THE IMPACT OF SPORT AND RECREATION ON SOCIETY

LEAVING SCHOOL WITHOUT FIVE OR MORE A*-C GCSEs

Number of people affected: **2 in 5**

9.8% of **16** to **18** year olds in England are categorised as **NEET**

Physical activity can cause changes in the brain which lead to enhanced neurochemical capacity for memory, learning and higher thinking.

£ THE CURRENT GENERATION OF NEETS WILL COST ★35 BILLION★ OVER A LIFETIME

LINKS TO

ANTISOCIAL BEHAVIOUR
Men who have been NEET are 5x more likely to have a criminal record.

DEPRESSION
At age 23 men and women without qualifications are around twice as likely to be depressed.

UNEMPLOYMENT
In 2010, almost 1 in 4 (23%) 25-29 year olds without qualifications wanted paid work but didn't have it.

CARDIOVASCULAR DISEASE

180,000 DEATHS A YEAR

(skull) = 10,000

ANNUAL COST TO ECONOMY
£30.7 billion

ANNUAL COST TO NHS
£14.4 billion

150 minutes a week physical activity = 40% reduction in risk of cardiovascular disease.

PREVALENCE

Women under 75: **1 in 5**

Men under 75: **1 in 4**

OVERWEIGHT AND OBESITY

ANNUAL COST TO ECONOMY
£16 billion

ANNUAL COST TO NHS
£5.1 billion

6 IN 10 ADULTS

3 IN 10 CHILDREN

LINKS TO

PANCREATIC CANCER
Obesity doubles the risk of pancreatic cancer.

DIABETES
Obese women are 13 times more likely than non-obese women to develop type 2 diabetes, obese men are 5x more likely.

DEPRESSION
Obese people have a 55% increased risk of developing depression over time.

UNEMPLOYMENT

3 IN 10 PEOPLE IN ENGLAND ARE CURRENTLY UNEMPLOYED

ANNUAL COST TO ECONOMY

£15.5 billion
Youth unemployment alone

MAY 2012

2.63 million
people unemployed

1.59 million
claiming jobseeker's allowance

Research has shown the positive impact of participation in sport or recreation equates to around an additional year's worth of work when applying for jobs.

LINKS TO

ANTISOCIAL BEHAVIOUR

Being employed reduces the risk of offending by between a third and a half.

DEMENTIA

Aged 80 plus: 1 in 6

Aged 65 plus: 1 in 14

800,000
Sufferers in the UK

670,000
Acting as primary carers

ANNUAL COST TO SOCIETY

£23 billion

The risk of developing dementia is reduced by two to three times amongst the most active.

DIABETES

Number of people affected: 1 in 20

2.9 million
people diagnosed

an estimated further

850,000
undiagnosed

ANNUAL COST TO NHS

£9 billion

150 minutes a week is twice as effective as medication at reducing the risk of developing type 2 diabetes.

LINKS TO

CARDIOVASCULAR DISEASE

Persons with diabetes are at least twice as likely to have cardiovascular disease than those without.

DEPRESSION

People with long-term illnesses such as diabetes have double the rate of depression in comparison to the general population.

PHYSICAL ACTIVITY AND PHYSICAL HEALTH

INTRODUCTION

The impact of sport and recreation on physical health is one of the easier relationships to explore. There has historically been a greater research focus on this relationship and physical health is more scientifically quantifiable than, for example, social cohesion, making it easier to isolate the role of sport and to explore causality and impact. The research focus in this area has however focused largely on the impact of physical activity on the health of people without disabilities. A 2010 review examined research published between 1986 and 2006 that focused on community physical activity interventions for persons with disabilities and were concerned with health outcomes. 80 studies were found with a range of methodologies and sample sizes covering 11 disability groups in total but predominantly focusing on stroke (20% of the studies), multiple sclerosis (15%) and intellectual disability (13%). Rimmer et al. (2010) concluded that research in this area is broad in scope with limited relevance to any specific disability group and a lack of consensus in findings, not helped by the small sample sizes of some of the disability groups studied. There is therefore a lack of research focusing on physical activity and specific disabilities, but where possible relevant studies have been included in this review.

Back in 2002 The Sport and Recreation Alliance produced ***Saving Lives, Saving Money***, a policy document detailing how physical activity represented a sound investment for public health and summarising data on the prevalence of inactivity, related illnesses and their costs. Much more recently Sport England has used existing research to estimate that if the UK had an additional 1 million people participating in sport once a week it would save £22.5 billion in health and associated costs[3]. Estimates such as this are possible partly as a result of research on the health costs of physical inactivity, although unfortunately these are not as up-to-date as they could be. The Government Office for Science ***Foresight*** report (2007) remains the definitive source for estimates on the economic cost of obesity and overweight and includes predictions for the year 2050.

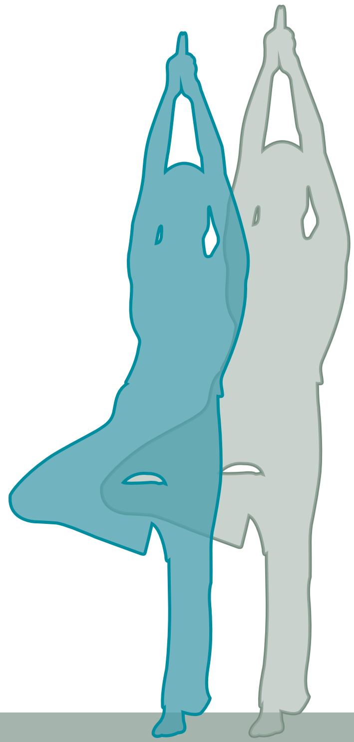
3 Sport England, *Sport's Role in Improving the Health of the Nation* http://www.sportengland.org/about_us/our_news/sport_and_healt/sport_and_health_statement.aspx, last accessed 03.02.2012.

THE IMPACT OF SPORT AND RECREATION ON PHYSICAL HEALTH IS ONE OF THE EASIER RELATIONSHIPS TO EXPLORE

Statistics on Obesity, Physical Activity and Diet, England 2011 (2011) provides the latest accessible numbers on the prevalence of obesity, although the data used is from the ***Health Survey for England*** (2009). These figures state that 23% of all adults are obese, and six in ten adults (61.3%) are either overweight or obese. The picture is not much better for children, with three in ten two to 15 year olds (29.5%) classed as overweight or obese. More recently in the August 2011 issue of The Lancet, Wang et al. have predicted the "Health and economic burden of the projected obesity trends in the USA and the UK", estimating that if current trends continue then by 2030 in the UK 41-48% of men and 35-43% of women could be obese. This would equate to 11 million more obese adults in the UK, with 3.3 million of these being over 60 years old, potentially creating a new problem of ageing obesity. This paper also builds on the 2007 ***Foresight*** report and utilises 2009 ***Health Survey for England*** data.

Two of the contributing factors to obesity are physical inactivity and poor diet (Government Office for Science, 2007; World Health Organisation, 2011). Prentice and Jebb (1995) argue that in the UK decreasing activity levels play a larger role than increasing calorie intake in our rising levels of obesity (cited in the Ramblers, 2010). Given that adults in the UK spend an average of six hours of their daily leisure time being sedentary, Prentice and Jebb could have a valid point. Only half (54%) of adults in the UK report that they partake in sport or exercise in their leisure time compared to nine in ten adults (89%) who watch television in their free time (Office for National Statistics, 2011). This demonstrates that there is enormous scope in the UK for increased physical activity to influence health, body mass and ultimately the obesity epidemic. Comparisons of the amounts and intensity of physical activity amongst 7,695 Americans showed that significantly more adults of normal weight engaged in moderate and vigorous intensity physical activity, and did so for longer durations, than their overweight or obese counterparts (Spees, Scott and Taylor, 2012). This lesson is not just one for the UK to learn, however, as physical inactivity accounts for 6% of deaths globally, making it the fourth leading risk factor for global mortality (World Health Organisation, 2010).

During the bidding process for the London 2012 Olympic and Paralympic Games, the Government committed to establishing Sport and Exercise Medicine as a new medical speciality. This has resulted in the production of a new NHS guide which outlines how sport and physical activity can deliver improved quality of care and productivity. The report, ***Sport and Exercise Medicine, A Fresh Approach*** (2012), argues for sport and exercise medicine to be commissioned across the NHS. As the findings in this chapter indicate, physical activity can reduce the risk of a range of illnesses from cardiovascular heart disease (around a 40% risk reduction) to dementia (by two to three times compared to the least active) and can be used in the management or treatment of others such as diabetes and obesity. Indeed, on a par with the findings in this review, the NHS report states that, *"the health benefits of physical activity are seen irrespective of age and social-economic group or cultural origin. There are also clear indirect benefits of physical activity to the wider economy. People who are physically active are more productive than those who are not. They take less time off work, consume fewer health care resources and are happier. The evidence that physical activity prevents major chronic disease is indisputable"* (Jones, Weiler, Hutchings et al., 2012, p.16).



LEVELS OF LEISURE TIME PHYSICAL ACTIVITY

It is thought that physically inactive individuals spend an average of 38% more days in hospital, make 5.5% more GP visits, access 13% more specialist services and 12% more nurse visits than an active individual (Jones et al., 2012). The British Association of Sport and Exercise Sciences utilised a panel of experts to produce a literature review and subsequent guidance on the relationship between physical activity and health in 2010. They highlight research from the 1950s and 1960s as early evidence of the empirical benefits of physical activity for health. O'Donovan et al. (2010) track the 1970s and 1980s as a time when research centred around high-intensity activity in the pursuit of aerobic fitness for health before the 1990s revealed that moderate-intensity activity also had significant health benefits and the question of how much activity is required for health benefits became popular. Using a meticulous and detailed methodology for experts within each topic to conduct literature and evidence reviews, this work is thorough. The headings addressed by experts were: physical activity and the prevention of overweight and obesity, physical activity and the prevention of type 2 diabetes, physical activity and the prevention of cardiovascular diseases, physical activity and the prevention of common cancers, physical activity and psychological wellbeing, minimal and optimal levels of physical activity and physical fitness, physical activity and health in children and adolescents, and the prevention of musculoskeletal injury. This is therefore arguably the most up-to-date and comprehensive paper on physical activity and health at present and as such is a useful reference to further research.

PHYSICAL ACTIVITY IS EFFECTIVE IN THE PRIMARY AND SECONDARY PREVENTION OF PREMATURE DEATH AND THE PREVENTION OF CHRONIC DISEASES

From reviewing existing cross sectional studies[4], experimental studies[5] and cohort studies[6], O'Donovan et al. highlight the difficulty of demonstrating causality[7] between physical activity and a reduction in risk from disease, and show that this in turn can lead to conservative estimates on the impact of physical activity. Nevertheless, O'Donovan et al. summarise from the cohort studies reviewed that after adjusting for confounding variables, inactivity results in a two-fold increase in the risk of cardiovascular disease, type 2 diabetes and overweight and obesity. The cohort studies also showed strong evidence that physical activity has a causal relationship with a reduction in the risk of post-menopausal breast cancer and depression, and moderate evidence that this is the case for colon cancer, psychological wellbeing, cognitive impairment and prostate cancer. This supports earlier findings from Warburton, Nicol and Bredin (2006a) who explored the evidence from over 150 pieces of observational[8] and randomised[9] research on the health benefits of physical activity. They found that existing research showed irrefutable evidence that regular physical activity is effective in the primary and secondary prevention of premature death and the prevention of chronic diseases including cardiovascular disease, diabetes, cancer, hypertension, obesity, depression and osteoporosis.

4 In this context, cross sectional studies compare risk factors for disease in those who exercise regularly as part of their lifestyle against sedentary counterparts at a given point in time.

5 Experimental studies assess risk factors for disease before and after a specific physical activity intervention whilst controlling for other influencing factors such as a change in diet.

6 Cohort studies are conducted over a long period of time and involve studying a large group of healthy people to observe the incidence of disease and death. This can then be compared by physical activity levels of individuals and groups.

7 A scientifically observable, predictable and reproducible relationship showing in this instance that physical activity directly results in a reduced risk from disease.

8 Observational research is not a scientific experiment with controlled parameters. It involves direct observation of participants in their natural environments, for example, observation of the physical activities undertaken by a sample of participants.

9 Randomised research is a scientific experiment. It takes the total number of eligible participants recruited and randomly assigns them to different intervention groups, such as running for 30 minutes a day or running for 60 minutes a day. A randomised trial assigns participants to different intervention groups only. A randomised controlled trial assigns some of the participants to a placebo group to increase the validity of a study.

Based on their review of the evidence, O'Donovan et al. (2010) propose that healthy adults (18-65 years) should participate in 150 minutes of moderate intensity aerobic exercise a week, or 75 minutes if it is of a vigorous intensity, with minimum bouts of ten minutes. This is echoed in the Government's current adult guidelines for physical activity which are at least 30 minutes of moderate intensity activity five times a week, and the acknowledgement that bouts of ten minutes or longer several times a day can have just as positive an impact (Department of Health, 2011b). For children (5-18 years), O'Donovan et al. recommend accumulating at least 60 minutes of moderate-to-vigorous intensity activity a day, which should include vigorous-intensity aerobic activities aimed at improving bone density and muscle strength. Again, this is supported by the Government guidelines, which elaborate to say that moderate-vigorous intensity physical activity should be at least 60 minutes and up to several hours a day and that muscle and bone strengthening exercises should be included at least three days a week, whilst extended periods of sedentary behaviour should be minimised.

Using data from the 2003-2004 American National Health and Nutrition Examination Survey, Strath et al. (2008) looked at body mass index, waist circumference and objectively determined levels of physical activity for 3,250 adults. Strath et al. compared the body mass index and waist circumference of those who reported 30 continuous minutes of moderate-to-vigorous intensity physical activity with those who had accumulated 30 minutes of moderate-to-vigorous intensity physical activity through bouts of ten minutes or more. Regression analysis showed a body mass index reduction of 1.2kg/m2 and a 2.7cm decrease in waist girth amongst participants who accumulated 30 minutes of moderate-to-vigorous intensity physical activity in bouts of ten minutes or longer when compared to all others. Those who had undertaken 30 minutes of moderate-to-vigorous intensity physical activity in one go had a body mass index reduction of 0.3kg/m2 and a 0.9cm decrease in waist girth. These findings suggest that there are in fact greater benefits for exercising at sufficient intensity for shorter time periods. However given that the analysis used previously gathered data that relied on people's self-reporting of activity levels, the true extent of the benefits of moderate-to-vigorous exercise for ten minutes or more needs further exploration.

Wen et al. (2011) explored the health impact of exercising less than the recommended 30 minutes five times a week. They concluded that 15 minutes of moderate intensity physical activity a day or 90 minutes over a week may be enough to bring about health benefits even in those who are at risk of cardiovascular disease.

In a prospective cohort study with 416,175 Taiwanese people between 1996 and 2008 (average follow up of 8.05 years), participants self-reported their amount of weekly exercise, which the researchers categorised into one of five levels of exercise intensity: inactive, low, medium, high or very high activity. These groups were then compared for their risk of mortality and life expectancy. The low level activity group was characterised by an average of 15 minutes physical activity a day and had a 14% lower risk of all-cause mortality and a three year longer life expectancy than those in the inactive group. Wen et al. found that every additional 15 minutes of physical activity beyond the initial 15 minutes resulted in a further 4% reduction in all-cause mortality and a 1% reduction in cancer mortality. These findings remained true when accounting for age, gender and risk of cardiovascular disease. This research suggests that some exercise is better for our health than none, but going beyond the current recommended daily guidelines can have further health benefits. It is possible, however, that for those who are already in good health, overtraining in an activity that involves resistance training can ultimately lead to a decrease in performance, greater fatigue and mood disturbance. It should be noted that this extreme is not easy to reach and happens when the balance between training and recovery isn't appropriate (Halson and Jeukendrup, 2004, cited in O'Donovan et al., 2010).

There is a significant body of further evidence that, as found by Wen et al., even relatively low levels of physical activity improve general physical wellbeing (for comprehensive overviews see Powell, Paluch and Blair, 2011, Pavey et al., 2011, Thompson, 2009 and Tuomilehto et al., 2005). Previously, Warburton, Nicol and Bredin's (2006a) examination of existing research on the health benefits of physical activity led them to conclude that overall health can be improved from low-intensity physical activity even when there is little or no change in physical fitness. Following this finding, Warburton, Nicol and Bredin (2006b) conducted further research into the intensity, time, type and frequency of physical activity and improvements in health. They conclude that there is no one solution for how much a given activity should be done at a set intensity and frequency; effective physical activity for physical health is dependent on the existing health of individuals and their health goals. For example, unfit sedentary people will see greater benefits from low intensity exercise than someone who is already very fit, and they will also be more easily able to participate in low intensity exercise and less likely to incur injury. In order for an individual weighing 60 kilograms to achieve the recommended daily energy expenditure from exercise (150-400 kcal), they could cycle vigorously for 15 minutes or dance (social or ballroom) quickly for 33 minutes. Someone weighing 130 kilograms would need to do half this amount (seven and 15 minutes respectively), but due to their weight may be more likely to meet the target through 23 minutes bowling or 28 minutes fishing from a boat (Warburton, Nicol and Bredin, 2006b).

A report from Substance (2012) on the social and community benefits of angling, in which the second chapter focuses on angling, health and wellbeing, also highlights the accessibility of angling for those who have previously led sedentary lifestyles or are recovering from an illness. With a range of case-study, anecdotal and quantitative evidence (the latter largely found in the previous chapter on participation) this report demonstrates that angling is not as physically demanding as, for example, football, and can be participated in at various levels of activity, from very low intensity, such as sitting by a canal having driven there in a car, to high intensity, as would be experienced when wading in a river and constantly casting and retrieving spinners.

The benefits of physical activity for health come from both increased fitness and a healthy body weight. A sample of 3,250 adults aged 20-49 years were tested on a treadmill for their cardiorespiratory fitness. Those who had high levels of leisure time physical activity, defined as 1,000 MET[10]-minutes/week or greater, were fitter than those who reported no physical activity or less than 500 MET-minutes/week activity. Men had VO2max[11] scores of 45 to 42 respectively and women VO2max scores of 37 to 34 (Wang et al., 2009). It should be noted that in this sense, it is possible to be both fit and overweight. Even small improvements in physical fitness are evidenced to reduce the risk of premature death, with previously sedentary people making modest improvements to their physical fitness seeing large improvements to their health. Research by Warburton, Nicol and Bredin (2006a) over a five year period found that those who went from unfit to fit in this time had a 44% reduction in their relative risk of mortality when compared to people who remained unfit. Brisk walking is an easy, accessible, cost free activity to increase fitness amongst sedentary people. The Ramblers (2010) highlight from a number of other sources that the best impact on health occurs when walking is brisk, as at this pace the performance of the heart, lungs and circulation will improve, blood pressure can be lowered and the risk of coronary heart disease and strokes can be reduced. In addition, regular walking at any pace can help to manage weight, reduce the risk of type 2 diabetes, reduce the risk of colon, breast and lung cancer, improve flexibility and strength of joints, muscles and bones, increase "good" cholesterol and boost the immune system. However, maintaining a healthy weight confers further health benefits. From analysing 19 existing cohort studies which included 1.46 million white (non-Hispanic) American adults and 160,087 deaths and accounting for confounding factors such as smoking or prevalent disease, Berrington de Gonzalez et al. (2010) identified a body mass index of between 20.0 and 24.9 as having the lowest risk of all-cause mortality.

10 MET is the estimate of a person's resting metabolic rate. It is how much energy he or she expends when sitting quietly. 1 MET can be defined as 1 kcal per kilogram per hour, or 3.5ml of oxygen per kilogram per minute.

11 VO2max is the maximum capacity that an individual's heart, lungs and blood has for transporting oxygen to muscles and the utilisation of this oxygen during exercise. It is used to measure cardiorespiratory fitness.

REGULAR WALKING AT ANY PACE CAN HELP TO MANAGE WEIGHT, REDUCE THE RISK OF TYPE 2 DIABETES, REDUCE THE RISK OF COLON, BREAST AND LUNG CANCER

WEIGHT MAINTENANCE

From a review of existing research, the Department of Health (2011b) believes there to be strong evidence that aerobic physical activity at the recommended level (30 minutes moderate intensity activity five times a week) consistently has an effect on maintaining weight so that weight change is in a 3% or lower range of initial body weight; this has also been confirmed by Jakicic (2009) and Wing (1999). Physical activity contributes to weight maintenance by enabling an energy balance, but the difficulty comes with truly understanding the long-term effects of regular exercise, for which there is relatively little research.

Acknowledging this issue, Hankinson et al. (2010) conducted a cohort study over 20 years in order to evaluate the relationship between physical activity levels and changes in body mass index and waist circumference during this time. The sample consisted of 3,554 American men and women who at enrolment were aged between 18 and 30 years. At the beginning of the research and at follow up intervals of two, five, seven, ten, 15, and 20 years afterwards physical activity levels were measured in order to create a habitual physical activity level over the 20 years. Measurements of physical activity were calculated from answers to a questionnaire on 13 specific moderate and vigorous intensity activities over the last year, using an algorithm that assigned scores for activities based on intensity, frequency and duration. The outcome was a score expressed in exercise units to show the usual level of activity over the previous year and these were externally validated. A score of 300 exercise units was approximately the same as the Government guidelines of 150 minutes moderate intensity activity a week. Based on this, Hankinson et al. divided these activity scores into low, moderate and high habitual levels of physical activity by gender.

PHYSICAL ACTIVITY CONTRIBUTES TO WEIGHT MAINTENANCE BY ENABLING AN ENERGY BALANCE

They found that men who habitually maintained high levels of physical activity (more than 608 exercise units, equivalent to approximately 350 minutes of moderate intensity activity a week) gained 2.6 fewer kilograms a year than those with low levels of physical activity (less than 340 exercise units) and gained 3.1 fewer centimetres in waist circumference. Women with habitually higher levels of physical activity (at least 398 exercise units) gained 6.1 fewer kilograms than their low activity level (less than 192 exercise units) counterparts and had waist circumferences that were 3.8 centimetres smaller. These findings demonstrate a considerable difference by gender and indicate that in men, weight maintenance requires more than the Government's recommended levels of activity.

HIGH LEVELS OF LEISURE TIME PHYSICAL ACTIVITY SUCH AS SPORT AND RECREATION...WERE SEEN TO CORRELATE WITH A LOWER BODY MASS INDEX AND LOWER LEVELS OF BODY FAT

Hankinson et al.'s research also demonstrates that maintaining a high level of physical activity as a young adult (18-30 years) can lessen weight gain as middle age approaches, and that this is particularly the case for women. Evidence for weight maintenance through regular physical activity does appear to differ and to be somewhat contradictory with regards to effectiveness by gender. This is likely to be due to methodological differences such as relying on participants to self-report on their levels of activity, small sample sizes, reliance on participants to stick to exercise routines and so on. High levels of leisure time physical activity such as sport and recreation (as opposed to being active through cleaning, for example) were seen to correlate with a lower body mass index and lower levels of body fat amongst women in a sample of 1,302 Australians. After regression and controlling for variables, Ball et al. (2001) found that women who were moderately active were 2.3 times more likely than sedentary women to have a body mass index in the normal range for women and 2.4 times more likely to be in the lower body fat category. Women who were highly active were 2.6 times more likely to have a body mass index in the normal range and 2.9 times more likely to be in the lower body fat category. This research found no significant differences amongst men, however other research has found no difference between men and women. Mozaffarian et al. (2011) conducted a prospective study drawing on data from three other cohort studies in America. Their total sample consisted of 98,320 women and 22,557 men who at the beginning of the research were not overweight or suffering from a chronic disease. Over 20 years this research assessed weight gain and the role of lifestyle factors in this. Across the entire sample over the 20 year period the average weight gained was 1.2 stone or 2.4% of body weight every four years. Participants who increased their physical activity over time gained 0.13 stone less within each four year period, and these findings were similar for men and women.

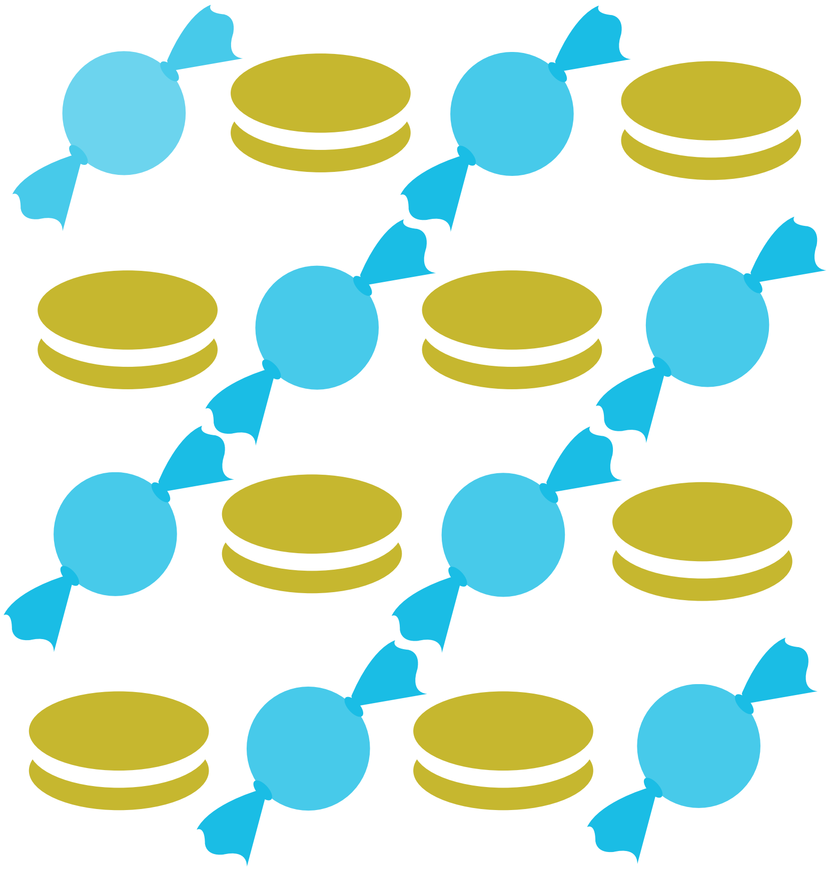
The National Weight Control Registry in America contains the details of individuals who have self-reported losing 30 pounds (just over two stone) and maintained this for a year. Analysis of the 784 men and women in this register by Klem et al. (1997) concluded that 2,800 kcal/week of leisure time physical activity was necessary for their weight maintenance, demonstrating that higher levels of activity may be necessary for those who have previously been overweight. 2,800 kcal/week or 400 kcal a day could be achieved through approximately 30 minutes of boxing or 30 minutes of cycling at 6mph. Alternatively, it could be achieved through 60 minutes playing basketball, swimming, hiking or fast ballroom dancing.

The Department of Health (2011b) also proposes that physical activity alone cannot cause weight loss greater than a 5% change from initial body weight unless undertaken in excessive proportions and/or combined with restricted calorie intake. This affects the energy balance that regular exercise maintains. Goodpaster et al. (2010) concluded from a one year randomised trial amongst severely obese adults in Pittsburgh, America, that physical activity and dietary intervention can successfully reduce obesity. This research examined the impact of a 12 month physical activity programme combined with dietary interventions against a 12 month dietary intervention with a physical activity programme only in the last six months. The physical activity programme consisted of moderate intensity activity such as brisk walking and was built up to 60 minutes a day, five days a week, although this could be accumulated in ten minute or more sessions. This level of activity is not extreme and could be incorporated into an existing lifestyle without too much difficulty. At completion 101 participants remained: nearly 30% of these achieved weight loss greater than 10% of their initial body weight and a further 10% had lost more than 20% of their initial body weight. Whilst at the end of 12 months there was no significant difference in weight loss between the two groups, those who had exercised for the entire 12 months lost significantly more weight in the first six months. 80% of those who exercised from the beginning had lost more than 5% of their initial body weight at the six month mark compared to 60% of those who were only following the dietary intervention at that point. At the end of the year the proportion of participants who had lost more than 5% of their initial body weight was 78% and 65% respectively (Goodpaster et al., 2010).

As evidenced by Goodpaster et al., research supports that if combined with a moderate restriction in diet, between 150 minutes and 250 minutes of exercise could be effective as a means of weight loss for those who are overweight or obese (Donnelly et al., 2009). Without a dietary change, research emphasises the need to go beyond the recommended guidelines for general health benefits to 250 minutes or more of moderate intensity activity a week. This additional level of activity would be equivalent to five sessions of 50 minutes a week, or 35 minutes every day. Although Hill and Wyatt (2005) suggest that actually 60 minutes of moderate intensity activity a day is needed to maintain a significant weight loss, this is echoed by Jakicic and Otto (2005), who conclude that evidence shows 60 minutes or more per day is needed in order to maximise and maintain weight loss.

In a randomised controlled trial, 52 obese Canadian men were observed for three months in one of four groups: diet-induced weight loss, exercise-induced weight loss, exercise without weight loss and a control group. Those who were exercising for weight loss expended 700 kcal a day through exercise and followed a weight maintenance diet that all participants had followed for four to five weeks beforehand. Those who were exercising without weight loss carried out the same amount of exercise but compensated for this through diet. For both exercise groups the exercise consisted of brisk walking or light jogging on a treadmill for the length of time it took to expend 700 kcal and every session was supervised. Participants who lost weight through exercise lost an average of 6.1kg of body fat compared to an average of 4.8kg for those who lost weight through their diet. The other two groups had no significant changes in body fat (Ross et al., 2000). Whilst the time taken to burn 700 kcal will vary dependent on weight and fitness, the average duration of exercise for participants who lost weight from exercise was 60 minutes. These findings are supportive of the notion that significant weight loss requires high levels of activity if diet remains unchanged, but also show both physical activity and dietary interventions to be effective. More moderate levels of activity with moderate changes in diet may therefore be the most effective approach to tackling overweight and obesity.

MORE MODERATE LEVELS OF ACTIVITY WITH MODERATE CHANGES IN DIET MAY THEREFORE BE THE MOST EFFECTIVE APPROACH TO TACKLING OVERWEIGHT AND OBESITY



Research on a sample of 6,215 male and female Scottish adults explored the impact of different levels of physical activity and sedentary behaviour on obesity. Obesity was considered in two separate instances, firstly as defined by a body mass index of 30kg/m2 or higher, and secondly as a waist circumference of 88cm or more in women and 102cm or more in men. Activity levels were categorised into inactive (no moderate-to-vigorous intensity activity), insufficiently active (less than 150 minutes of moderate-to-vigorous intensity activity), sufficiently active for general health benefits (between 150 and 420 minutes of moderate-to-vigorous intensity activity) and sufficiently active for obesity prevention (at least 60 minutes a day of moderate-to-vigorous intensity activity), whilst sedentary behaviour was considered to be time in front of the television and other screen-based entertainment. Stamatakis, Hirani and Rennie (2008) found that not only is physical activity associated with the prevention of obesity, but also that sedentary behaviour is independently associated with obesity, therefore, along with the right diet, physical activity should be encouraged whilst sedentary behaviour is discouraged.

Even when participants spent 150 minutes a week or more on moderate intensity activity, where participants had four or more hours a day of sedentary behaviour there was a greater chance of both types of obesity than when sedentary activity made up less than two hours of the day. 27.5% of respondents meeting these criteria were classified as obese from their waist circumference and 20% were classified as obese from their body mass index. This is compared to 12% and 11.5% respectively for those who spent 150 minutes a week or more on moderate intensity activity and had spent less than two hours a day being sedentary. However, even the researchers for this study acknowledge that there is a possibility that this finding is due to over-reporting of activity from obese participants, considering that studies have shown that, *"obese individuals have the tendency to over-report physical activity in general"* (Stamatakis, Hirani and Rennie, 2008, p.769).

Stamatakis, Hirani and Rennie (2008) differentiated between sports (approximately 90 sport and recreation activities), walking and domestic activity. Whilst no trend was found with domestic activity and obesity, walking and sports were strongly related to waist circumference obesity, and walking was significantly related to body mass index obesity. Domestic activity levels showed little (1%) difference in the prevalence of both types of obesity, around 25% for body mass index obesity and 34% for waist circumference obesity, regardless of how much time was spent undertaking domestic activity. Amongst those who participated in 30 minutes or more moderate intensity sport a day, 21% were waist circumference obese compared to 40% of those who spent no time participating in sport. Sports participation at a moderate intensity for 30 minutes a day and 30 minutes a day or more of walking were associated with half the level of waist circumference obesity. 19% of those who walked for 30 minutes or more were waist circumference obese, again compared to 40% of those who spent no time walking. For body mass index obesity, 20% of those who participated in 30 minutes or more of sport were obese compared to 29% of those who didn't participate in sports. With walking the findings were 16% and 30% respectively. It is possible that a relationship between sports participation and body mass index obesity was not established because those with high levels of absolute muscle mass, and so relatively low levels of body fat, will have been classified as overweight or obese by the parameters of this research. Physical activity has not just been associated with reducing levels of obesity in the general population – there is also solid evidence that regular physical activity can go as far as to offset genetic susceptibility to obesity. From further analysis of 45 studies generating a sample size of 218,000 adults, Kilpeläinen et al. (2011) found that the effect of the FTO gene (a gene associated with a 20-30% increased risk of obesity) was reduced by 27% more in those classed as physically active in comparison to their sedentary counterparts. This has led the Medical Research Council (2011) to confirm that physical activity can be beneficial even if there is a genetic predisposition to obesity. Similarly, Li et al. (2010) assessed the role of physical activity on a genetic predisposition to obesity in a UK population study with 20,430 participants. This research found that regular physical activity can lessen a genetic predisposition to obesity by about 40%. This conclusion was reached by examining the extent to which groups of genes (alleles) responsible for obesity susceptibility influenced the chance of obesity. In physically inactive individuals the odds were 1.158 per allele, whilst in physically active individuals they were 1.095 per allele.

In 2011 the direct costs associated with obesity were estimated to be £5.1 billion per year in the UK; it is thought that this will reach £6.4 billion by 2015. The indirect costs of obesity are also significant: excluding for the moment further disease or illness brought about by obesity (obese women are almost 13 times more likely than non-obese women to develop type 2 diabetes whilst men are five times more likely[12]), it is thought that between £2.35 and £2.6 billion a year in lost earnings can be attributed to obesity through either obesity-related premature mortality or obesity related sick days (estimated at around 16 million sick days). Overall, in 2007 the total cost of overweight and obesity to society and the economy was thought to be around £16 billion (Department of Health, 2011). Calderdale Council in West Yorkshire had 43,000 obese adults in 2010. In 2009 the council invested £130,000 in a lifestyle programme (dietary and physical activity interventions) to help 700 adults lose 5% of their body weight. The year two saving to the NHS from this intervention was estimated at £53,000, with a year three saving of £160,000 (Director of Public Health, 2010). In short, obesity is incredibly expensive for our nation, whereas interventions involving physical activity, comparatively, are not.

12 Department of Health Website (2012), *Facts and Figures on Obesity*, http://www.dh.gov.uk/health/2012/04/obesityfacts/, last accessed 23.08.2012.

An economic evaluation of the cost-effectiveness of exercise referral schemes concluded from the evidence available that such schemes are cost-effective interventions in sedentary populations with and without a medical diagnosis. Pavey et al. (2011) assessed four previous economic evaluations, three of which were trial-based economic evaluations and one of which was a model-based analysis; three were also UK-based whilst one was outside of the UK, and all focused on adults aged 40-60 years old, as therefore did Pavey et al.'s modelling. Previous to Pavey et al.'s analysis, research on the cost effectiveness of exercise referral schemes has been equivocal and approaches have often varied. Using the model of quality-adjusted life years (QALY)[13] to measure cost effectiveness, Pavey et al. considered the impact of exercise referral schemes on coronary heart disease, stroke and type 2 diabetes, as the relationship between physical activity and the incidence of these diseases is quantifiable and data already exists on the loss of QALYs from developing these conditions. This makes the calculations more robust but does not account for the entire potential impact of exercise referral schemes, which may also bring about benefits in other ways such as the prevention of musculoskeletal diseases and improved mental health. The cost effectiveness of exercise referral schemes is ultimately seen to lie in their ability to increase the probability of an individual becoming active as it is physical activity that is related to improved life expectancy and quality of life through reducing the risk of coronary heart disease, stroke and type 2 diabetes.

To give context to Pavey et al.'s findings, NICE guidelines are that a drug or intervention that costs up to £30,000 per QALY is justified. Pavey et al.'s work indicates that exercise referral schemes are more cost effective per QALY for those who already have a medical diagnosis. They found that the cost per QALY was £20,876[14] in sedentary individuals without a medical diagnosis, £14,618 per QALY in sedentary obese individuals, £12,834 per QALY in sedentary hypertensive patients, and £8,414 per QALY for sedentary individuals with depression. Analysis also showed that when short term benefits of physical activity, such as increased mood or greater motivation for activity, were included the cost in those without a medical diagnosis reduced to between £17,032 and £18,559 per QALY.

13 The QALY model is a measure of disease burden that accounts for both the quality and quantity of life lived; it is often used for assessing the value for money of a given medical intervention. The final QALY figure is calculated on the number of years of life that the medical intervention adds. A year of perfect health is represented by the value of 1.0 whilst death is represented as 0.0. Extra years not lived in full health are given values between 0 and 1 to account for the loss of health dependent on its extent. The lower the cost to the higher QALY saved, the more cost-effective a medical intervention can be deemed to be.

14 All financial figures from Pavey et al. (2011) are at 2010 prices.

Compared to usual care, this research finds exercise referral schemes on average to be £169.54 per person more expensive, however this results in greater gains of eight QALYs per 1000 people. It should be noted that there are some limitations in the data that Pavey et al. used to calculate these costs; the costs are best treated as conservative estimates as a result. Even accounting for this, the figures indicate that exercise referral schemes and the benefits of physical activity on health fall under the NICE guidance £30,000 threshold and therefore are financially viable as treatments.

Yet conversely, Van Baal et al. (2008) have argued that whilst tackling obesity can reduce the costs of obesity related diseases such as diabetes and heart disease, this cost reduction will be offset by the costs of diseases unrelated to obesity that are experienced in the life-years gained from no longer being obese. This argument highlights how difficult it truly is to calculate costs relating to inactivity. McPherson (2008) explores the contradictions of this argument: *"Obese people cost less because individuals die younger and hence with less chronic morbidity associated with old age... But is it worth knowing that obese individuals are cheaper than lean ones for the health sector in the long run?... We have to be clear, therefore, about the distinction between lower lifetime health costs associated with obese individuals and higher costs of obese populations."* (McPherson, 2008, n.p.). It is also worth considering taking Van Baalet al.'s argument to the extreme.

MORE RESEARCH IS NEEDED INTO BOTH THE SHORT AND LONG-TERM COST EFFECTIVENESS OF PHYSICAL ACTIVITY INTERVENTIONS FOR HEALTH.

Given that there is evidence that physical activity can increase life expectancy – 15 minutes a day can increase life expectancy by three years compared with doing little or no exercise (Wen et al.2011) – does this then mean that the overall lifetime health costs of these individuals will be higher, even if they have a higher quality of life, and how might this change if these individuals have fewer episodes of poor health and so make greater contributions to society and the economy?

It is clear that much more research is needed into both the short and long-term cost effectiveness of physical activity interventions for health. However, controlling for all parameters of interest for such research will be near impossible.

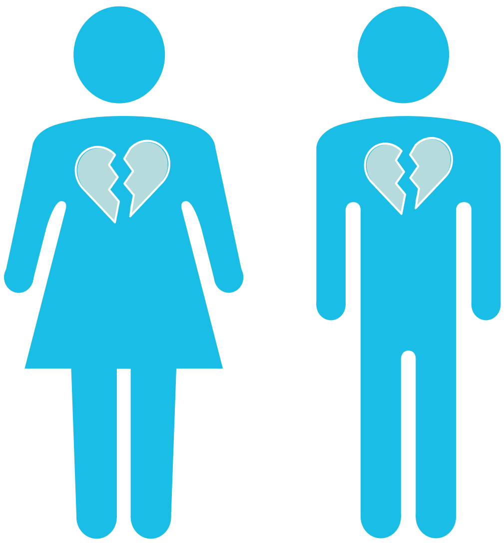
CARDIOVASCULAR DISEASES

We have already touched on an association between physical activity and a reduced risk of coronary heart disease. Almost half (46%) of the 180,000 deaths from cardiovascular diseases in the UK in 2009 were as a result of coronary heart disease. It is estimated that overall cardiovascular diseases cost the UK economy £30.7 billion a year (British Heart Foundation, 2011). It is thought that reducing cardiovascular disease in 1% of the population of England and Wales would save the National Health Service at least £30 million a year (Barton et al., 2011).

In the 1950s it was discovered that bus drivers in London were twice as likely to experience mortality from coronary heart disease as their counterpart bus conductors. This led to the hypothesis that the activity involved in the work of bus conductors, for example walking the length of the buses and going up and down the stairs on double-decker buses rather than remaining sedentary behind the wheel, protected bus conductors from coronary heart disease (Morris et al. 1953). The work of Paffenbarger and colleagues throughout the 1980s and 1990s is well known in this field of research as producing pioneering large scale, scientific studies aimed at understanding the relationship between physical activity and the risk of death from cardiovascular disease. Paffenbarger et al. (1986) assessed 16,936 male Harvard alumni from the ages of 35-74 to establish influences on rates of mortality from all causes and length of life. The sample completed questionnaires about their lifestyle characteristics, including physical activity, at start and follow up, which occurred after 12-16 years. During this time 1,413 alumni died. Physical activity in this research was defined as walking, stair climbing and playing sports. Burning 2000 kcal or more a week was seen to reduce all-cause mortality by between 22% and 27% and coronary mortality by 25%-33%. In addition physical activity was seen to increase life expectancy by an average of one to two years at the age of 80.

Later analysis by Warburton, Nicol and Bredin (2006a) of several studies found that mortality from a cardiovascular disease was 20% less likely following an increase in physical fitness of one metabolic equivalent (MET)[15]. Focusing specifically on the risk of heart failure in men, Kenchaiah, Sesso and Gaziano (2009) evaluated a prospective cohort of 21,094 male physicians from the American Physicians' Health Study. The sample had a mean age of 53 and no known coronary heart disease at the start in 1982. Data on participant demographics, medical history and lifestyle variables was gathered at the start through a questionnaire at six month intervals during the first year and then annually for the remainder of the study. After adjusting for confounding variables, compared to those who rarely or never undertook physical activity, men who exercised five to seven times a week had a 36% reduction in the risk of heart failure. The risk was 20% lower for those who exercised one to four times a week and 23% lower for those who exercised one to three times a month. The lower risk of heart failure in more active physicians held true within five years of follow up.

15 MET is the estimate of a person's resting metabolic rate. It is how much energy he or she expends when sitting quietly. 1 MET can be defined as 1 kcal per kilogram per hour, or 3.5ml of oxygen per kilogram per minute.



Large scale analysis on men and women echo these findings. Shiroma and Lee (2010) outline the evidence for lower rates of cardiovascular disease and coronary heart disease amongst those who are physically active. Drawing firstly on an evidence review that supported the 2008 Physical Activity Guidelines for Americans, Shiroma and Lee highlight 30 prospective cohort studies published between 1995 and 2007 that use self-reported data on physical activity to explore the risk of coronary heart disease. Conducted in the United States, the United Kingdom, Finland, Sweden, Canada, Israel and Norway, these studies had a total sample of more than 141,000 men and more than 263,000 women in gender specific analyses and more than 50,000 men and women in combined gender analyses. The conclusion from these 30 studies was that compared to their inactive counterparts, on average the most active men and women had a 30%-35% reduced risk of developing coronary heart disease. The threshold of 150 minutes of moderate-intensity activity a week was clearly associated with a risk reduction, but even small amounts of activity were seen to have an effect on reducing risk. These findings were on a par with those for the relationship between physical activity and cardiovascular disease.

The evidence for cardiovascular disease came from 20 prospective cohort studies also published during the same timeframe. These studies were conducted in the United States, Finland, the United Kingdom, Germany, Sweden, Norway, Canada and China and had a total sample of more than 68,000 men and 347,000 women in gender specific analyses and more than 88,000 men and women in combined gender analyses.

Four further prospective cohort studies published since 2008 are identified by Shiroma and Lee (2010). These found an average risk reduction for cardiovascular heart disease and coronary heart disease of around 40% (range 25% to 50%) for physically active people. Shiroma and Lee note that these findings cannot be considered as evidence of a causal relation due to their observational methodology but highlight that there is strong evidence available to support causality and, more importantly, there are biological mechanisms to support causality that have been demonstrated in randomised clinical trials.

Sattelmair et al. (2011) conducted meta-analysis of 33 prospective cohort studies to identify how much physical activity is required to reduce the risk specifically of coronary heart disease. These studies provided 30 assessments of leisure time physical activity, ten of which included quantitative data. Across the studies physical activity was associated with a 26% risk reduction for coronary heart disease, although this ranged between a 6% and 51% risk reduction across the studies. The risk was more greatly reduced amongst women than men, with studies conducted on men showing a 22% lower risk for physically active people when compared with the least active, and studies on women showing a risk reduction of 33%. Data from all studies showed that greater leisure time physical activity was associated with a reduction in the risk of coronary heart disease. In terms of quantity of physical activity, those who met the recommended guidelines of 150 minutes of moderate-intensity activity a week, equivalent to between 3 and 6 METs or 550 kcal a week, had a 14% lower risk of coronary heart disease compared to their inactive counterparts. 300 minutes of moderate intensity activity or 1100 kcal a week was associated with a 20% lower risk of coronary heart disease. Sattelmair et al. also found that, *"Additionally lower risks of moderate magnitude were observed among those with higher physical activity levels; e.g., there was a 25% lower risk for those active at 5 times the basic guideline"* (2011, p.792), indicating a dose-response relationship. This corresponds with the findings of O'Donovan et al. (2010), who argue that the evidence of a dose-response relationship between physical activity intensity and cardiovascular disease is compelling. Furthermore, the NHS believes there to be compelling evidence for a 40% reduction in the risk of ischaemic heart disease by being physically active.

From eight cohort studies with a combined sample of over 370,000, O'Donovan et al. conclude that activities characterised by more than 6 METs, typically described as vigorous intensity, are associated with a lower risk of cardiovascular disease than moderate intensity activities which are characterised by 3-6 METs. Unlike in Sattelmair et al.'s research, this appears to be more so for men than women. The intensity of an activity will vary by an individual's health, fitness, age, gender and the effort he or she is putting into the activity. Moderate activity can be gauged as that which raises the heart rate and breathing but so that it remains comfortable to speak conversationally, whilst vigorous activity results in a higher heart rate, more intense breathing and difficulty in holding a conversation. A huge range of sports are appropriate for allowing an individual to reach a moderate or vigorous intensity workout even as their fitness improves. These include, but are not limited to, tennis, running, cycling, brisk walking, badminton and dancing.

In a randomised control trial Flynn et al. (2009) found aerobic physical activity to also be beneficial for patients already suffering from heart failure. A sample of 2,331 medically stable outpatients with heart failure from 82 health centres in the United States, Canada and France were randomly split into two intervention groups. One group received usual care and aerobic exercise training, which was delivered through 36 supervised sessions and then home-based sessions. Exercises included walking, running and cycling at 60% to 70% intensity three times a week whilst under supervision and then five times a week at the same intensity at home. The other group acted as a control by receiving the usual care only. A questionnaire assessed health status with a score between 0 and 100, where higher scores indicated better health. These questionnaires were completed at the beginning of the research, every three months for the first year and then annually for up to four years. At three months health scores had improved by an average of 5.21 points for those who had been exercising and by 3.28 points in the control group, and this difference was statistically significant. Following this initial three months there was no decrease in this benefit but neither group experienced significant changes. At an individual level an improvement of five points or more was deemed to be clinically noticeable. After 12 months half (53%) of the patients who were exercising had an improvement of five or more points compared to just a third (33%) of the control group, leading Flynn et al. to conclude that, *"Exercise training conferred modest but statistically significant improvements in self-reported health status compared with usual care without training. Improvements occurred early and persisted over time"* (2009, p.1451).

In addition, research has shown that the progression of coronary heart disease can be halted by an additional energy expenditure of around 1,600 kcal per week and that additional energy expenditure of around 2,200 kcal has been associated with plaque reduction for those who already have heart disease (Warburton, Nicol and Bredin, 2006a).

Hamer and Stamatakis (2009) utilised data from the Scottish Health Surveys in 1995, 1998 and 2003 to identify 837 men and women with clinically diagnosed cardiovascular disease. Follow ups took place at an average of five years and found that 175 of the sample had died. Participating in sport for at least 20 minutes a week resulted in a 68% lower risk of all-cause mortality for patients with cardiovascular disease, whilst walking for 20 minutes or more a week resulted in a 26% risk reduction. The findings were similar for mortality from cardiovascular disease, showing that even low levels of physical activity can contribute to the secondary prevention of mortality and in particular mortality from cardiovascular disease.

The Changing the Physical Activity Landscape (CPAL) programme is an NHS County Durham initiative designed to encourage people aged between 40 and 74 with an estimated or actual risk of cardiovascular disease greater than 20% to increase activity levels though local partnerships with a range of sports and activities. The aim is to bring about a measured increase in the level of both structured and unstructured physical activity after six months and to reduce the risk of cardiovascular disease. The NHS has committed £4.5 million to the programme over three years.

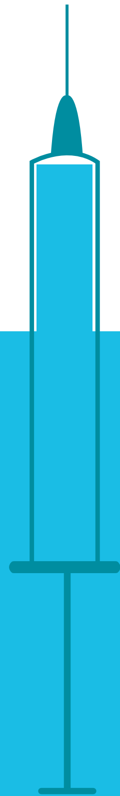
Participants are offered a range of activities which are delivered by 23 different organisations from the public, private, voluntary and community sectors; these include the Rugby Football Union, Amateur Swimming Association, the Ramblers and England Athletics. The project covers more than 100 of the top 30% most deprived wards across County Durham and is on course to meet the targets set by the NHS. At the end of December 2011, 8,409 people had benefitted from CPAL. Using a financial model developed by an independent consultancy, the most recent evaluation suggests that at the half way point in the programme it is achieving a return on the investment to date of £1.26 for every £1 invested. The evaluation also concluded that the programme has the potential to deliver up to £2.63 for every £1 invested by the end of March 2013, and a far greater return (£3.62 for every £1 invested) in the target group of those who are most at risk of cardiovascular disease (County Durham Sport and NHS County Durham, 2012).

DIABETES

One risk factor for cardiovascular disease is diabetes: people with diabetes are at least twice as likely to have cardiovascular disease than those without[16]. 2011 saw 2.9 million people diagnosed in the UK with diabetes. In addition, it is estimated that there are a further 850,000 people in the UK living undiagnosed with diabetes. This equates to more than one in 20 people (Diabetes UK, 2011). In adults diagnosed with diabetes, approximately 90% have type 2 diabetes, whilst 85% of children with diabetes have type 2. According to Diabetes UK, *"Type 2 diabetes develops when the body can still make some insulin, but not enough, or when the insulin that is produced does not work properly (known as insulin resistance). In most cases this is linked with being overweight"* (2011, p.3). It would therefore be logical that physical activity could have an impact on reducing prevalence of type 2 diabetes. Indeed, it is estimated that physical inactivity is the principal cause of 27% of diabetes globally (World Health Organisation, 2009). Currently in the UK diabetes is costing the National Health Service £286 a second, or around £9 billion a year, and the cost of 37.7 million prescriptions relating to diabetes in England in 2010 was nearly £713 million (Diabetes UK, 2011).

With regards to type 2 diabetes specifically, a prospective study of 5,990 men, 202 of whom developed type 2 diabetes, found that for every increase of 500 kcal of energy expenditure per week there was a 6% decrease in the incidence of type 2 diabetes (Helmrich et al., 1991, cited in Warburton et al., 2006a). In a randomised controlled trial over several years 3,234 non diabetic adults identified as at risk for type 2 diabetes were split into

16 World Heart Federation website (2012), *Diabetes*, http://www.world-heart-federation.org/cardiovascular-health/cardiovascular-disease-risk-factors/diabetes/, last accessed 23.08.2012.



three groups. One group took a placebo, the second took metformin and the third were prescribed a lifestyle modification programme that included a target of 7% weight loss and a minimum of 150 minutes of physical activity a week. Findings were that for every 100 person years in the placebo group the incidence of diabetes was 11.0 cases, for those taking metformin it was 7.8 cases, and for those with the physical activity lifestyle intervention it was 4.8 cases. In comparison to the placebo and prescribed drug, the lifestyle intervention was more effective in reducing the incidence of diabetes, having reduced it by 58% compared to 31% for metformin. The research concluded that, *"to prevent one case of diabetes during a period of three years, 6.9 persons would have to participate in the lifestyle-intervention program, and 13.9 would have to receive metformin"* (Knowler et al., 2002, p.393). This demonstrates that physical activity as part of a healthy lifestyle is twice as effective as drugs in preventing type 2 diabetes. It is also a fraction of the cost. Using the UK Diabetes data above, reducing type 2 diabetes in the UK by 6% through physical activity would not only enrich the lives of over 150,000 individuals but could save the NHS an estimated £4.9 billion a year[17].

Earlier academic research has focused on the specific biological changes brought about by physical activity that may be responsible for reducing diabetes. Ivy (1997) reviewed a range of epidemiological studies into the relationship between physical activity and both insulin resistance and type 2 diabetes. Highlighting that increased abdominal fat and a loss of muscle mass are associated with developing a resistance to insulin, Ivy concludes that regular physical activity can be beneficial in alleviating insulin resistance through causing fat loss around the abdomen. By preventing muscle atrophy and stimulating muscle development regular physical activity can also help to combat the reduced ability of insulin to stimulate muscle blood flow (as often occurs in insulin-resistant obese individuals and those with type 2 diabetes). Such benefits of muscle use and development would indicate that even when there is no weight loss, physical activity can be beneficial for type 2 diabetes. This was found by Balducci et al. (2010) in their 12 month randomised control trial. Balducci et al. concluded that physical activity, independent of weight loss, was associated with the reduction of hs-CRP[18] and other biological indicators of inflammatory and insulin resistance in patients with type 2 diabetes.

17 90% of 2.9 million people diagnosed with diabetes have type 2 diabetes; this is 2.61 million people. 2.9 million diabetics cost the NHS £9 billion a year, and this amounts to an average cost per person of approximately £3,100. 6% of 2.1 million people with type 2 diabetes is 156,600 people. 156,600 x £3,103.45 =£486,000,270

18 hs-CRP is a protein found in the blood. High base levels of hs-CRP are associated with an increased risk of diabetes.

Whilst there are benefits from physical activity generally, evidence shows that a combination of aerobic and resistance exercises is most beneficial for the management of type 2 diabetes. Church et al. (2010) explored the benefits of aerobic activity alone, resistance activity alone and both activities together on glycosylated haemoglobin[19]. The research consisted of a nine month randomised controlled trial with 262 men and women in Louisiana. All participants were sedentary, aged between 30 and 75, had type 2 diabetes and had glycosylated haemoglobin levels of between 6.5% and 11%. Alongside a control group that undertook stretching and relaxation classes, the participants were divided into an aerobic exercise group, a resistance exercise group and a combined exercise group, and all were supervised during exercising. The aerobic group undertook 150 minutes of moderate intensity exercise a week at a dose of 12 kcal/kg per week. The resistance group exercised three days a week, during which they carried out two sets of nine exercises. The combination group undertook resistance training of one set of the same nine exercises twice a week and carried out 150 minutes of moderate intensity aerobic exercise at a slightly lower dose of ten kcal/kg per week. Church et al. found that the aerobic group's exercise totalled between 623.7 and 681.9 MET/min per week whilst the combination group totalled between 532.0 and 572.8 MET/min per week.

In comparison to the control group, Church et al. found that there was a significant 0.34% reduction in glycosylated haemoglobin levels for those in the combination exercise group. The changes in the aerobic and resistance exercise groups were not significant compared to the control at a reduction of 0.24% and 0.16% respectively. Interestingly, when analysed by participants who had a glycosylated haemoglobin level of 7.0% or higher at the beginning of the research, aerobic exercise was seen to be effective in comparison to the control, with a reduction of 0.50% in glycosylated haemoglobin levels; for the combination group with this subset there was a 0.53% reduction. Using the measure of either a decrease in hypoglycaemic medication or a reduction in glycosylated haemoglobin levels of 0.5% without increasing medication as a primary outcome, Church et al. found that this occurred in 22% of the control group, 26% of the resistance exercise group, 29% of the aerobic exercise group and 41% of the combination exercise group. This means that type 2 diabetes patients who undertake 150 minutes of moderate intensity aerobic exercise and two resistance training sessions per week are 2.9 times more likely than their inactive counterparts to see an improvement in their levels of glycosylated haemoglobin.

A 2009 review of the evidence around exercise as a means of managing type 2 diabetes also explored the different impacts of aerobic and resistance exercise both independently and as combined factors. Zanuso et al. (2009) cite, amongst others, Kelley and Kelley's 2007 meta-analysis of seven studies which found that aerobic exercise reduced glycosylated haemoglobin and also reduced low-density lipoprotein[20] levels by around 5%. Kelley and Kelley (2007) focused on randomised controlled trials that had exposed participants with type 2 diabetes to supervised aerobic exercise for eight weeks or more. From seven studies in five different countries, the total sample was 220 men and women. Five of these studies had sufficient data to assess the impact of aerobic exercise on glycosylated haemoglobin; on average this was reduced by 0.4% in these studies.

The evidence on resistance exercise considered by Zanuso et al. supports the hypothesis that resistance exercises are beneficial for diabetes patients because they increase the skeletal muscle

19 Glycosylated haemoglobin can be used to measure average blood glucose levels over several months. Higher amounts of glycosylated haemoglobin indicate poorer control of blood glucose levels. Glycosylated haemoglobin levels of 6.5% or higher are associated with diabetes.

20 Low-density lipoprotein is a biochemical assembly that enables the transport of many different fat molecules, such as cholesterol, within the water around cells and within the water-based bloodstream. Increased concentrations of low-density lipoprotein particles are associated with the development of diabetes.

storage of glucose, which in turn improves glycaemic control. This aligns with the evidence from Ivy (1997) and Balducci et al. (2010) that shows physical activity can be beneficial for those with type 2 diabetes independent of weight loss. Early research highlighted by Zanuso et al. showed that whilst five months of progressive circuit resistance training didn't significantly reduce levels of glycosylated haemoglobin, it did prevent it from increasing, as a 0.4% rise was seen in the control group. This research also showed that resistance exercise reduced low-density lipoprotein cholesterol levels and reduced fasting triglyceride levels (Honkola et al., 1997, cited in Zanuso et al., 2009). Later, Castaneda (2002, cited in Zanuso et al., 2009) conducted a randomised controlled study with 62 older adults who either undertook high intensity progressive resistance training or were assigned to a non-exercise control group. Those who participated in resistance exercise had a 31% increase in muscle glycogen storage and a 1.1% reduction in glycosylated haemoglobin levels. Castaneda (2002) also found that medication for diabetes was reduced by 73% for those in the resistance exercise group compared to just 3% in the control group.

As Church et al. (2010) also found, Zanuso et al. conclude that evidence supports the notion that combined exercise is the most effective for patients with type 2 diabetes. Much of the research considered by Zanuso et al. (2009) is conducted with small samples. However the key findings largely hold true across the range of studies considered, including numerous other meta-analyses. As echoed by the findings of Church and colleagues, Zanuso et al. conclude that, *"the benefits of aerobic exercise are well documented and their effects in patients with type 2 diabetes are widely perceived to be beneficial for glycaemic control, weight loss, and the control of lipids and lipoproteins"*, and that *"resistance training has been shown to be beneficial with type 2 diabetic patients in a number of studies"*, whilst, *"a combined training program of strength and aerobic exercise could induce positive adaptations on glucose control, insulin action, muscular strength and exercise tolerance… Combined exercise training seems to determine additional change inHbA1c [glycosylated haemoglobin] that can be seen significant if compared with aerobic training alone and resistance training alone"* (Zanuso et al., 2009, pp.20-21).

It should be noted that the evidence assessed here by Zanuso et al. is not as robust as for aerobic and resistance exercise independently. Two studies focus only on the impact of combined programmes on postmenopausal women, and all but two have sample sizes smaller than 30. Of the two with larger sample sizes, one allowed for the

120 participants to self-select into an exercise or non-exercise group and no report was made on the post-intervention change between the two groups. This leaves only the work of Sigal et al. (2007) that stands up to scrutiny. Sigal et al. conducted a randomised controlled trial with 251 men and women aged 39-70 years and with type 2 diabetes. Participants were placed into an aerobic exercise group, a resistance exercise group, a combined exercise group and a no exercise control group. Those who were exercising did so three times a week and progressed in intensity and duration. For the aerobic group workouts progressed from 15-20 minute sessions at 60% of heart rate reserve to 45 minutes at 75% of heart rate reserve. The resistance group completed seven different exercises, progressing from two to three sets at the maximum weight that could be lifted for seven to nine repetitions. Participants in the combined exercise group did the full training of both the aerobic and resistance group. Glycosylated haemoglobin levels reduced significantly in the combined and resistance exercise groups, with 0.51% and 0.38% reductions respectively when compared to the control group. However, there was no statistically significantly difference between the groups for changes in blood pressure and lipid values.

The UK now has an ageing population due to increased life expectancy and a fall in birth rates. By 2035 it is thought that 23% of the UK population will be aged 65 or older, and it is estimated that 3.5 million of these will be aged 85 or over (Office of National Statistics, 2012). Alongside social, economic and political considerations there are of course significant health implications of this. Demakakos et al. (2010) found that for adults aged 70 and over, low intensity physical activity at least once a week was associated with a reduced risk of type 2 diabetes, whilst for adults aged between 50 and 69 the activity needed to be of moderate-vigorous intensity at least once a week. A sample of 7,466 men and women across England who did not have diabetes at the beginning of the research

BY 2035 IT IS THOUGHT THAT 23% OF THE UK POPULATION WILL BE AGED 65 OR OLDER AND IT IS ESTIMATED THAT 3.5 MILLION OF THESE WILL BE AGED 85 OR OVER

were followed on average for 45 months. After analysing the data by age, the research showed that the risk of type 2 diabetes was almost halved (hazard ratio 0.53) by low-intensity physical activity at least once a week for those aged 70 and over, whilst at this level of activity the odds remained around the same for those aged 50 to 59 years and 60-69 years (hazard ratio 1.09 and 1.15 respectively). But when those aged 50 to 59 years undertook moderate-vigorous intensity activity once a week or more, the risk of type 2 diabetes was reduced by half (hazard ratio 0.51). A risk reduction from moderate-vigorous intensity activity was still present in those aged 60-69, but was not as strong (hazard ratio 0.86). Interestingly, an increase in intensity of activity for those aged 70 and over did not have much of an effect on their risk of type 2 diabetes, with a hazard ratio amongst this group of 0.57.

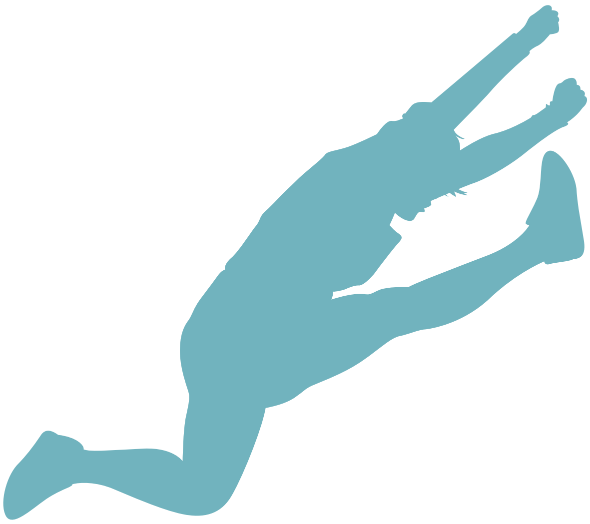
MUSCULOSKELETAL HEALTH

Evidence shows that low intensity exercise and exercise that focuses on muscular strength and endurance can benefit health in people of all ages by helping in the treatment and maintenance of musculoskeletal conditions including osteoporosis, which causes one in three women and one in 12 men to develop broken bones during their lifetime (National Osteoporosis Society, 2004). Physical activity can lower the risk of falls and fractures, reduce pain, improve muscle strength and stamina, and improve balance, posture and morale. This is, however, also particularly relevant for the ageing population in the UK, as greater musculoskeletal health in old age facilitates independence amongst elderly people, and, furthermore, in the first year after a hip fracture the mortality rate for elderly individuals is 15-20% (Schurch et al., 1996, cited in Kohrt et al., 2004). There are two widely accepted strategies for musculoskeletal health: firstly to maximise bone mineral density during the first 30 years of life, and secondly to minimise decline in bone mineral density after the age of 40, when bone mass decreases by 0.5% a year or more (Kohrt et al., 2004).

Cardiovascular or aerobic activities alone are not thought to be the most effective for musculoskeletal health. Kohrt et al. (2004) propose that, in accordance with the principles of exercise training, overloading forces applied to bones stimulate an adaptive response, and in order for this to continue the overload must be increased progressively. This stimulation is the physical deformation of bone cells as opposed to metabolic or cardiovascular stress that results in increased fitness as measured by VO2max[21]. Nybo et al. (2010) divided 36 untrained men into three exercise groups and a control. One exercise group completed 12 weeks of intense interval running training for a total of 40 minutes a week, the second group participated in prolonged running for 150 minutes a week and the third group spent 150 minutes a week on resistance exercises. Despite the shorter exercise time, those who had carried out intense interval training had a 14% increase in VO2max compared to a 7% and 3% for prolonged runners and the strength training group respectively. However, interval running and prolonged running had no significant impact on total bone mass/skeletal health and muscle mass, whilst resistance exercises improved total bone mass from an average of 3.31kg before to 3.37kg afterwards and bone mass in legs increased from 1.29kg to 1.32kg. Whilst this sample is small and the research period relatively short, these findings on the nature of activity needed to improve bone health are generally supported by other research in the area.

For example, Kohrt et al. (2004) considered small randomised controlled trials and large observational studies on both animals and humans to determine the relationship between physical activity and bone health. They found sufficient evidence that activities such as tennis, jogging, stair climbing (characterised as weight-bearing), volleyball, basketball and other activities involving jumping and resistance exercise or weight lifting can preserve bone health in adulthood, but that gains in bone mineral density do not appear to remain if regular exercise stops.

21 VO2max is the maximum capacity an individual's heart, lungs and blood has for transporting oxygen to muscles and the utilisation of this oxygen during exercise. It is used to measure cardiorespiratory fitness.



Kohrt et al. propose that these activities need to be of moderate-to-high intensity and that weight-bearing activities should be undertaken three to five times a week, with resistance exercises undertaken two to three times a week.

Janssen and LeBlanc (2010) examined ten experimental studies on changes in bone mineral density in response to exercising amongst children. They concluded that when combined with general weight bearing aerobic activities known for cardiovascular benefits, such as jogging or football, as little as ten minutes of moderate-to-high impact activities a day, two or three times a week can have an effect on bone mineral density. High impact activities are those where both feet leave the ground simultaneously creating high-intensity ground-reaction forces, such as jumping, skipping, gymnastics and ballet. Jumping, for example, can create a ground-reaction force 6-8 times an individual's body weight, whilst gymnastics includes moves that can generate a force 10-15 times an individual's body weight. Walking, on the other hand, typically generates a force 1-2 times an individual's body weight (McNitt-Gray, 1993, cited in Kohrt et al., 2004).

A four year longitudinal study assessed the impact of jumping on bone mineral content in children. Gunter et al. (2008) studied 107 girls and 98 boys with an average age of 8.6 years at enrolment. The children were from a number of schools and were randomly assigned to an intervention group that incorporated jumping into the PE curriculum, and a control group that ran a similar PE curriculum without any jumping. The intervention lasted seven months but the effects were followed up for three years. Bone mineral content was assessed for the whole body, total hip, femoral neck and lumbar spine; all were found to be improved for the intervention group and the effect was greatest immediately following the seven month intervention. Total hip bone mineral content was 8.4% higher for the intervention group compared with the control, lumbar spine bone mineral content was 7.9% higher, femoral neck 7.7% higher and whole body 7.3% greater.

After controlling for confounding variables, the three year follow up also found greater bone mineral content for those who had jumped as part of their PE curriculum. Femoral neck bone mineral content was 4.4% greater than the control, total hip 3.2%, whole body 2.9% and lumbar spine 2.3%. The research concludes that, *"short-term high impact exercise in pre-puberty has a persistent effect over and above the effects of normal growth and development. If the benefits are sustained until BMC plateaus in early adulthood, this could have substantial effects on fracture risk"* (Gunter et al., 2008, p.710).

Moayyeri et al. (2010) analysed data from the European Prospective Investigation of Cancer – Norfolk Study to explore the risk of fractures in relation to leisure time physical activity and non-leisure physical activity such as housework. 14,903 men and women from the original data were analysed at an average age of 63 years amongst the 6,514 men and an average age of 61.5 years for the 8,389 women. Amongst these there were 504 fractures of any type, including 164 hip fractures. Information on physical activity was only gathered through self-completed questionnaires at the start of the Norfolk study in 1998, but included four sections of activity: activity in and around the home, during work, transportation to work and recreational physical activity. After adjusting for confounding variables, Moayyeri et al. found a positive association between levels of leisure time physical activity and broadband ultrasound attenuation[22]. High levels of leisure time physical activity were associated with an increase of 0.76 in broadband ultrasound attenuation levels, whilst conversely higher levels of physical activity in the home saw reductions of 0.42 in broadband ultrasound attenuation levels, demonstrating additional benefits when physical activity is undertaken recreationally.

This research found a U-shaped association between total levels of physical activity (in all scenarios) and risk of fracture amongst men. That is, the lowest and highest levels were associated with an increased risk whilst moderate levels of activity were not. This was similarly found with the risk of home and leisure time activities on hip fractures in women. However, more than 300 MET-h/week of leisure time physical activity significantly reduced the risk of hip fractures in men. Walking for less than 90 minutes a week, either for leisure or transport, was associated with a reduction in risk for any type of fracture in women (hazard ratio 0.71), and for hip fractures specifically the risk reduction was greater with a hazard ratio of 0.56.

22 Broadband ultrasound attenuation is an indirect measure of bone mineral density.

When genders and duration of walking were combined, analysis showed an overall reduction in the risk of fracture from walking (hazard ratio 0.74).

In addition, 2,623 of the participants recorded participation once a month or more in high-impact exercises such as mountain climbing, aerobics, running competitively, rugby, hockey, horse-riding and wrestling amongst others. Only six of the 164 hip fractures occurred in this population, and all were in women. Floor exercises, including yoga and dancing, were not associated with risk of fracture at all in this sample. Moayyeri et al.'s research does not seem to be conclusive (for example, higher broadband ultrasound attenuation levels did not translate to estimates for the risk of fracture) but it does suggest that moderate leisure time physical activity is beneficial for the prevention of fractures in men and women, but that there are gender differences in the optimum type and intensity of activity. The findings also indicate that activities like yoga and dance can reduce the risk of fractures, whilst high impact activities do not increase it.

Michaëlsson et al. (2007) conducted a longitudinal population-based study with 2,205 men aged 49-51 to explore the relationship between leisure time physical activity and an osteoporotic fracture over a 35 year period. 482 men had at least one fracture during this time. Michaëlsson et al. found that 20.5% of the men with low physical activity levels suffered a hip fracture in comparison to 8.4% of those with high physical activity levels. The researchers conclude that, *"according to the estimation of population-attributable risk, one third of all hip fractures could be prevented by participation in regular sports activities"* (Michaëlsson et al., 2007, n.p.). Currently it is thought that there are 70,000 instances of hip fractures in the UK each year and that the overall associated costs are almost £2 billion a year (National Hip Fracture Database, 2011). By Michaëlsson et al.'s estimations, over 23,000 of these could be prevented through sport, which could potentially equate to a saving of over £600 million.

Community dwelling older adults at risk of falls and subsequent injuries can reduce this risk through general exercise, muscle strengthening and balance programmes or Tai Chi according to Gillespie et al. (2009). 111 randomised and quasi-randomised trials on interventions to prevent falls gave a sample of 55,303 participants, mostly aged 60 and over, from 15 countries. 43 trials explored the effect of exercise on falls and in all but two trials exercises were supervised to some extent. Exercise interventions included walking, gait balance and functional training, strength/resistance training, Tai Chi and square stepping. Gillespie et al. found that exercise classes that combined two or more categories of exercise significantly reduced both the rate of falls (pooled rate ratio 0.78) and also the risk of falling (pooled rate ratio 0.83). The studies also showed Tai Chai, which combines strength and balance training, to be effective in reducing the rate of falls (pooled rate ratio 0.63) and the risk of falling (pooled rate ratio 0.65). Gait, balance or functional training was seen to significantly reduce only the rate of falls (pooled rate ratio 0.73) but not the risk of falling, whilst other exercises had no significant impact. Additionally, data from Korpelainen's 2006 study showed a lower risk of fracture amongst women who exercised compared to the control group, with a 7% and 20% incidence of fracture respectively, although the sample size here was fairly small (160 participants). These findings suggest that activities that incorporate a combination of exercises are most beneficial for reducing the risk of falls for the elderly as they facilitate increased strength and better balance.

CANCER

The relationship between cancer and physical activity has been much examined, with the overall conclusion that routine physical activity can reduce the incidence of breast and colon cancer in particular. Globally it is estimated that physical inactivity is the principal cause for approximately 21-25% of breast and colon cancer (World Health Organisation, 2009). Professor Martin Wiseman, medical and scientific adviser for the World Cancer Research Fund (WCRF), has estimated that in Britain around 80,000 cases of cancer every year could be prevented if people ate better, maintained a healthy weight and exercised regularly (cited in The Daily Telegraph, 13 September 2010). The WCRF (2009) have concluded from their analysis of secondary data and a literature review that, *"regular sustained moderate and vigorous physical activity protects against colon cancer and probably against postmenopausal and endometrial cancer. It also protects against overweight and obesity and thus the cancers of which these are causes. It further protects against cardiovascular disease and a range of other chronic physical diseases, is good for psychological health, and improves general wellbeing."*

This statement indicates several relationships between physical activity and cancer. Evidence shows that regular exercise can reduce the incidence of breast and colon cancer and may reduce the risk of prostate, endometrial and lung cancer (Rajarajeswaran and Vishnupriya, 2009), reduce overweight and obesity – estimated to contribute to between 14 and 20% of all cancer-related mortality in the United States (Calle et al., 2003, cited in Kushi et al., 2012), enhance survival rates amongst breast, colorectal and pancreatic cancer patients and increase quality of life in all cancer patients.

BREAST CANCER

Eliassen et al. (2010) cite 11 studies on the association between physical activity and risk of breast cancer as finding between a 10-30% risk reduction for women with the highest levels of physical activity when compared to those with the lowest levels. The American Nurses' Health Study has previously found that moderate-to-vigorous intensity activity was associated with a lower risk of breast cancer. Using the same data, Eliassen et al. conducted further analysis to determine the importance of long-term and recent activity, changes in activity and specific types of activity. A sample of 95,396 married registered nurses aged 30 to 55 years at enrolment in 1986 completed a questionnaire in 1986, 1988, 1992, 1996, 1998, 2000 and 2004. The questionnaire recorded average time per week spent on each activity: walking/hiking outdoors, jogging, running, cycling, lap swimming, playing tennis, calisthenics/aerobics/aerobic dance/rowing machine and squash or racketball. Usual walking pace (easy/casual, less than 2 miles per hour; normal/average, between 2 and 2.9 miles per hour; brisk, between 3 and 3.9 miles per hour; very brisk/striding, more than 4 miles per hour) and number of flights climbed daily were also recorded. From this information MET hours per week (MET-h/week) were calculated.

Follow up recorded 4,782 cases of breast cancer. Higher levels of activity were associated with significantly lower risk of breast cancer, with 27 MET-h/week or more associated with a hazard ratio of 0.85 compared to women who did less than 3 MET-h/week (hazard ratio 0.98). This was also the case with body mass index, and those with a body mass index of less than 25 had lower risk of breast cancer compared to those with a body mass index of 25 or higher (hazard ratios 0.88 and 0.91 respectively). Looking at changes in activity over time, Eliassen et al. found that women who increased their activity from less than 9 MET-h/week at menopause to at least 9 MET-h/week afterwards had a reduced risk of

THE AMERICAN PROSPECTIVE NURSES' HEALTH STUDY HAS PREVIOUSLY FOUND THAT MODERATE-TO-VIGOROUS INTENSITY ACTIVITY WAS ASSOCIATED WITH A LOWER RISK OF BREAST CANCER

breast cancer compared to women who did less than 9 MET-h/week throughout (hazard ratio 0.90). Similarly, those who did 9 MET-h/week or more at menopause and continued at this level had a lower risk (hazard ratio 0.93). However, women who did 9 MET-h/week or more at menopause and did not continue at this level or higher did not have a reduced risk (hazard ratio 0.97), indicating that the benefits of physical activity on the risk of breast cancer require regular and continued physical activity of at least 9 MET-h/week. From an activity-specific perspective, whilst no activities resulted in an increased risk of breast cancer, only brisk walking was statistically significant in its association with reduced risk. Five hours a week (20 MET-h/week) of brisk walking resulted in a hazard ratio of 0.91.

Eliassen et al. highlight that other prospective studies with samples larger than 500 have predominantly observed a lower risk of breast cancer from physical activity (nine studies in favour to three against). Their research confirms this and expands on the importance of recent activity and the impact of specific activities. Lynch, Neilson and Friedenreich (2011) support Eliassen et al.'s findings, concluding from 73 studies across the world that high levels of physical activity were associated with a 25% reduction in the risk of breast cancer compared to low levels of activity, and that leisure time physical activity, sustained activity both over a lifetime and or after menopause, and moderate-to-vigorous intensity activity performed regularly had the strongest associations. Whilst all participants in the Nurses' Health Study were married and marriage has been associated with mental and physical health benefits (see Rendall, Weden, Favreault and Waldron, 2011, for an up-to-date review), it should be noted that the consensus amongst research on marital status and risk of cancer is that there is little evidence of an association (for a discussion of relevant research see Helgeson and McUmber, 2010).

Patel et al. (2003) used data from the American Cancer Society Cancer Prevention Study II Nutrition Cohort to explore the association between physical activity levels and postmenopausal breast cancer risk. The final cohort consisted of 72,608 postmenopausal women without cancer in 1992 when the study began. They completed a self-administered questionnaire at the beginning of the study and at regular intervals throughout the five year follow up period, during which time 1,520 incidents of breast cancer were identified. Women who took part in more than 42.0 MET-h/week of physical activity in 1992 had a 29% lower incidence of breast cancer compared to women who did less than 7.0 MET-h/week. This threshold of 42.0 MET-h/week is considerably higher than the 27 MET-h/week explored by Eliassen et al. (2010). The UK guidelines of 150 minutes of moderate intensity activity would equate to around 7.5 MET-h/week. 60 minutes of moderate intensity activity a day, or 420 minutes a week, is equivalent to around 21.5 MET-h/week. From Patel et al.'s study, reducing risk of breast cancer by 29% would require two hours of moderate intensity activity a day, a goal that is not realistic for many. Patel et al. hypothesise that physical activity causes this reduction in risk by influencing ovarian hormone production. This aligns with other research that has shown a higher risk of breast cancer with higher circulating oestrogen and androgen levels (Eliassen et al., 2006, Kaaks et al, 2005, Missmer et al., 2004 and Key et al., 2002, cited in Eliassen et al. 2010).

The work of Eliasson et al. (2010) and Patel et al. (2003) shows considerable variation in the amount of recreational activity required to reduce breast cancer risk. 9 MET-h/week appears to be the minimum level of activity required to reduce risk of breast cancer (hazard ratio 0.90 compared to less than 9 MET-h/week), which can typically be covered by 30 minutes of vigorous activity three times a week or 60 minutes of moderate intensity activity three times a week.

However, 20 MET-h/week expended through five hours of brisk walking has been shown to reduce the risk of breast cancer with a hazard ratio of 0.91, whilst 27 MET-h/week or more, equivalent to around a minimum of 75 minutes of moderate intensity activity a day, reduces the risk further (hazard ratio 0.85 compared to less than 3 MET-h/week). In addition, two hours of moderate intensity activity can reduce the risk by 29%. These differences are likely to be heavily influenced by the cohort methodology and reliance on self-reporting of physical activity levels. A brief look at some of the other large cohort studies between 2003 and 2010 highlights further discrepancies in activity levels. Tehard et al. (2006) studied 90,509 French women aged between 40 and 65 years at the start of the research. Between 1990 and 2002 there were 3,424 cases of breast cancer in the cohort. Women who spent more than five hours a week doing vigorous leisure time physical activity had a relative risk of breast cancer of 0.62 compared to their counterparts who were inactive during leisure time. Analysing their data by total leisure time MET-h/week, Tehard et al. noted a relative risk of 0.88 for 22.3-33.8 MET-h/week compared to inactivity, and 0.81 for 33.8 MET-h/week or more. Leisure time activity reduced risk more than domestic physical activity. McTiernan et al. (2003) studied a sample of 74,171 women aged 50-79 years across America. During the period of the study (1993 -1998), 1,780 cases of breast cancer occurred. Women who walked at a brisk pace for between 75 and 150 minutes a week had an 18% decreased risk of breast cancer (relative risk 0.82) compared to their inactive counterparts, this amounts to between 5.1 and 10 MET-h/week. However, women who exercised at a rate of more than 40 MET-h/week had a 22% reduction in risk (relative risk 0.78).

Cohort studies therefore show that physical activity is effective in reducing breast cancer risk by between 10% and 30%, and this is particularly so for postmenopausal women. Longer duration or higher intensity activity such as 60 minutes of vigorous intensity or two hours of moderate intensity activity a day brings about the most benefits, but moderate activity like brisk walking for several hours a week can also be beneficial. Findings from case control studies considering total activity (domestic and leisure time) have found greater associations: in a review of 17 studies including case control and cohort studies, Rajarajeswaran and Vishnupriya (2009) concluded that there is convincing evidence that physical activity reduces the risk of breast cancer by an average of 30-40%. Monninkhof et al. (2007) considered the evidence on physical activity and breast cancer risk from 19 cohort studies and 29 case control studies and also found that it was convincing, citing a 20-80% risk reduction in postmenopausal breast cancer, and an overall reduction of 15-20% from physical activity.

A recent case control study on 800 women in Tunisia conducted by Awatel et al. (2011) supports the trend for greater associations evidenced from case controlled studies. 400 women aged 25-75 years had breast cancer, the other 400 did not. All women completed a questionnaire on the types of physical activity they undertook and the duration, frequency and intensity of these. Women with breast cancer had lower lifetime averages in total physical activity than the control group; this was the case when measured in actual hours of exercise and MET hours. High levels of total physical activity led to a significant reduction in risk of breast cancer compared to low levels (odds ratio of 0.27 for high levels of activity and 0.42 for low levels). Postmenopausal women who were physically active had a greater reduction in risk (68%). Similarly, Ratnasinghe et al. (2010) conducted a multinational case control study with 1,463 breast cancer patients and 4,862 controls without breast cancer and after adjusting for confounding variables found that physical activity once a week or more gave women a 50% lower risk of breast cancer than those who exercised less than once a week.

Across all ethnic groups in the study (Caucasian-Americans, African-Americans, Hispanic-Americans, Tunisian-Arabs and Polish-Caucasians) physical activity of more than 30 minutes a week led to a minimum of a 35% reduction in risk.

COLON CANCER

There is also convincing research evidence for physical activity levels leading to a reduced risk of colon cancer. Wolin et al. (2009) conducted meta-analysis on 52 case control or cohort studies with a colon cancer end point. Physical activity in these studies included leisure time, domestic, occupational and commuting activity. Results showed a significant 24% reduction in the risk of colon cancer and little difference by gender (relative risk for men was 0.76 and for women was 0.79) or the structure of the studies. Ten case control studies and 16 cohort studies had data specifically on leisure time physical activity; these showed a similar risk reduction with a relative risk of 0.77 but this was greater in the cohort studies examined (relative risk 0.82) compared to the case control studies (relative risk 0.69) examined.

Using a sample of 83,767 female participants in the Nurses' Health Study, Wei et al. (2009) explored risk factors for incidence of colon cancer before the age of 70. 701 cases of colon cancer occurred in the sample between 1980 and 2004. Being consistently physically active at a level of 21 MET-h/week (around 60 minutes of moderate intensity activity a day) was associated with a 49% risk reduction in comparison to activity levels of 2 MET-h/week. Wolin et al. (2010) found further support for regular, high levels of physical activity and an inverse relationship with colon cancer. In a 156,331 mixed gender cohort from the American Cancer Society Cancer Prevention Study II Nutrition Cohort, 1,863 incidents of colon cancer and 846 fatal colon cancers were identified. This prospective study looked at changes in activity levels over ten and 15 years. Whilst changes in levels over time were seen to have no association (potentially due to only 4% of the sample increasing their activity levels over four years), at the ten year follow up, participants who had regularly exercised for 30 MET-h/week or more were 30% less likely to develop colon cancer compared to their inactive counterparts. Although no relationship for risk was seen at 15 years, further analysis revealed that consistent activity over time was still beneficial, as after 15 years these participants had a significantly reduced risk of death from colon cancer (hazard ratio 0.45).

CANCER AND OBESITY

Patel et al. (2005) also examined data from the American Cancer Society Cancer Prevention Study II Nutrition Cohort to assess the relationship between recreational physical activity, obesity and pancreatic cancer; they found that obesity was associated with double the risk of pancreatic cancer. The final cohort consisted of 145,627 men and women aged between 50 and 74 in 1992 when the study began. At enrolment, participants completed a ten page self-administered questionnaire that amongst other things gathered information on height and weight (for calculating body mass index) and frequency, type and intensity of physical activity undertaken; from 1997 onwards this questionnaire was sent out every two years for participants to self-complete. Patel et al. conducted their analysis from seven years of follow up, in which time there were 242 incidents of pancreatic cancer.

Taking a body mass index of over 30 as indicating overweight or obesity, Patel et al. found that compared to men and women of normal weight (defined by a body mass index of between 18.5 and 24.9), those with a body mass index of more than 30 had a relative risk of pancreatic cancer of 2.08. Furthermore, a body mass index of more than 23 at the age of 18 meant a 33% greater risk of pancreatic cancer in comparison to those with a body mass index of less than 21 at age 18. Patel et al. note that their findings on body mass index obesity and the risk of pancreatic cancer aligned with seven of eight previous studies observing large samples and the impact of a body mass index higher than 30. These seven studies found an increased risk of pancreatic cancer ranging from 20 to 180% for this group, with the eighth reporting no association, although the researchers noted that other additional studies had evidenced no association and that these differences were likely to be a result of methodology. However, Patel et al.'s study found no statistically significant relationship between leisure time physical activity levels and the risk of pancreatic cancer. This was confirmed by Bao and Michaud's (2008) systematic review of physical activity and the risk of pancreatic cancer and O'Rorke et al.'s (2010) systematic review and meta-analysis on the topic.

Parr et al. (2010) did not find obesity to increase the risk of pancreatic cancer amongst a large, diverse Asia-Pacific cohort (Asia, Australia and New Zealand), but did find it to increase all cancer overall and seven specific types of cancer. From 39 cohort studies Parr et al. analysed pooled data for 424,519 male and female participants with a mean age of 48 years. The final sample of 401,215 participants experienced 4,872 cancer deaths. Analysis adjusted for confounding variables found an increased risk of all-cause cancer mortality in obese (defined by a body mass index of 30kg/m2 or more) participants at a hazard ratio of 1.21 compared to those with a normal weight (defined by a body mass index between 18.5 and 24.9kg/m2). When explored, the risk of mortality was higher for seven specific cancers. Hazard ratios for obese participants compared to normal weight participants were 4.21 for cervix cancer, 2.62 for ovary cancer, 1.68 for rectum cancer, 1.66 for leukaemia, 1.63 for breast cancer in women aged 60 or over, 1.50 for colon cancer and 1.45 for prostate cancer. Overall, there was very little evidence of differences in risk by regions.

However, UK-based research on the Million Women Study found increased body mass index was associated with a significantly increased risk in ten of the 17 most common types of cancer. Reeves et al. (2007) conducted a prospective cohort study with 1.2 million women aged between 50 and 64 at enrolment. The participants were followed up for cancer incidence (average 5.4 years) and cancer mortality (average 7.0 years). 45,037 cases of cancer occurred and there were 17,203 mortalities. Reeves et al. concluded that amongst postmenopausal women in the UK, around 6,000 cases of cancer a year are attributable to being overweight or obese, which equates to 5% of all cancers in the UK. Compared to those of a normal weight (defined in this study as a body mass index between 22.5 and 24.9kg/m2), the relative risk for all cancers for those with a body mass index of 30kg/m2 or more was 1.12, and the relative risk of mortality from all cancers was 1.14. Of the specific cancers where an increased risk was evidenced for those with a body mass index of 30kg/m2 or more, the highest risks were for endometrial cancer (relative risk 2.73), adenocarcinoma of the oesophagus (relative risk 2.54) and kidney cancer (relative risk 1.52). For risk of a cancer-specific mortality the highest risks were also seen with these three cancers: adenocarcinoma of the oesophagus, relative risk 2.75, endometrial cancer, relative risk 2.28, and kidney cancer, relative risk 1.71.

It has already been documented that 250 minutes or more of moderate intensity physical activity can help address overweight and obesity (Donnelly et al., 2009). We have now also seen clear evidence that this in turn can reduce the risk of multiple types of cancer. This is not taking into consideration the influences that other obesity related conditions, such as diabetes, can have on risk of cancer and the impact of physical activity on these risk factors.

CANCER PATIENTS AND SURVIVORS

Physical activity is also held to be beneficial for improving the health and quality of life for people diagnosed with cancer. Traditionally, rest was thought to be beneficial for patients recovering from cancer, however research shows that physical activity is important for treating symptoms such as anxiety, fatigue and impaired mobility, improving quality of life in cancer patients and increasing chances of survival. As a result, Macmillan Cancer Support (2011) has calculated that of the 2 million cancer survivors in the UK, 1.6 million are not currently physically active to recommended levels.

Recommended levels in the UK for cancer patients are the same as those for the general population at 150 minutes of moderate intensity activity a week, but this should be gradually built up. The American Cancer Society recommends a higher dose of 150-300 minutes of moderate-to-vigorous intensity activity a week but the general consensus is that any level of physical activity is preferable to sedentary behaviour (Davies, Batehup and Thomas, 2011). From a range of evidence Macmillan concluded that, *"physical exercise for people with a cancer diagnosis is vital"* (2011, pg.4). A 12 week physical activity programme with 200 cancer survivors in Bournemouth found that in year one 100% experienced a boost in their self-image, 97% reported improved wellbeing, 94% felt less tired, 93% had improved cardio fitness and 59% lost weight. In addition, for those with high blood pressure, 90% experienced a decline, demonstrating clear health benefits (Macmillan, 2011).

Research carried out at the University of Hong Kong supports the Macmillan findings. Fong et al. (2012) conducted analysis on results from 34 different trials that assessed the effects of physical activity for adult cancer patients. Trials had an average of 93 patients who had suffered from one of six types of cancer. It was concluded that patients who had received breast cancer treatment and then taken part in physical activity programmes had improved health with regards to their blood sugar control, BMI and body weight, physical functions (such as limb strength), psychological outcomes (such as depression) and quality of life. Patients who had received treatment for other types of cancer had improved health with regards to their BMI, body weight, physical functions (such as oxygen consumption), depression and quality of life.

Davies, Batehup and Thomas (2011) conducted a literature review on the role of physical activity and diet in breast, colorectal and prostate cancer survivors to update a 2010 literature review they undertook for the National Cancer Survivorship Initiative. They concluded that *"regular physical activity is associated with improved cancer prognosis for breast, prostate and colon cancer survivors… Overall, the evidence suggests that the physical activity recommendations of the Department of Health (2011) are sufficient for cancer survivors – a total of at least 30 min a day of moderate-intensity physical activity on 5 or more days of the week"* (2011, n.p.). This echoes the more limited findings of a 2010 systematic review on physical activity and cancer survival, which considered only ten prospective cohort studies but nonetheless concluded that, *"patients diagnosed with cancer demonstrated a trend toward increased survival with greater levels of physical activity"* (Barbaric et al., 2010, p.25).

Examining the evidence for each type of cancer individually the research summarised by Davies, Batehup and Thomas is compelling; Irwin et al. (2008) found that women with breast cancer who were physically active at a level of 9 MET-h/week or more two years after diagnosis were considerably less likely to die (hazard ratio 0.33) than women who were inactive before and after diagnosis. Irwin et al. also found that whilst women who increased their physical activity levels after diagnosis almost halved their risk of mortality (hazard ratio 0.55), for those who decreased activity levels, the risk of mortality increased fourfold (hazard ratio 3.95). Similarly Holick et al.'s (2008) prospective study of 4,482 breast cancer survivors found that physical active of 2.8 MET-h/week was associated with a 35-49% reduction in risk of mortality from breast cancer.

More recently, Patterson et al. (2010) systematically reviewed leisure time physical activity and breast cancer survivors and concluded an association of a 30% decreased risk of mortality, whilst meta-analysis of six small studies from Ibrahim and Al-Homaidh (2011) found post-diagnosis activity reduced mortality from breast cancer by 34%, all-cause mortality by 41% and disease recurrence by 24% (all cited in Davies, Batehup and Thomas, 2011).

The evidence drawn on by Davies, Batehup and Thomas for physical activity and prostate cancer survivors includes Kenfield's (2010) prospective study of 2,686 men from the Health Professionals Follow-Up Study. Kenfield found that engaging in more than 3 MET-h/week after diagnosis reduced risk of all-cause mortality by 35% compared to those who did less activity. In addition, walking for 90 minutes a week at a normal-brisk rate was associated with a 51% reduction in risk of all-cause mortality in comparison to men who walked at an easy pace less than 90 minutes a week. However, in order to reduce the risk of cancer-specific mortality, men needed to engage in more vigorous activity. A more recent randomised controlled trial (Bourke et al., 2011, cited by Davies, Batehup and Thomas, 2011) showed that patients who received a 12-week lifestyle programme of aerobic and resistance exercise combined with dietary advice had increased quality of life compared to the control group. Although the sample was small at 50 men, the lifestyle programme group had improved exercise behaviour, dietary fat intake, total energy intake, fatigue, aerobic exercise tolerance and muscle strength.

For colorectal cancer survivors, the evidence from Davies, Batehup and Thomas is not as substantial, although it includes interesting findings from Haydon et al.'s (2006) observational study of 526 colorectal cancer survivors. Haydon et al. saw that at least one session of physical activity a week prior to diagnosis was associated with a greater chance of survival post-diagnosis – giving a 73% chance of five year survival compared to 61% for those who were active less than once a week.

Meyerhardt et al. (2009) also used data from the Health Professionals Follow-Up Study. From 661 male participants with colorectal cancer there were 88 colorectal cancer specific deaths and a further 170 deaths. Participants were divided into the following physical activity categories: 3 MET-h/week or less (15.4% of participants), 3.1-9 MET-h/week (18.9% of participants), 9.1-18 MET-h/week (15.3% of participants), 18.1-27 MET-h/week (12.3% of participants), and more than 27 MET-h/week (38.1% of participants). In comparison to men who expended 3 MET-h/week or less, men reporting between 18.1 and 27 MET-h/week had a hazard ratio of 0.76 for mortality from colorectal cancer and 0.74 for all-cause mortality. Expending more than 27 MET-h/week had a greater impact, with a hazard ratio of 0.47 for colorectal cancer mortality and 0.59 for all-cause mortality.

Further analysis by Meyerhardt et al. revealed that between 6-12 MET-h/week were beneficial for protection from mortality, whilst after 35 MET-h/week no additional benefits were seen. At a five year follow up, the proportion of men free of colorectal cancer mortality who engaged in less than 3 MET-h/week was 85.2% compared to 87.4% of men who engaged in between 3 and 27 MET-h/week and 92.1% for men engaging in more than 27 MET-h/week. At a ten year follow up, the proportions were 79.4%, 81.2% and 88.3% respectively.

CONCLUSION

The physical health benefits of leisure time physical activity are considerable. For optimum gain a range of activities – aerobic, resistance and weight bearing – should be undertaken regularly. For many health benefits, such as reducing the risk of cardiovascular disease and mortality and the risk of breast and colon cancer, a dose-response relationship has been evidenced. This highlights that some physical activity is better than none, and actually gains can be made up to a point by going beyond the recommended Government guidelines of 150 minutes of moderate-vigorous intensity a week. In order to tackle the obesity epidemic, physical activity is best combined with a dietary intervention and once weight is lost it is extremely effective for weight maintenance. Whilst obesity itself is a major health issue, there are health benefits such as musculoskeletal strength and improved management of type 2 diabetes that appear to come from improved fitness rather than a lower body weight or body mass index.