what kind of transportation do you use?
    0. I never go out
    1. Car
    2. Public transport
    3. Bicycle
    4. Walking

Household score = (Q1 + Q2 + ...+ Q10)/10

SPORT ACTIVITIES

Do you play a sport?
Sport 1: name.....
intensity (code)..... (1a)
hours per week (code)..... (1b)
period of year (code)..... (1c)
Sport 2: name.....
intensity (code)..... (2a)
hours per week (code)..... (2b)
period of year (code)..... (2c)

Sport score = $\sum$ (a*b*c)

LEISURE TIME ACTIVITIES

Do you do any other physical activities?
Activity 1: name.....
intensity (code)..... (1a)
hours per week (code)..... (1b)
period of year (code)..... (1c)
Activity 2-6: as activity 1.

Leisure time activity score = $\sum$ (a*b*c)

QUESTIONNAIRE SCORE = Household score + Sport score + Leisure time activity score

Codes:

Intensity code:

0.	lying, unloaded	0.028
1.	sitting, unloaded	0.146
2.	sitting, movements hand or arm	0.297
3.	sitting, body movements	0.703
4.	standing, unloaded	0.174
5.	standing, movements hand or arm	0.307
6.	standing, body movements, walking	0.890
7.	walking, movements hand or arm	1.368
8.	walking, body movements, cycling swimming.	1.890

Hours per week:

1. less than 1h.wk^{-1}	0.5
2. 1-2 h.wk^{-1}	1.5
3. 2-3 h.wk^{-1}	2.5
4. 3-4 h.wk^{-1}	3.5
5. 4-5 h.wk^{-1}	4.5
6. 5-6 h.wk^{-1}	5.5
7. 6-7 h.wk^{-1}	6.5
8. 7-8 h.wk^{-1}	7.5
9. more than 8h.wk^{-1}	8.5

Months per year:

1. less than 1 month.yr^{-1}	0.04
2. 1-3 months	0.17
3. 4-6 months	0.42
4. 7-9 months	0.67
5. more than 9 months.yr^{-1}	0.92

UNIVERSITY OF ST. ANDREWS
DEPARTMENT OF PHYSICAL EDUCATION

Exercise Benefits and Barriers and their relation to activity status in adults aged 55 - 74 years.

PHYSICAL ACTIVITY QUESTIONNAIRE

Name..... Subject No .....

SECTION 1: HOUSEHOLD ACTIVITIES

1.	6.	Total Score =
2.	7.	
3.	8.	**HOUSEHOLD SCORE =**
4.	9.	
5.	10.	

SECTION 2: SPORT ACTIVITIES

Sport 1:Name	Sport 2:Name
Intensity code	Intensity code
Hours per week code	Hours per week code
Months per year code	Months per year code
	SPORT SCORE =

SECTION 3: LEISURE ACTIVITIES

Activity 1:Name	Activity 2:Name
Intensity code	Intensity code
Hours per week code	Hours per week code
Months per year code	Months per year code
Activity 3:Name	Activity 4:Name
Intensity code	Intensity code
Hours per week code	Hours per week code
Months per year code	Months per year code

Activity 5:Name

Intensity code

Hours per week code

Months per year code

Activity 6:Name

Intensity code

Hours per week code

Months per year code

ACTIVITY SCORE =

TOTAL SCORE = _____

APPENDIX E Methods of determining activity category

Shown in tables (a) and (b) are the methods for placing subjects in activity categories according to their responses to items 1-4 in the first section of the questionnaire. Also shown is 5-point Stage of Exercise classification (Marcus & Simkin, 1993; Marcus *et al*, 1992b).

(a) 4-Point LRC activity classifications (Ainsworth *et al*, 1993a).

		Response to Q1.		
		Much more active	**Somewhat more active/the same**	**Somewhat less/ much less active**
Regular vigorous activity? (Q2.)	**Y**	1. high active	2. moderately active	
	N	3. low active		4. very low active

(b) 9-Point Activity classification.

Frequency of vigorous activity	**Frequency of non-vigorous activity**	**Activity Category**
Often	Often Sometimes Rarely or Never	1. Most active 2. 3.
Sometimes	Often Sometimes Rarely or Never	4. 5. 6.
Rarely or Never	Often Sometimes Rarely or Never	7. 8. 9. Least active

(c) Stage of exercise classification (Marcus & Simkin, 1993).

1. I currently do not exercise.	true	false
2. I intend to exercise in the next 6 months.	true	false
3. I currently exercise regularly.	true	false
4. I have exercised regularly for the past 6 months.	true	false

1. **Precontemplation**	Item 1=true and Item 2=false
2. **Contemplation**	Item 1=true and Item 2=true
3. **Preparation**	Item 1=false and Item 3=false
4. **Action**	Item 3=true and Item 4=false
5. **Maintenance**	Item 3=true and Item 4=true

(d) Stage of exercise classification (Marcus *et al*, 1992b).

1. **Precontemplation**	I currently do not exercise and I do not intend to start exercising in the next 6 months.
2. **Contemplation**	I currently do not exercise but I am thinking about starting to exercise in the next 6 months.
3. **Preparation**	I currently exercise a little but not regularly.
4. **Action**	I currently exercise regularly but I have only begun doing so within the last 6 months.
5. **Maintenance**	I currently exercise regularly and have done so for longer than 6 months.

APPENDIX F Pilot study covering letter

16 August 1993

Dear

We are writing to ask if you would be willing to help with a research project looking at exercise in the population. The aim is to find out about people's attitudes and beliefs concerning exercise, and the amount of exercise which people take.

The study will be carried out by Alan Montgomery of the Department of Physical Education, University of St Andrews.

For the initial stage, we would very much appreciate it if you could fill in the enclosed questionnaire, and also give some comments at the end. Once you have completed the questionnaire, please return it in the prepaid envelope as soon as you can. All information given will remain confidential and be used for statistical purposes only.

We hope that you will be able to help us.

Thank you in anticipation.

Yours sincerely

Dr Daniel Rutherford Mr Alan Montgomery

APPENDIX G Main study covering letter

7 July 1994

Dear

We are writing to ask if you would be willing to help with a research project looking at physical activity in the population. The aim of the project is to find out about people's attitudes and beliefs concerning exercise, and the amount of activity which people take. This will help with the planning and provision of exercise for people in Fife in the future.

The people who receive a questionnaire were selected at random from patients registered with a Fife doctor. The study itself will be carried out by the University of St. Andrews. We would very much appreciate it if you could fill in the enclosed questionnaire. Please return it in the prepaid envelope as soon as you can. All information which you give will remain confidential.

We hope that you will be able to help us.

Thank you in anticipation.

Yours sincerely,

Alan A. Montgomery
Project Researcher

Martin R. Farrally
Senior Lecturer

APPENDIX H Validation study covering letter

1st September 1994

Dear

Over the past couple of months, you and a large number of other people in Fife aged between 55 and 74 have taken part in a study by St. Andrews University. As you will know, this involved completing a questionnaire about your physical activity level, and some of your attitudes and beliefs towards exercise. I am delighted to tell you that the response to the questionnaire has been excellent, and we now wish to start the second part of the study.

From the questionnaires which were returned, a smaller sample of people have been chosen at random to be invited to take part in the second stage of the study. This second phase will involve a physical appraisal comprised of some very quick and simple measures which will then be related to your questionnaire responses.

None of the tests involve a high level of exertion. The measurements will be carried out in the subject's own home, except for a walk which will be undertaken in a local school or sports hall a few days later. Travelling costs will be reimbursed.

Please understand that this is merely an invitation to take part. This type of study has not previously been done, and the results may have important bearing for the 55-74 age group in Fife. Your co-operation in responding would be greatly appreciated, but you are not under any obligation to reply.

If you agree to take part, you will be contacted nearer the time that testing will take place. If you read this letter having returned from holiday and would still like to take part, please return the enclosed slip, as testing will take place over several weeks. You remain entirely free to change your mind at any time, and are under no obligation to complete all of the tests. All written records of your involvement are strictly confidential and will be destroyed on completion of the study.

If you would like to take part, or want to know more details, either complete and return the enclosed slip or telephone St. Andrews 462180.

Yours sincerely,

Alan A. Montgomery
Project Researcher

APPENDIX I Reliability study covering letter

1st September 1994

Dear

Firstly, let me thank you for participating in the Physical Activity Study, and for returning the questionnaire which was sent out in June. The response to the survey was very encouraging. The purpose of this second, identical questionnaire is to obtain peoples' responses a couple of months later, and this will help us to decide how good the questionnaire is. It should give similar information as before, unless of course, you have altered the amount of activity you do a great deal since June.

A small sample of people have been sent this second questionnaire. They were chosen completely at random from those who responded to the first one. It does not have anything to do with the way you answered the questions in the first questionnaire. What we would like you to do is to answer this questionnaire as it applies to you now. Don't try and remember how you responded the first time, it is your answers now which we are interested in.

You may also have received a letter about another part of this study. This is quite separate, and you should consider the two independently.

As before, it is very important that we receive as many completed questionnaires as possible. We would therefore appreciate it if you could take the time to complete and return the questionnaire as soon as you can.

If you have any further queries, please telephone Alan Montgomery on 0334 462180.

Yours sincerely,

Alan A. Montgomery
Project Researcher

APPENDIX J Validation study return form

Please complete and return as soon as possible to:

Physical Activity Study
Department of PE
University of St. Andrews
St. Leonards Road
St. Andrews KY16 9DY

*Delete as appropriate

***I would/would not like to take further part in this study.**

Name Dr/Mr/Mrs/Miss/Ms.....

Date of Birth.....

Address.....

.....

.....

.....**Postcode**.....

Telephone .....

Are there any dates, days of the week, or times which are unsuitable?
If yes, give details

.....

.....

.....

Any other relevant details?

.....

.....

.....

The following questions relate to any medical conditions you may have.
* Please delete where appropriate.

1. Do you suffer, or have you ever suffered from:

Asthma?	yes/no *
Diabetes?	yes/no *
Bronchitis?	yes/no *
Epilepsy?	yes/no *

2. Do you suffer, or have you ever suffered from, any form of heart complaint?
yes/no *

3. Do you currently have any form of muscle or joint injury?
yes/no *

4. Have you had to consult your doctor about any other complaint within the last six months? yes/no *

If yes, please give details

.....

5. Are you presently taking any form of medication?
yes/no *

If yes, please give details

.....

6. Are there any other relevant medical details which you feel we should know about?
yes/no *

If yes, please give details

.....

FOR OFFICE USE ONLY: No. H A S

APPENDIX K Validation study informed consent form

UNIVERSITY OF ST. ANDREWS
SCHOOL OF BIOLOGICAL & MEDICAL SCIENCES

INFORMED CONSENT FORM

Exercise Benefits and Barriers and their relation to activity status in adults aged 55-74 years.

NAME.....DATE

OF BIRTH.....AGE.....

SUBJECT No. .....

In this study you will be asked to complete the following tests:
(a) Height and weight.
(b) Flexibility of shoulders and hips.
(c) Leg and handgrip strength.
(d) A one-mile walk, on level ground and indoors, at your own walking pace.

IF AT ANY TIME DURING THE TESTS YOU WISH TO WITHDRAW FROM THE STUDY, YOU MAY DO SO. YOU ARE UNDER NO OBLIGATION TO COMPLETE ALL OF THESE TESTS.

ALL WRITTEN RECORDS OF YOUR INVOLVEMENT WILL BE DESTROYED ON COMPLETION OF THE STUDY.

Please complete the following questionnaire. Your cooperation is greatly appreciated.

* Please delete where appropriate.

1. Do you suffer, or have you ever suffered from:

Asthma?	yes/no *
Diabetes?	yes/no *
Bronchitis?	yes/no *
Epilepsy?	yes/no *

2. Do you suffer, or have you ever suffered from, any form of heart complaint?
yes/no *

3. Do you currently have any form of muscle or joint injury?
yes/no *

4. Have you had to consult your doctor about any other complaint within the last six months?

yes/no *

If yes, please give details

.....

5. Are you presently taking any form of medication?

yes/no *

If yes, please give details

.....

6. Is there anything to your knowledge that may prevent you from successfully completing the series of tests that has been outlined to you?

yes/no *

I HAVE ANSWERED THE QUESTIONS TO THE BEST OF MY KNOWLEDGE AND GIVE MY CONSENT TO ACT AS A SUBJECT.

SIGNATURE OF SUBJECT.....

DATE.....

SIGNATURE OF SUPERVISOR.....

CALTRAC NOTES

Introduction

The Caltrac measures the amount of Calories which you use by detecting body movement. It can be programmed for use by anyone, and once your personal details of height, weight, age, and sex are entered, it is very simple to use. Don't be put off if you have not seen anything like this before or think that it looks very complicated. There are only a couple of buttons which you will need to use, the rest of the time you can just wear it and forget about it.

Proper Position for Wearing Your Caltrac

The Caltrac should be worn at waist level (clipped on to your belt or waistband), and most people wear it midway between the side and front of their body.

Always keep the Caltrac horizontal. Do not put the Caltrac sideways in a pocket.

When to wear your Caltrac

The Caltrac should be worn during **all** your waking hours. Put it on when you first get up in the morning, and take it off when you go to bed. The only other times it should be removed are if you shower, bathe, or go swimming (the Caltrac is not waterproof), and when you change clothes (remove the Caltrac and place on a table or bench while you change, then replace it). If the Caltrac is removed for anything longer than a couple of minutes, note the length of time and the reason why it was removed.

When to take the Readings

The amount of Calories which you have used during the day should be written on the Results Sheet last thing at night. This is very easy to do, and will be explained later in the Instructions section. It is very important that you note the time of day at which you put on the Caltrac in the morning and when you remove it at night.

Using the Caltrac

Once you have cleared the memory each morning, you won't normally have to do anything else or press any other buttons until you read the scores when you go to bed at night. Caltrac will measure most activities accurately while in normal mode. Some activities though, may be underestimated because they involve arm or leg movement without moving the whole body and its weight. There is a special feature on the Caltrac which allows these types of activities to be estimated more accurately. Please see below.

Bicycle and Weightlifting Modes

As already stated, most of the time you do not need to touch any of the buttons. Certain kinds of activities (not necessarily just cycling or weightlifting - see list below) require that you press one of two buttons.

Pressing the key will **turn-on** and **turn-off** the bicycle mode. PM appears on the screen, indicating that Caltrac is in the **Pedal Mode**.

Pressing the key will **turn-on** and **turn-off** the weightlifting mode. A *flashing* PM appears on the screen, indicating that Caltrac is in the **Weightlifting Mode**.

You will probably rarely use these two buttons. Many users think that they must turn on the function buttons when they walk up a hill. Do not do this! When you walk up a hill, the increased work is cancelled out by the decreased work of walking back down again.
Make sure you turn off either the Pedal Mode or Weightlifting Mode by pressing the button again after you've finished the activity.

Here are a list of activities and the button to use when performing them.

Activity	Button to Use
Bicycling	Pedal Mode

Weightlifting	
Short rest periods: 1.5 minutes or less	Pedal Mode
Long rest periods: 1.5 minutes or more	Weightlifting Mode
(rest period is the time between sets of repetitions)	
Rowing	Pedal Mode
Lifting Work (for example)	
Moving furniture	Weightlifting Mode
Chopping logs	Weightlifting Mode
Gardening (for example)	
Digging	Weightlifting Mode
Hoeing	Weightlifting Mode
Raking	Weightlifting Mode
Weeding	Weightlifting Mode
Mowing lawn	Normal Mode

Important Safeguards

1. Caltrac is fairly sturdy, but guard against dropping it on hard surfaces.

2. Caltrac is not waterproof. It is not meant to be used while showering, bathing, swimming, or outdoors in the rain without being covered by protective clothing. If you are involved in strenuous activity where you will perspire, do not wear Caltrac next to your skin where it can get wet. If Caltrac is exposed to water, dry it immediately with a dry, clean cloth.

3. It is sometimes possible to press either the Pedal or Weightlifting buttons accidentally by brushing the Caltrac against your arm or some object. You should check occasionally that you have not done this. If you wish, you can guard against this by switching off the Caltrac display. Do this by holding down SHIFT (green button) and pressing the DISPLAY button (key on extreme right). The Caltrac will continue to record your movement, but pressing any of the buttons now will not do anything. To get the display back on the screen, simply hold down SHIFT and press DISPLAY. You can now press the Pedal or Weightlifting buttons if required.

INSTRUCTIONS FOR USE

1. When you are ready in the morning, make sure that the display on the screen reads CALS USED. If it does not, press the DISPLAY button (key on extreme right) until CALS USED appears on the screen. Then hold down SHIFT (green button) and press CLEAR (2nd button from right).
Clip the Caltrac into position on your belt-line, and note the time of day on the Results Sheet.
The Caltrac will now measure your activity continuously throughout the day.

2. Do not remove the Caltrac unless showering or swimming etc, or changing clothes. If you do remove the Caltrac, write down the approximate length of time and the reason why it was removed.

3. Use the PEDAL / WEIGHTLIFTING Modes as required (see notes). Remember to turn off either the Pedal or Weightlifting Mode after you have finished the activity.

4. When going to bed, remove the Caltrac and note the following two scores on the results sheet:

(a) **CALS USED.** On the screen should be the words 'CALS USED' and a number. This is the total number of Calories you have used today. Write it down in the appropriate space on the Results Sheet.

Then press DISPLAY button (key on extreme right) 4 times. This changes the display on the screen to the following:

(b) **CALS USED / ACTM.** On the screen now should be the words 'CALS USED' on the left, and 'ACTM' in the top right corner, along with a number. This is the number of Calories due to physical activity which you have used today. It should be less than the CALS USED number. Write it down in the appropriate space on the Results Sheet.

Then press DISPLAY button once again. The screen should again show CALS USED and the number you have already written down.

Note the time of day on the Results Sheet. That is all you need to do for today. Tomorrow morning, simply start again by holding down SHIFT and pressing CLEAR.

5. Your Calories should be recorded for **FIVE DAYS**, two of which should be over the weekend. The three weekdays do not need to be consecutive, but should be typical days for you.

6. If you have any problems at all with the Caltrac, phone and leave a message for me on 0334 462180 and I will contact you as soon as possible.

CALTRAC RESULTS SHEET

NAME Dr/Mr/Mrs/Miss/Ms.....

Date of Birth.....**Subject No.**(Office Use Only).....

DAY 1

Day of Week and Date.....

Start Time in Morning.....Finish Time at Night .....

Calorie Scores: **CALS USED =.....**

CALS USED / ACTM=.....

Was the Caltrac removed at any time for more than two minutes?
If 'yes', please give details below:

Reason for removal (eg showering, swimming)	**Length of time of removal** (eg 20 minutes)
.....	.....
.....	.....
.....	.....

Any other comments

.....
.....
.....

APPENDIX M Demographic data

Appendix M Table 1. Work category (Percent of subjects. n=548)

Work Category	Percent
Working full-time	17.7
Working part-time	7.6
Self-employed	5.3
Unemployed	1.7
Unable to work (sick/disabled)	4.8
Retired	50.8
Looking after home/family	12.1

Appendix M Table 2. Household income (Percent of subjects. n=548)

Household Income	Percent
Less than £5, 000	17.9
£5, 000 - £9, 999	28.8
£10, 000 - £14, 999	20.1
£15, 000 - £19, 999	10.9
£20, 000 - £24, 999	6.0
Over £25, 000	7.8
No response	8.5

Appendix M Table 3. Highest educational level attained (Percent of subjects. n=548)

Educational level	Percent
No qualifications	28.7
Secondary school certificates	34.1
Further education	14.2
Higher education	11.4
Don't know/can't remember	11.6

Appendix M Table 4. Housing tenure (Percent of subjects. n=548)

Housing tenure	Percent
Own home	72.3
Rent from council	22.5
Rent privately	2.8
Other	2.4

APPENDIX N Validation study demographic data

Appendix N Table 1. Work category of validation sample.

Work Category	Validation Sample % (n=86)	Others % (n=462)	All % (n=548)
Working full-time	15.1	18.2	17.7
Working part-time	8.1	7.4	7.6
Self-employed	5.8	5.2	5.3
Unemployed	0.0	2.0	1.7
Unable to work (sick/disabled)	1.2	5.5	4.8
Retired	53.5	50.3	50.8
Looking after home/family	16.3	11.4	12.1

Appendix N Table 2. Household income of validation sample.

Household Income	Validation Sample % (n=86)	Others % (n=462)	All % (n=548)
Less than £5, 000	11.6	19.0	17.9
£5, 000 to £9, 999	26.7	29.2	28.8
£10, 000 to £14, 999	29.1	18.4	20.1
£15, 000 to £19, 999	12.8	10.6	10.9
£20, 000 to £24, 999	7.0	5.8	6.0
Over £25, 000	9.3	7.6	7.8
No response	3.5	9.3	8.5

Appendix N Table 3. Educational level of validation sample.

Educational level	Validation Sample % (n=86)	Others % (n=462)	All % (n=548)
No qualifications	26.2	29.1	28.7
Secondary school certificates	38.1	33.3	34.1
Further education	9.5	15.0	14.2
Higher education	19.0	9.9	11.4
Don't know/can't remember	7.1	12.6	11.6

Appendix N Table 4. Housing tenure of validation sample.

Housing tenure	Validation Sample % (n=86)	Others % (n=462)	All % (n=548)
Own home	83.7	70.2	72.3
Rent from council	11.6	24.6	22.5
Rent privately	2.3	2.8	2.8
Other	2.3	2.4	2.4

APPENDIX O Benefit and Barrier factor scores

Appendix O Table 1: 4-point actvity classification

Factor	Group	n	Mean	SD	95% CI
BENEFITS:	1. High	33	19.75	8.88	16.60 - 22.90
Physical Performance	2. Moderate	104	23.23	6.47	21.97 - 24.49
	3. Low	285	24.64	6.45	23.89 - 25.40
	4. Very low	73	25.27	6.65	23.72 - 26.82
Social	1.	33	14.90	5.17	13.07 - 16.74
	2.	104	17.16	5.41	16.11 - 18.21
	3.	285	17.31	4.57	16.78 - 17.85
	4.	73	17.71	4.79	16.59 - 18.82
Weight Control	1.	33	11.13	4.55	9.51 - 12.74
	2.	104	11.38	3.26	10.75 - 12.01
	3.	285	12.00	3.35	11.60 - 12.39
	4.	73	11.91	3.53	11.09 - 12.73
Enjoyment	1.	33	10.03	3.89	8.65 - 11.41
	2.	104	12.50	3.99	11.73 - 13.28
	3.	285	13.13	3.56	12.72 - 13.55
	4.	73	14.59	4.32	13.58 - 15.60
Psychological	1.	33	8.67	3.88	7.29 - 10.05
	2.	104	9.50	3.25	8.87 - 10.14
	3.	285	10.25	2.98	9.90 - 10.59
	4.	73	10.51	3.12	9.78 - 11.24
Total Benefits	1.	33	64.49	23.68	56.09 - 72.88
	2.	104	73.79	19.16	70.05 - 77.50
	3.	285	77.33	17.40	75.30 - 79.36
	4.	73	79.99	19.62	75.41 - 84.56
BARRIERS:	1.	34	44.38	9.89	40.94 - 47.82
Opportunities	2.	105	43.27	8.68	41.58 - 44.95
	3.	286	39.92	8.11	38.98 - 40.86
	4.	66	37.74	7.53	35.89 - 39.59
Physical Exertion	1.	34	-55.59	10.88	-51.79 - -59.38
	2.	105	-50.68	9.10	-48.92 - -52.44
	3.	286	-46.82	8.77	-45.80 - -47.84
	4.	66	-41.55	8.36	-39.50 - -43.61
Time	1.	34	21.97	4.97	20.24 - 23.71
	2.	105	20.80	4.40	19.95 - 21.65
	3.	286	20.30	3.51	19.89 - 20.70
	4.	66	20.57	3.78	19.64 - 21.49
Limiting Health	1.	34	9.18	3.13	8.08 - 10.27
	2.	105	9.30	2.90	8.74 - 9.86
	3.	286	9.92	2.51	9.63 - 10.21
	4.	66	9.35	3.13	8.58 - 10.12
Support	1.	34	-20.45	3.71	-19.15 - -21.74
	2.	105	-19.38	3.73	-18.66 - -20.10
	3.	286	-18.35	3.06	-17.99 - -18.71
	4.	66	-16.82	3.42	-15.98 - -17.66

Appendix O Table 1 (continued)

Factor	Group	n	Mean	SD	95%CI
Total Barriers	1.	34	151.57	27.61	141.93 - 161.20
	2.	105	143.42	24.28	138.73 - 148.12
	3.	286	135.31	20.90	132.87 - 137.74
	4.	66	126.03	19.75	121.18 - 130.89
BEN/BAR RATIO	1.	31	0.45	0.18	0.39 - 0.52
	2.	98	0.53	0.17	0.50 - 0.57
	3.	262	0.58	0.15	0.57 - 0.60
	4.	61	0.65	0.16	0.61 - 0.69

Appendix O Table 2: 9-point activity classification

Factor	Group	n	Mean	SD	95% CI
BENEFITS:	1. Most active	35	20.46	6.60	18.19 - 22.73
Physical Performance	2.	38	22.21	7.48	19.75 - 24.67
	3.	6	22.00	3.94	17.86 - 26.14
	4.	84	23.86	7.13	22.31 - 25.40
	5.	101	23.58	5.86	22.42 - 24.73
	6.	20	25.11	7.77	21.48 - 28.75
	7.	42	24.19	5.39	22.52 - 25.87
	8.	68	25.39	7.43	23.59 - 27.19
	9. Least active	102	25.70	6.51	24.42 - 26.98
Social	1.	35	16.06	5.19	14.27 - 17.84
	2.	38	16.20	4.79	14.63 - 17.78
	3.	6	13.71	3.63	9.89 - 17.52
	4.	84	17.92	5.46	16.73 - 19.10
	5.	101	17.14	4.53	16.25 - 18.04
	6.	20	16.32	5.24	13.87 - 18.78
	7.	42	16.85	4.83	15.35 - 18.36
	8.	68	17.61	4.96	16.41 - 18.81
	9.	102	17.58	4.34	16.73 - 18.44
Weight Control	1.	35	10.97	3.51	9.76 - 12.17
	2.	38	11.55	3.55	10.38 - 12.72
	3.	6	11.83	2.03	9.70 - 13.96
	4.	84	12.09	3.50	11.33 - 12.85
	5.	101	11.31	3.18	10.69 - 11.94
	6.	20	10.56	3.83	8.77 - 12.36
	7.	42	12.16	3.16	11.18 - 13.15
	8.	68	12.25	3.49	11.40 - 13.09
	9.	102	12.22	3.61	11.51 - 12.93
Enjoyment	1.	35	10.51	3.18	9.42 - 11.61
	2.	38	11.19	3.62	10.00 - 12.38
	3.	6	10.83	4.17	6.45 - 15.21
	4.	84	12.74	3.77	11.92 - 13.56
	5.	101	13.24	3.43	12.56 - 13.91
	6.	20	12.08	4.19	10.12 - 14.04
	7.	42	12.47	2.90	11.57 - 13.38
	8.	68	13.61	4.20	12.59 - 14.63
	9.	102	14.65	4.14	13.84 - 15.47
Psychological	1.	35	8.94	2.99	7.91 - 9.99
	2.	38	9.46	3.54	8.29 - 10.62
	3.	6	9.05	1.72	7.24 - 10.86
	4.	84	10.07	3.40	9.33 - 10.81
	5.	101	9.99	3.13	9.37 - 10.61
	6.	20	9.41	3.54	7.76 - 11.07
	7.	42	10.29	2.15	9.62 - 10.96
	8.	68	10.19	3.29	9.39 - 10.99
	9.	102	10.56	2.99	9.98 - 11.15
Total Benefits	1.	35	66.94	18.61	60.54 - 73.33
	2.	38	70.61	19.62	64.17 - 77.06
	3.	6	67.41	13.13	53.63 - 81.19
	4.	84	76.68	19.75	72.39 - 80.96
	5.	101	75.26	17.73	71.76 - 78.76
	6.	20	73.49	20.67	63.82 - 83.17
	7.	42	75.98	14.10	71.59 - 80.37
	8.	68	79.05	19.24	74.40 - 83.71
	9.	102	80.73	19.15	76.96 - 84.49

Appendix O Table 2 (continued)

Factor	Group	n	Mean	SD	95% CI
BARRIERS:	1.	37	45.26	10.89	41.63 - 48.90
Opportunities	2.	34	46.05	6.82	43.67 - 48.43
	3.	6	38.77	7.93	30.45 - 47.09
	4.	87	42.23	8.24	40.48 - 43.99
	5.	103	39.00	7.04	37.63 - 40.38
	6.	18	39.21	9.50	34.49 - 43.93
	7.	43	42.73	7.44	40.44 - 45.02
	8.	64	40.09	8.01	38.09 - 42.09
	9.	99	37.13	8.16	35.50 - 38.75
Physical Exertion	1.	37	-55.93	11.29	-52.17 - -59.70
	2.	34	-54.91	7.45	-52.31 - -57.51
	3.	6	-43.70	15.68	-27.24 - -60.15
	4.	87	-49.69	8.63	-47.85 - -51.53
	5.	103	-46.49	7.53	-45.02 - -47.97
	6.	18	-49.20	8.69	-44.88 - -53.52
	7.	43	-50.35	7.41	-48.07 - -52.63
	8.	64	-44.53	9.02	-42.28 - -46.78
	9.	99	-41.68	8.20	-40.04 - -43.31
Time	1.	37	22.26	5.56	20.40 - 24.11
	2.	34	21.54	4.31	20.04 - 23.05
	3.	6	21.11	3.40	17.54 - 24.68
	4.	87	20.38	3.68	19.59 - 21.16
	5.	103	19.94	3.50	19.25 - 20.62
	6.	18	19.83	4.62	17.53 - 22.13
	7.	43	21.14	4.12	19.87 - 22.40
	8.	64	20.46	3.32	19.63 - 21.29
	9.	99	20.33	3.47	19.64 - 21.02
Limiting Health	1.	37	9.33	2.93	8.35 - 10.30
	2.	34	9.61	2.95	8.58 - 10.64
	3.	6	9.43	2.73	6.56 - 12.29
	4.	87	9.77	2.81	9.17 - 10.37
	5.	103	9.50	2.78	8.96 - 10.04
	6.	18	10.51	2.60	9.21 - 11.80
	7.	43	8.67	2.32	7.95 - 9.38
	8.	64	10.12	2.96	9.38 - 10.86
	9.	99	9.91	2.44	9.43 - 10.40
Support	1.	37	-20.96	3.96	-19.64 - -22.28
	2.	34	-20.24	2.95	-19.21 - -21.27
	3.	6	-18.91	4.44	-14.25 - -23.56
	4.	87	-19.06	3.18	-18.38 - -19.73
	5.	103	-17.92	2.99	-17.33 - -18.50
	6.	18	-18.39	4.06	-16.37 - -20.41
	7.	43	-18.94	3.06	-18.00 - -19.88
	8.	64	-17.80	3.44	-16.94 - -18.66
	9.	99	-17.33	3.11	-16.71 - -17.95

Appendix O Table 2 (continued)

Factor	Group	n	Mean	SD	95% CI
Total Barriers	1.	37	153.74	30.48	143.57 - 163.90
	2.	34	152.36	20.94	145.05 - 159.66
	3.	6	131.91	28.18	102.34 - 161.48
	4.	87	141.13	21.18	136.62 - 145.65
	5.	103	132.85	19.63	129.01 - 136.69
	6.	18	137.14	23.20	125.60 - 148.67
	7.	43	141.83	19.72	135.76 - 147.90
	8.	64	133.00	21.87	127.54 - 138.46
	9.	99	126.38	19.00	122.59 - 130.17
BEN/BAR RATIO	1.	33	0.47	0.23	0.39 - 0.55
	2.	33	0.50	0.13	0.45 - 0.55
	3.	6	0.54	0.16	0.37 - 0.70
	4.	79	0.55	0.15	0.51 - 0.58
	5.	98	0.58	0.14	0.55 - 0.61
	6.	17	0.57	0.16	0.49 - 0.65
	7.	40	0.55	0.12	0.51 - 0.59
	8.	61	0.60	0.16	0.56 - 0.64
	9.	85	0.65	0.15	0.62 - 0.68

Appendix O Table 3: 5-point activity classification

Factor	Group	n	Mean	SD	95% CI
BENEFITS:	1. Precontemplation	91	26.87	7.14	25.38 - 28.35
Physical Performance	2. Contemplation	29	22.19	6.63	19.67 - 24.71
	3. Preparation	178	24.64	6.23	23.72 - 25.56
	4. Action	10	23.08	7.30	17.86 - 28.30
	5. Maintenance	188	22.59	6.66	21.63 - 23.55
Social	1.	91	18.34	4.77	17.35 - 19.33
	2.	29	16.78	4.18	15.19 - 18.37
	3.	178	17.38	4.45	16.72 - 18.03
	4.	10	16.35	4.18	13.35 - 19.34
	5.	188	16.49	5.28	15.73 - 17.25
Weight Control	1.	91	12.23	3.78	11.45 - 13.02
	2.	29	10.72	3.89	9.24 - 12.20
	3.	178	11.91	3.07	11.46 - 12.37
	4.	10	11.70	3.53	9.17 - 14.22
	5.	188	11.63	3.55	11.12 - 12.14
Enjoyment	1.	91	15.37	4.59	14.41 - 16.32
	2.	29	13.20	3.97	11.69 - 14.71
	3.	178	13.40	3.13	12.94 - 13.87
	4.	10	11.71	3.92	8.90 - 14.51
	5.	188	11.49	3.57	10.98 - 12.01
Psychological	1.	91	11.29	3.37	10.59 - 12.00
	2.	29	9.18	2.65	8.17 - 10.19
	3.	178	10.29	2.95	9.86 - 10.73
	4.	10	9.11	2.63	7.23 - 10.99
	5.	188	9.28	3.10	8.83 - 9.73
Total Benefits	1.	91	84.10	21.16	79.70 - 88.51
	2.	29	72.07	17.85	65.28 - 78.86
	3.	178	77.62	16.80	75.14 - 80.11
	4.	10	71.94	17.93	59.11 - 84.77
	5.	188	71.48	18.37	68.83 - 74.12
BARRIERS:	1.	85	38.72	8.20	36.95 - 40.48
Opportunities	2.	27	37.78	8.01	34.61 - 40.95
	3.	175	38.47	7.84	37.30 - 39.64
	4.	9	42.37	5.89	37.84 - 46.89
	5.	195	43.78	8.43	42.59 - 44.97
Physical Exertion	1.	85	-40.85	9.18	-38.87 - -42.83
	2.	27	-42.85	7.18	-40.01 - -45.69
	3.	175	-45.76	7.53	-44.64 - -46.88
	4.	9	-49.30	8.66	-42.64 - -55.96
	5.	195	-52.69	9.04	-51.41 - -53.96
Time	1.	85	20.07	3.78	19.25 - 20.88
	2.	27	20.57	2.97	19.40 - 21.74
	3.	175	19.53	3.46	19.02 - 20.05
	4.	9	21.25	3.08	18.88 - 23.62
	5.	195	21.68	4.13	21.09 - 22.26
Limiting Health	1.	85	10.33	2.44	9.80 - 10.85
	2.	27	10.74	2.30	9.84 - 11.65
	3.	175	9.93	2.81	9.52 - 10.35
	4.	9	8.07	2.17	6.39 - 9.74
	5.	195	9.06	2.74	8.67 - 9.45

Appendix O Table 3 (continued)

Factor	Group	n	Mean	SD	95% CI
Support	1.	85	-17.46	3.50	-16.70 - -18.21
	2.	27	-17.96	3.38	-16.62 - -19.30
	3.	175	-17.60	2.93	-17.17 - -18.04
	4.	9	-19.22	3.70	-16.37 - -22.06
	5.	195	-19.82	3.38	-19.34 - -20.30
Total Barriers	1.	85	127.41	21.87	122.70 - 132.13
	2.	27	129.91	17.45	123.00 - 136.81
	3.	175	131.30	19.26	128.43 - 134.17
	4.	9	140.20	19.70	125.06 - 155.34
	5.	195	147.03	23.44	143.72 - 150.34
BEN/BAR RATIO	1.	80	0.67	0.16	0.64 - 0.71
	2.	25	0.56	0.12	0.51 - 0.61
	3.	160	0.60	0.15	0.58 - 0.63
	4.	9	0.55	0.10	0.47 - 0.63
	5.	178	0.50	0.14	0.48 - 0.52

APPENDIX P ANOVA tables for Benefits and Barriers

Appendix P Table 1: One-Way ANOVA: Benefits and Barriers by 4-point LRC Activity classification.

Factor	Source	DF	Sum of Squares	Mean Squares	*F* Ratio	*p*	Groups sig different at p<0.05
BENEFITS:							
Physical Performance	Between	3	886.38	295.46	6.64	.000	1<2,3,4
	Within	491	21837.10	44.47			
	Total	494	22723.48				
Social	Between	3	196.37	65.46	2.81	.039	1<2,3,4
	Within	491	11456.78	23.33			
	Total	494	11653.15				
Weight Control	Between	3	44.98	14.99	1.26	.288	
	Within	491	5853.21	11.92			
	Total	494	5898.19				
Enjoyment	Between	3	505.82	168.61	11.71	.000	1<2,3<4
	Within	491	7068.76	14.40			
	Total	494	7574.58				
Psychological	Between	3	120.10	40.03	4.11	.007	1<3,4; 2<3
	Within	491	4786.01	9.75			
	Total	494	4906.11				
Total Benefits	Between	3	6546.67	2182.22	6.32	.000	1<2,3,4
	Within	491	169481.81	345.18			
	Total	494	176028.47				
BARRIERS:							
Opportunities	Between	3	1901.81	633.94	9.23	.000	1,2>3,4
	Within	487	33465.40	68.72			
	Total	490	35367.21				
Physical Exertion	Between	3	5749.45	1916.48	23.94	.000	1>2>3>4
	Within	487	38991.63	80.06			
	Total	490	44741.08				
Time	Between	3	94.11	31.37	2.10	.099	
	Within	487	7260.01	14.91			
	Total	490	7354.12				
Limiting Health	Between	3	47.50	15.83	2.12	.096	
	Within	487	3633.02	7.46			
	Total	490	3680.52				
Support	Between	3	403.94	134.65	12.30	.000	1,2>3>4
	Within	487	5329.08	10.94			
	Total	490	5733.02				
Total Barriers	Between	3	20304.63	6768.21	13.95	.000	1,2>3>4
	Within	487	236285.34	485.19			
	Total	490	256589.97				
BEN/BAR RATIO	Between	3	.97	.32	13.38	.000	1<2<3<4
	Within	448	10.80	.02			
	Total	451	11.77				

<mean score of group is less than; >mean score of group is greater than

Appendix P Table 2: One-Way ANOVA: Benefits and Barriers by 9-point activity classification.

Factor	Source	DF	Sum of Squares	Mean Squares	*F* Ratio	*p*	Groups sig different at p<0.05
BENEFITS:							
Physical Performance	Between	8	1053.78	131.72	2.97	.003	1<8,9
	Within	487	21602.01	44.36			
	Total	495	22655.79				
Social	Between	8	246.90	30.86	1.32	.231	
	Within	487	11394.06	23.40			
	Total	495	11640.96				
Weight Control	Between	8	125.68	15.71	1.33	.226	
	Within	487	5753.21	11.81			
	Total	495	5878.89				
Enjoyment	Between	8	713.84	89.23	6.33	.000	1<4,5,8,9; 2<5,8,9; 4,5,7<9
	Within	487	6859.99	14.09			
	Total	495	7573.83				
Psychological	Between	8	101.25	12.66	1.29	.247	
	Within	487	4781.65	9.82			
	Total	495	4882.90				
Total Benefits	Between	8	7546.63	943.33	2.72	.006	1<8,9
	Within	487	168755.82	346.52			
	Total	495	176302.45				
BARRIERS:							
Opportunities	Between	8	3770.94	471.37	7.23	.000	1,2,4,7>9; 1,2,4>5; 1>8; 2>6, 8
	Within	482	31438.26	65.22			
	Total	490	35209.20				
Physical Exertion	Between	8	9430.56	1178.82	16.17	.000	1,2>3,4,5,7,8,9; 1>6; 4,5,6,7>9; 4>5; 4,7>8
	Within	482	35147.05	72.92			
	Total	490	44577.62				
Time	Between	8	213.79	26.72	1.80	.074	1>5
	Within	482	7146.36	14.83			
	Total	490	7360.15				
Limiting Health	Between	8	83.79	10.47	1.41	.190	
	Within	482	3582.94	7.43			
	Total	490	3666.72				
Support	Between	8	565.08	70.63	6.68	.000	1>4,5,7,8,9; 2>5,8,9; 4>9
	Within	482	5095.50	10.57			
	Total	490	5660.58				
Total Barriers	Between	8	34991.37	4373.92	9.55	.000	1,2>4,5,7,8,9; 4>5,9; 7>9
	Within	482	220746.84	457.98			
	Total	490	255738.21				
BEN/BAR RATIO	Between	8	1.12	.14	5.84	.000	1,2,4,5,7<9; 1,2<8; 1<5
	Within	443	10.65	.02			
	Total	451	11.77				

Appendix P Table 3: One-Way ANOVA: Benefits and Barriers by 5-point Stage of Exercise classification.

Factor	Source	DF	Sum of Squares	Mean Squares	*F* Ratio	*p*	Groups sig different at p<0.05
BENEFITS:							
Physical Performance	Between	4	1294.40	323.60	7.40	.000	5,3,2<1; 5<3
	Within	491	21463.41	43.71			
	Total	495	22757.81				
Social	Between	4	230.66	57.67	2.48	.043	5<1
	Within	491	11401.77	23.22			
	Total	495	11632.43				
Weight Control	Between	4	59.03	14.76	1.24	.293	
	Within	491	5847.57	11.91			
	Total	495	5906.61				
Enjoyment	Between	4	983.37	245.84	18.31	.000	5,4,3,2<1; 5<3
	Within	491	6593.33	13.43			
	Total	495	7576.71				
Psychological	Between	4	292.72	73.18	7.78	.000	5,3,2<1; 5<3
	Within	491	4618.26	9.41			
	Total	495	4910.98				
Total Benefits	Between	4	10900.93	2725.23	8.10	.000	5,3,2<1; 5<3
	Within	491	165200.77	336.46			
	Total	495	176101.70				
BARRIERS:							
Opportunities	Between	4	3312.06	828.02	12.55	.000	5>1,2,3
	Within	486	32057.86	65.96			
	Total	490	35369.92				
Physical Exertion	Between	4	10141.45	2535.36	35.47	.000	5>1,2,3; 4,3>1
	Within	486	34737.99	71.48			
	Total	490	44879.44				
Time	Between	4	453.19	113.30	7.98	.000	5>1,3
	Within	486	6903.56	14.20			
	Total	490	7356.75				
Limiting Health*	Between	4	175.47	43.87	6.08	.000	1,2,3>5
	Within	486	3503.77	7.21			
	Total	490	3679.24				
Support	Between	4	586.49	146.62	13.85	.000	5>1,2,3
	Within	486	5144.29	10.58			
	Total	490	5730.78				
Total Barriers	Between	4	34552.86	8638.22	18.88	.000	5>1,2,3
	Within	486	222326.37	457.46			
	Total	490	256879.23				
BEN/BAR RATIO	Between	4	1.88	.47	21.16	.000	5,3,2<1; 5<3
	Within	447	9.92	.02			
	Total	451	11.79				

APPENDIX Q Discriminant Analysis classification tables

Appendix Q Table 1. 4-point LRC classification

Actual Group	Cases	Predicted Group Membership (n, %)			
		1	2	3	4
1. High Active	27	5	3	19	0
		18.5	11.1	70.4	0
2. Moderate Active	86	4	2	79	1
		4.7	2.3	91.9	1.2
3. Low Active	238	4	3	224	7
		1.7	1.3	94.1	2.9
4. Very Low Active	57	0	0	49	8
		0	0	86.0	14.0

Percent of cases correctly classified = 58.58%

Appendix Q Table 2. 2-point LRC classification

Actual Group	Cases	Predicted Group Membership (n, %)	
		1	2
1. Yes vigorous	113	29	84
		25.7	74.3
2. No vigorous	295	21	274
		7.1	92.9

Percent of cases correctly classified = 74.26%

Appendix Q Table 3. 9-point classification

Actual Group	Cases	Predicted Group Membership (n, %)								
		1	2	3	4	5	6	7	8	9
1.	28	8	2	0	6	6	0	2	0	4
		28.6	7.1	0	21.4	21.4	0	7.1	0	14.3
2.	29	2	3	0	10	12	0	2	0	0
		6.9	10.3	0	34.5	41.4	0	6.9	0	0
3.	5	0	0	0	2	0	0	0	0	3
		0	0	0	40.0	0	0	0	0	60.0
4.	73	6	2	0	15	38	0	0	0	12
		8.2	2.7	0	20.5	52.1	0	0	0	16.4
5.	90	2	0	0	12	54	1	1	0	20
		2.2	0	0	13.3	60.0	1.1	1.1	0	22.2
6.	15	2	0	0	1	11	0	0	0	1
		13.3	0	0	6.7	73.3	0	0	0	6.7
7.	31	1	1	0	7	17	0	2	0	3
		3.2	3.2	0	22.6	54.8	0	6.5	0	9.7
8.	58	1	0	0	8	23	0	1	1	24
		1.7	0	0	13.8	39.7	0	1.7	1.7	41.4
9.	79	1	0	0	5	29	0	0	0	44
		1.3	0	0	6.3	36.7	0	0	0	55.7

Percent of cases correctly classified = 31.13%

Appendix Q Table 4. 3-point classification

Actual Group	Cases	Predicted Group Membership (n. %)		
		1	2	3
1. Often vigorous	62	16 25.8	41 66.1	5 8.1
2. Sometimes vigorous	178	9 5.1	110 61.8	59 33.1
3. Never vigorous	168	6 3.6	72 42.9	90 53.6

Percent of cases correctly classified = 52.94%

Appendix Q Table 5. 5-point Stage of Exercise classification

Actual Group	Cases	Predicted Group Membership (n, %)				
		1	2	3	4	5
1. Precontemplation	76	30 39.5	0 0	39 51.3	0 0	7 9.2
2. Contemplation	23	6 26.1	0 0	13 56.5	0 0	4 17.4
3. Preparation	146	11 7.5	0 0	96 65.8	0 0	39 26.7
4. Action	9	1 11.	0 0	3 33.3	0 0	5 55.6
5. Maintenance	154	3 1.9	0 0	39 25.3	0 0	112 72.7

Percent of cases correctly classified = 58.33%

Appendix Q Table 6. 3-point Stage of Exercise classification

Actual Group	Cases	Predicted Group Membership (n, %)		
		1	2	3
1. Precont/Cont	99	45 45.5	44 44.4	10 10.1
2. Preparation	146	19 13.0	86 58.9	41 28.1
3. Act/Maint	163	7 4.3	39 23.9	117 71.8

Percent of cases correctly classified = 60.78%

APPENDIX R Physical appraisal data

Men

Variable	functional threshold	Mean		% below threshold	
		PRESENT STUDY	ADNFS (1992)	PRESENT STUDY	ADNFS (1992)
BMI (kg/m^2)	Obese≥30	26.6 (2.8)	26 (3)	10	12
Shoulder flexibility (°)	<120°	140 (12)	134 (-)	2	10
Sit and Reach (cm)	-	25.2 (8.6)	-	-	-
Grip strength (N)	<150N	418 (69)	396 (114)	0	0
Grip strength (N/kg)	<20% bodyweight	5.3 (1.0)	5.2 (1.5)	0	0
Leg strength (N/kg)	<50% bodyweight	5.2 (1.2)	6.4 (1.6)	49	22
$\dot{V}O_{2max}$ (ml/kg/min)	*a* ≥70% HR_{max} at 21ml/kg/min	26.1 (7.1)	35.0 (7.0)	-	76
Walk time (min/$^1/_{100}$min)	-	17.41 (1.81)	14.92 (1.68) *b*	-	-

- data not available

a 70% HR_{max} estimated to equal anaerobic threshold and 21 ml/kg/min the average oxygen uptake required for walking at 3mph up a 5% gradient.

b mean for 34 men and women aged 60-69 years who also completed a maximal treadmill test (Kline *et al*, 1987).

Women

Variable	functional threshold	Mean		% below threshold	
		PRESENT STUDY	ADNFS (1992)	PRESENT STUDY	ADNFS (1992)
BMI (kg/m^2)	Obese≥28.6	26.0 (3.8)	27 (4)	27	30
Shoulder flexibility (°)	<120°	144 (9)	131 (-)	0	14
Sit and Reach (cm)	-	27.1 (7.7)	-	-	-
Grip strength (N)	<150N	272 (43)	241 (67)	0	1
Grip strength (N/kg)	<20% bodyweight	4.1 (0.8)	3.6 (1.1)	0	0.5
Leg strength (N/kg)	<50% bodyweight	3.8 (1.1)	5.0 (1.6)	82	54
$\dot{V}O_{2max}$ (ml/kg/min)	*a* ≥70% HR_{max} at 21ml/kg/min	18.4 (8.2)	27.3 (4.8)	-	93
Walk time (min/$^1/_{100}$min)	-	18.03 (1.66)	14.92 (1.68) *b*	-	-

- data not available

a 70% HR_{max} estimated to equal anaerobic threshold and 21 ml/kg/min the average oxygen uptake required for walking at 3mph up a 5% gradient.

b mean for 34 men and women aged 60-69 years who also completed a maximal treadmill test (Kline *et al*, 1987).

APPENDIX S Factor analysis and Discriminant analysis

Factor Analysis

The central aim of factor analysis is the orderly simplification of a number of related measures. It seeks to account for the intercorrelations among *n* variables, by postulating a set of *common factors*, considerably fewer in number than the number of variables. Factors themselves cannot be directly observed, but instead can be thought of as underlying explanatory constructs. For example, love is not a single measurable entity, but it may be postulated that the construct exists in order to explain the correlations between a number of other, directly observable variables. To use an example from the research presented here, the social benefits of exercise may comprise a number of variables such as meeting new people, being part of a team, regular contact with friends, competition, and so on. Factor analysis identifies related items measuring the same construct, and allows these items to be grouped under one heading, in the above example 'social benefits' of exercise. A good factor solution is both simple and interpretable. If many factors are required to explain the observed correlations, little simplification occurs. The factors also need need to be meaningful.

The difference between factor analysis (FA) and principal components analysis (PCA) ought to be pointed out at stage. Although the aims and end results of the two analyses are similar, and the terms often used interchangeably ('factor' is often used to describe the constructs produced by a PCA although strictly speaking, these should be called 'principal components'), there are different statistical techniques involved.

In FA we are interested in analysing the *common* variance of the variables. The common variance of any variable is called its *communality*, and the total common variance is the sum of the communalities. In the factor matrix, the proportion of a variable's variance that is attributable to a common factor is the square of its loading on that factor. In PCA, the technique used in the present research, we are interested in analysing the *total* variance. The total variance of any variable is unity (1.0), and the total variance of all the variables is equal to *n*, the number of variables. Again, the proportion of a variable's variance that is attributable to a given component is the square of its loading on that component. In PCA linear combinations of the observed variables are formed. The first principal component (factor) is the combination that accounts for the largest amount of variance in the sample. The second principal component accounts for the next largest amount of variance and is uncorrelated with the first. Successive components explain progressively smaller portions of the total sample variance. PCA

is used when the main aim is to reduce the total number of variables under consideration and obtain accurate estimates of the scores of individuals on this smaller number of derived variables.

PCA usually proceeds in four steps:

- First, the correlation matrix for all variables is computed.
- The second step, extraction, determines the number of factors necessary to represent the data.
- Thirdly, the rotation phase makes the factors more interpretable.
- The fourth step is the calculation of scores for each factor. These scores can then be used in subsequent analyses.

Examination of the correlation matrix enables a decision to be made as to the appropriateness of the factor model. Since a goal of PCA is to obtain factors that help explain correlations between variables, small correlations make it unlikely that the variables share any common factors.

During the extraction phase, PCA will extract as many factors as there are variables. In order to determine how many are required to adequately represent the data, it is useful to examine the percentage of total variance explained by each. The variance explained by each factor is called its *Eigenvalue*, and in this research, only factors with an Eigenvalue greater than 1.0 are included. This is because a factor with an Eigenvalue of less than 1.0 is no better than a single variable, since each variable has a variance of 1.0. After the factors with Eigenvalues greater than 1.0 have been retained (for example, 5 Benefits factors), it is possible to judge how well this solution fits the original variables. The proportion of variance of each variable which is explained by the 5-factor model is simply the sum of the variance proportions explained by each of the five factors.

Although the factor matrix obtained in the extraction phase indicates the relationship between the factors and the individual variables, they often do not appear to be correlated in any interpretable pattern. Since a goal of PCA is to identify factors which are meaningful (in the sense that they summarise sets of closely related variables), the rotation phase attempts to transform the initial matrix into one that is easier to interpret. This means that we would like each factor to have nonzero loadings for only some of the variables, and also each variable to have nonzero loadings for preferably only one factor.

Although the factor matrix changes during rotation, it does not affect the percentage of total variance explained. However the percentage of variance accounted for by each of the factors does change. Rotation redistributes the explained variance for the individual factors. There are a number of different methods of rotation which can be used. *Orthogonal* rotation (so called because on a plot of factor loadings, the axes are maintained at right angles during rotation) results in factors that are uncorrelated. Although appealing, allowing for some correlation among the factors can simplify the pattern matrix. During *oblique* rotation (called *oblimin* in SPSS), the axes are not maintained at right angles.

The end result of rotation is that the number of high and low loadings increase, and the factors become more easily interpretable. Deciding which variables are to be included on which factors depends on the strictness of the criteria the researcher wishes to apply. The criterion used in this research that a variable loading on a particular factor must have an absolute value of 0.45 or higher with loadings on other factors lower by at least 0.10 is more stringent than that recommended by Child (Child, D. 1970. *The essentials of factor analysis*. London: Holt, Rinehart & Winston), and the same as that employed by Steinhardt & Dishman (1989).

Calculating the score for each factor can be done by summing the products of the loading on that factor for **every** variable and the Likert score. This gives an exact factor score. For practical use, scores can be calculated more simply by summing the Likert scores of only those variables which meet the loading criteria for a particular factor.

Discriminant Analysis

This technique is used when there is one independent variable (two or more levels) and two or more dependent variables. It is a combination of multiple regression and one-way ANOVA, and uses a linear combination of the dependent variables to predict the independent variable (measured on a nominal or ordinal scale). As used in this research, benefits and barriers factors and demographic data are used to predict activity category. As in multiple regression, variables can be entered into the analysis in a forward, backward, or stepwise methods.

In the following description of discriminant analysis, the 4-point activity classification from the present research will be used as an example.
Discriminant analysis begins by calculating one-way ANOVA F values for each predictor variable. This determines whether any significant difference exists between the four activity categories, but does not explain the relationship among the predictor variables. In the next step, the variables are entered according to the method selected (forward, backward, or stepwise). Both the forward and stepwise techniques enter the variable with the largest F value first. Using a semipartial correlation procedure, the effect of the first dependent variable on all the others is removed, and the variable with the next largest F value is then entered. This continues until some criterion for stopping the process is met. The difference between the two methods is that in stepwise selection, the contribution of each dependent variable to the prediction of activity category is evaluated at every step, and a variable may be removed from the equation if it no longer contributes. In the example used here, the criterion for including and removing variables from the equation is when the significance of F reaches 0.05 or falls below 0.10 respectively.

The estimate of the variance in activity category which this linear combination of some of the dependent variables is then given. The proportion of subjects placed in each of the four activity category by the discriminant analysis or by actual questionnaire response can then be compared.