Personalised cardiovascular disease risk information as a motivator of behaviour change in individuals at high cardiovascular disease risk

Hermione Price

St Hugh's College

Thesis submitted to the Faculty of Clinical Medicine for the Degree of Doctor of Philosophy

University of Oxford

Trinity Term 2010

Nuffield Department of Clinical Medicine
Diabetes Trials Unit
Oxford Centre for Diabetes, Endocrinology & Metabolism
Churchill Hospital
Headington
Oxford OX3 7LJ

Personalised cardiovascular disease risk information as a motivator of behaviour change in individuals at high cardiovascular disease risk

Hermione Price, St Hugh's College

Thesis submitted to the Faculty of Clinical Medicine for the Degree of Doctor of Philosophy, Trinity Term 2010

Introduction
Cardiovascular disease (CVD) risk assessment is becoming increasingly common in routine clinical practice. Consequently many individuals are likely to be identified as being at increased CVD risk and risk reducing strategies implemented with a view to preventing future CVD. There are many steps along the pathway from CVD risk assessment to the prevention of CVD events. First, CVD risk needs to be accurately estimated using an appropriate CVD risk calculator. Secondly CVD risk information needs to be effectively communicated to the individual identified as being at increased risk. Thirdly, the risk information communicated needs to be capable of motivating behaviour change and finally behaviour change needs to result in a reduction in CVD risk. The evidence base for many of these steps has yet to be fully established.

Aims
The overall aims of this work were first to adapt the United Kingdom Prospective Diabetes Study (UKPDS) Risk Engine to better display risk and achievable risk. Secondly to investigate lay perceptions of risk and to develop two interventions designed to reduce CVD risk. The two interventions were a personalised 10-year CVD risk estimate and a brief lifestyle advice intervention. Finally, the capacity of these interventions to increase physical activity and improve CVD risk factors in adults at increased CVD risk was tested.

Methods
Three focus groups were held to investigate lay perceptions of risk and to inform the design of the UKPDS Risk Engine interface and a brief lifestyle advice intervention designed to motivate risk reducing behaviours. The two interventions were then tested in a 2x2 factorial randomised controlled trial.

Results
The focus group results demonstrated that public interest and understanding of risk was high. In addition participants expressed clear views regarding how risk information and lifestyle advice should be presented.
194 participants at increased 10-year CVD risk ($\geq$ 20%) were recruited from 4 Oxfordshire general practices. Neither a personalised 10-year CVD risk estimate nor a brief lifestyle advice intervention was capable of increasing physical activity or reducing estimated 10-year CVD risk in this group.

Conclusions
Whilst public interest in CVD risk appeared to be high this study was unable to demonstrate that a 10-year personalised CVD risk estimate or a brief lifestyle advice intervention was able to increase physical activity in adults at increased CVD risk.

Acknowledgements

First and foremost I would like to thank my supervisor Prof Rury Holman for his unwavering help, support and patience throughout my DPhil studies.

I would also like to acknowledge the vital input from Dr Simon Griffin particularly for his assistance in developing the brief lifestyle advice intervention and his expertise on measuring physical activity and behaviour.

I would like to thank Ruth Coleman for teaching me how to use the UKPDS Risk Engine, for developing equations for the Risk Engine based on LDL cholesterol and for drawing a Kernal Density plot.

I thank Dr Rebecca Simmons whose work on risk calculators in different populations was an essential underlying principle of this study.

Extreme thanks goes to the clinical research unit nursing staff including Christina Dudley, Sarah White, Beryl Barrow, Rachel Craven-Todd and Vanessa without whom the study would not have been possible.

I thank the Diabetes Trials Unit laboratory staff Robin Carter, Karen Fisher and Rhiannon Klyne for their management of my samples, particularly for processing them so rapidly to allow participants to receive their results and interventions at one study visit. I also thank the specialist immunoassay department at Addenbrooke's Hospital, Cambridge for analysing my plasma vitamin C samples and The Doctor's Lab, London for analysing my serum cotinine samples.

I thank Lynne Tucker and Luci Mansfield for their help with developing the protocol, obtaining ethical approval and producing study documentation.

I thank Ian Kennedy for creating the UKPDS Risk Engine interface used in my study and informatics for building my study database.

I thank all members of the DTU research review meeting past and present, for their helpful feedback and suggestions regarding my manuscripts. In particular I would like to thank Dr Andrew Farmer for his feedback on my study protocol and Dr Richard Stevens for his advice regarding risk estimation.

I thank the general practitioners, practice managers and administrative staff from all my participating practices for allowing me access to their patients and for making me feel welcome and assisting with my database searches.

I thank Kathy Waring and Lesley McMahon for their help with administration in particular, for all the photocopying, making of participant information packs and formatting of study documents and I thank Edward Gibbs for assisting me with funding applications.

Most importantly I thank those individuals who gave up their time and agreed to participate in my study.

Abbreviations used

4S	Scandinavian Simvastatin Survival Study
95% CI	95% Confidence interval
ASCOT	Anglo-Scandinavian Cardiac Outcomes Trial
ASSIGN	Assessing CVD risk using Scottish Intercollegiate Guidelines
AusDiab	Australian Diabetes, Obesity and Lifestyle Study
BMI	Body mass index
BP	Blood pressure
CARDS	Collaborative Atorvastatin Diabetes Study
CHOD-PAP	Cholesterol oxidase phenol-aminophenazone
CVD	Cardiovascular disease
DECODE	Diabetes epidemiology: collaborative analysis of diagnostic criteria in Europe score
ECG	Electrocardiograph
EIA	Enzyme immunoassay
ELISA	Enzyme-linked immunosorbent assay
EMIS	Egton Medical Information Systems
EQA	External Quality Assessment
GPO-PAP	Glycerol phosphate oxidase phenol-aminophenazone
GTT	Gamma-glutamyl transferase
HbA1c	Haemoglobin A1c
HDL	High density lipoprotein
HOT	Hypertension Optimal Treatment study
IFG	Impaired fasting glucose
IGT	Impaired glucose tolerance

IMDS	Index of multiple deprivation score
IQR	Inter-quartile range
LDL	Low density lipoprotein
LDS	Lipids in Diabetes Study
MRFIT	Multiple Risk Factor Intervention Trial
NADH	Nicotinamide adenine dinucleotide
NHS	National Health service
NICE	National Institute for Health and Clinical Excellence
ONS	Office for National Statistics
QOF	Quality and Outcomes Framework
SCORE	Systematic Coronary Risk Evaluation Project
SD	Standard deviation
SHHEC	Scottish Heart Health Extended Cohort
SPSS	Statistical Package for the Social Sciences
THIN	The Health Improvement Network
UK	United Kingdom
UKPDS	United Kingdom Prospective Diabetes Study
UV	Ultraviolet

Index of Tables, Boxes & Figures

Publications arising from this work

Cardiovascular Disease Risk Estimation: Why, When & How?
Price HC.
Diabetes & Primary Care 2009; **11**: 218-223

Use of focus groups to develop methods to communicate cardiovascular disease risk and potential for risk reduction to people with type 2 diabetes
Price HC, Dudley C, Barrow B, Kennedy I, Griffin SJ, Holman RR.
Family Practice 2009; **26**: 351-358

Impact of using a non-diabetes-specific risk calculator on eligibility for statin therapy in type 2 diabetes.
Price HC, Coleman RL, Stevens RJ, Holman RR
Diabetologia 2009; **52**: 394-397

The impact of individualised cardiovascular disease (CVD) risk estimates and lifestyle advice on physical activity in individuals at high risk of CVD. A Pilot 2x2 Factorial understanding risk trial.
Price HC, Tucker L, Griffin SJ, Holman RR
Cardiovascular Diabetology 2008; **7**: 21

Perceptions of heart attack risk amongst individuals with diabetes
Price HC, Dudley C, Barrow B, Griffin SJ, Holman RR
Primary Care Diabetes 2009; **3**: 239-244

Submitted manuscripts

Impact of a personalised cardiovascular disease risk estimate on physical activity
Price HC, Griffin SJ, Holman RR
BMJ

Impact of a brief lifestyle advice intervention on physical activity.
Price HC, Griffin SJ, Holman RR
BMJ

Risk Communication: Why, What & How?
Price HC
Diabetes & Primary Care

Background and aims

Chapter 1: Introduction

Cardiovascular disease (CVD) remains the leading cause of death in the United Kingdom (1). It is now clear that certain factors are associated with an increased likelihood of developing CVD. High blood pressure levels (2), an adverse lipid profile (3), cigarette smoking (4), obesity (5), presence of diabetes (6) and low levels of physical activity (7) have all been shown to be risk factors for CVD (8). In addition, the presence of a combination of these risk factors acts synergistically to increase CVD risk further (8).

Intervention studies have shown that addressing these risk factors can reduce the likelihood of developing a primary or secondary CVD event (9-11) and that addressing multiple risk factors has additional benefits (12, 13). Several large scale randomised controlled trials have firmly established the evidence for pharmacological treatment of CVD risk factors. The Scandinavian Simvastatin Survival Study (4S) (13) randomised 4444 individuals with a history of angina or myocardial infarction to receive simvastatin or placebo. A relative risk reduction of 42% for coronary death was seen in the simvastatin group (Odds Ratio 0.58, 95% confidence interval 0.46-0.73). Similarly, a 25% reduction in coronary death was seen in individuals with known coronary artery disease randomised to receive simvastatin rather than placebo in the Heart Protection Study (10). The Anglo-Scandinavian Cardiac Outcomes Trial (ASCOT) (12) was a primary prevention trial in which participants were randomised to receive the lipid-lowering agent atorvastatin or placebo and simultaneously randomised to receive either atenolol or amlodipine to reduce blood pressure. Atorvastatin resulted in a 36% relative risk reduction in non-fatal myocardial infarction and fatal coronary artery disease but in combination with amlodipine, this increased to a 53% relative risk reduction. The Hypertension Optimal Treatment

(HOT) study demonstrated the benefits of using pharmacological agents to reduce blood pressure in individuals with hypertension (14).

For individuals with type 2 diabetes CVD risk is an even greater problem as they have a 2-4 times greater CVD risk compared with non-diabetic individuals, even after adjustment for age, ethnicity, income, cholesterol level, systolic blood pressure and smoking (6). Pharmacological interventions addressing CVD risk factors in individuals with diabetes have also shown to be of benefit in terms of preventing CVD. These include tight glycaemic control (15, 16), lipid lowering therapy (17, 18) and intensive treatment of blood pressure (14, 19). CVD risk factors can also be ameliorated through lifestyle modification and in particular, physical activity. Physical activity reduces CVD risk independently of weight loss (20) and its impact is greatest in those at highest risk (21). In a meta-analysis of trials to promote physical activity among people with type 2 diabetes a 0.6% reduction in HbA1c was seen (22) and physical activity has also been shown to prevent or delay the onset of type 2 diabetes (23-25). The beneficial effects of physical activity on CVD risk are mediated through a lowering of blood pressure, increasing HDL cholesterol, reducing body fat and reducing insulin resistance (21).

With such a robust evidence base for the benefits of addressing CVD risk factors in order to prevent future CVD the identification and management of individuals at increased risk of CVD is gaining increasing credence particularly with the recent launch of the UK government vascular screening programme (26). However, whilst such a population approach to disease prevention is to be applauded there remains little conclusive evidence about the personal benefit of identifying individuals at increased risk in order to prevent future disease. This is in part because it has yet to

be shown that informing someone that they are at increased risk of future disease will result in them being motivated to adopt risk reducing behaviours.

The overall aims of this thesis are to explore the concept of risk, demonstrate methods to identify individuals at increased risk, discover engaging methods of communicating risk information and finally to determine if interventions designed to reduce risk in individuals at increased risk can be successful at motivating risk reducing behaviours. The two interventions to be tested are one, providing individuals with personalised estimates of risk and two, a brief lifestyle advice intervention.

Chapter 2: Cardiovascular Disease Risk Estimation

Risk assessment is fundamental to preventative medicine. Without it, individuals may not be identified as being at high risk of a disease and the chance to prevent that disease occurring may be lost. A variety of CVD risk calculators have been developed each from a different population and each with particular strengths and limitations. Many patients at increased CVD risk are easy to identify because they have high blood pressure, high cholesterol, diabetes or smoke cigarettes and their need for CVD risk reducing therapies is specified by national guidelines (27). Risk calculators are valuable because they allow identification of individuals without major risk factors who nevertheless are at high risk when the combined effect of their individual risk factor levels is taken into account. Identifying such people provides the opportunity to start treatments aimed at reducing CVD risk and allows equitable resource allocation.

Definitions of CVD

Risk calculators often differ slightly in their definition of a CVD event and hence CVD risk. Usual events to be included are myocardial infarction, stroke and death from a myocardial infarction or stroke. Additionally some calculators include angina, transient ischaemic attack, intermittent claudication, heart failure, coronary artery bypass grafting and percutaneous coronary angioplasty (28, 29). Essentially, the broader the definition of CVD, the more likely it is that an individual will have an event and this may explain why two risk calculators can give different estimates. A calculator has also been developed that only estimates the risk of dying from a CVD event (30).

Risk calculator selection

Participant characteristics

Risk calculators are usually created from data collected from clinical trials or epidemiological studies (Table 1). How well the individuals from the original study reflect the individuals in which the calculator is to be used will determine the appropriateness of any risk calculator (31). For example, the very commonly used Framingham equations (28, 32) (recommended by The National Institute of Health and Clinical Excellence (NICE) (33) and published in the British National Formulary (34)) were developed using data collected from the Framingham studies. Framingham is a town in Massachusetts, USA and has a mainly affluent White Caucasian population. These equations may therefore be less applicable in individuals living in an area with high levels of deprivation or in individuals from ethnic minority groups. In addition, all studies have inclusion and exclusion criteria. It may be inappropriate to estimate risk for a 45 year old if the study from which the calculator is derived only included people over the age of 50 years.

Validity

In order to be sure that a risk calculator is applicable to most patients it should have been shown to provide reliable and 'externally validated' estimates for many different individuals. For example, its results should have been tested and validated in individuals from different ethnic groups, of different ages and of different socioeconomic status. Many risk calculators only test their estimates by 'internal validation', using a sub set of the population from which the calculator was developed

to verify the results. This does not ensure that its result will apply in a population that is different from the one from which it was developed.

Missing data

Few studies will be able to collect every piece of information on every individual participant. It is important therefore to know how much information was missing and how the creators of the calculator handled this missing data. Often missing information will be imputed (35). Imputation is a statistical technique to replace missing data with estimated data based on what information is available. If large quantities of data are imputed then this may affect the accuracy of risk estimates produced.

Individuals with diabetes

Individuals with diabetes have a 2-4 fold greater risk of CVD than those without diabetes (6). This increased risk is not reflected by all risk calculators (36). This can be because only a small number of individuals with diabetes were included in the study from which the calculator is developed. For example, in the Framingham study only 428 of the 8491 individuals included in the calculator had diabetes.

Inclusion of multiple risk factors

Crude risk estimates can be made using simple clinical measurements for example waist circumference or body mass index (37). Including additional measures such as blood pressure and smoking status, and routine biochemical values such as LDL and HDL cholesterol can improve the accuracy of these estimates (32). However, many risk calculators attempt to increase the accuracy of their estimates further by including increasing numbers of risk factors (35, 38). Interestingly, including additional risk factors rarely improves the accuracy of risk estimates any further and makes many of these risk calculators redundant as novel risk factors, including highly sensitive C reactive protein levels or measures of carotid artery calcification, are not readily available in routine clinical practice (39, 40).

Although markers of obesity are often included in CVD risk equations in addition to routine biochemistry and blood pressure, (41, 42) when combined with these risk factors obesity no longer contributes to risk estimation. Whilst obesity is a major independent risk factor for CVD (43) the combined effects of downstream markers of risk (for example LDL cholesterol) provide a more accurate estimate of CVD risk (44).

Population based risk calculators

Framingham risk equations 2008

Data from the landmark Framingham Heart Study and Framingham Offspring Study have been used to update (28) the well-established Framingham risk equations (32). Framingham equations form the basis of many commonly used CVD risk prediction

charts including the New Zealand CVD risk tables (45). The equations are based on a population sample of 8491 adults aged 30-74 years. The great advantage of Framingham over other population study-derived risk equations is that data was extremely well collected and CVD events were meticulously assessed. Disadvantages include the dominance of White Caucasians and the relatively high socioeconomic status of the participants. The Framingham investigators realised their population was not ethnically diverse and have tested their equations in other ethnic groups including African Americans, Native Americans, Japanese American men, and Hispanic men (46). The equations were found to give reasonable estimates of 5-year CVD risk in non-diabetic African American men but overestimated risk in all other ethnic groups. Despite these drawbacks the Framingham equations remain the CVD risk calculator of choice for NICE (33) and are generally accepted to provide reliable risk estimates in the general population (47).

The Framingham equations only included a small number of individuals with diabetes (n=428) and the duration of known diabetes or other measures of disease severity such as HbA1c are not included. Both the original and more recent equations have been shown to underestimate CVD risk and coronary heart disease risk in individuals with diabetes although the newer equations perform much better (48, 49).

Systematic Coronary Risk Evaluation Project (SCORE)

The SCORE risk equation was developed to estimate the 10-year risk of dying from a CVD event in the general population only (30). The equations were produced based on pooled data from 12 European cohort studies including over 200,000 individuals and over 2.7 million patient years of follow up. Limitations of these equations

include the fact that each risk factor was only measured once and not repeated over a period of time. SCORE also only includes a limited number of risk factors (age, sex, total cholesterol or total:HDL cholesterol ratio, smoking status and systolic blood pressure). Whilst these are clearly the most important CVD risk factors, other key factors including diabetes and ethnicity are absent. The SCORE equations' accuracy has been tested in a large Austrian cohort of over 44,000 individuals drawn from the general population (50). Of these, 487 died from a CVD event. SCORE predicted that 666 CVD deaths should have occurred. However, SCORE did correctly identify those most likely to die from a CVD cause. The studies included in SCORE did not have a standard method of recording diabetes so unsurprisingly these equations have been shown to underestimate risk in people with diabetes (36) and therefore their use is not to be recommended in individuals with diabetes.

Diabetes epidemiology: collaborative analysis of diagnostic criteria in Europe score (DECODE)

The DECODE study group has developed risk equations to estimate the 5 and 10-year probability of dying from a CVD event. The equations were based on pooled data from 14 studies conducted across Europe. They include glucose categories based on fasting and 2-hour plasma glucose values, irrespective of whether or not an individual had a diagnosis of diabetes (41). The value of these equations in routine clinical practice however is questionable given the need for an oral glucose tolerance test. The studies included were all precise at determining if someone had died from a CVD event and at the end of the study vital status was known for more than 95% of participants. However, each study varied in how they collected biochemical

information. The authors also did not know how many of their participants had a history of a CVD event before entering into the study. This makes it difficult to interpret the risk estimates because of uncertainty in whether they are estimating the risk of having a primary or secondary CVD event. The investigators were also unable to include HDL cholesterol and triglycerides in their equations as these variables were not available. HDL has been shown to be an important CVD risk factor in other calculators (28, 51). Other limitations include the fact that only half of the studies collected data for ten years. This means that the 10-year risk estimates are based on much less information that the 5-year estimates. However, unlike many other studies, DECODE included a large number of younger people. Over half the male participants and one third of the female participants were under 50 years of age at entry to the study. Two of the studies included in this calculator did not record if participants had diabetes and so it is not recommended for people with diabetes.

QRISK2

The QRISK2 investigators aimed to develop a risk equation reflecting ethnicity and social deprivation as these factors are not included in the Framingham equations. QRISK2 (which supersedes QRISK (29)) uses data routinely collected from 531 UK general practices between 1993-2008 and includes information from 2.3 million patients (35). Participating practices were chosen because they used the Egton Medical Informations System (EMIS). QRISK2 holds data from more than 22,000 south Asians, 11,500 black Africans, 10,400 black Caribbeans and 19,700 Chinese and other ethnic groups and uses postcodes to determine economical status ('deprivation score'). QRISK2 also includes family history of premature CVD (CVD

event in a first degree relative under 60 years old), presence of rheumatoid arthritis, chronic kidney disease and atrial fibrillation. Another advantage of QRISK2 over QRISK is the link to the Office of National Statistics (ONS) to collect more accurate information on CVD deaths. QRISK2 has been found to be better than both QRISK and the Framingham equations in predicting the chance of having a CVD event (35). However, although QRISK2 uses information from a large sample of the general population it does have several limitations. It excluded all individuals taking statin therapy, those with no valid deprivation score, temporary residents and those without at least one year of follow up.

The exclusion of those already taking statin therapy is interesting as they would have already been identified as being at high CVD risk. The exclusion of those without a valid deprivation score or temporary residents may exclude some of the most deprived communities including those of no fixed abode or travelling communities. A particular problem with QRISK was the large amount of missing data particularly for total cholesterol (29). Missing data remained an issue for QRISK2 but investigators used a more sophisticated statistical technique to replace missing data (52). QRISK2 has been internally validated but has not been tested in any other populations whereas the original QRISK was successfully externally validated using data from the Health Improvement Network (THIN) (53).

Interestingly although QRISK2 was developed specifically to improve CVD risk estimation in deprived and ethnic minority groups, self-reported ethnicity was only available for a quarter of patients in the study. Type 2 diabetes is included in QRISK2 as yes/no and is therefore likely to underestimate risk in people with diabetes

as other calculators that do not include HbA1c or duration of known diabetes tend to underestimate risk in people with diabetes (36).

Assessing CVD risk using Scottish Intercollegiate Guidelines (ASSIGN)

The aim of the ASSIGN equations was to reduce health inequalities by including a measure of social deprivation in CVD risk calculations. The ASSIGN investigators felt that the Framingham equations did not adequately address the gradient in CVD risk associated with increasing social deprivation and that this may result in an inequitable allocation of resources. ASSIGN uses data from the Scottish Heart Health Extended Cohort (SHHEC) that included over 13,000 adults who had not had a CVD event when they entered the study (38). Participants were followed for between 10-21 years and during this time there were over 1000 CVD events. These equations have not been tested in any other population but ASSIGN was found to be in good agreement with, but no better than, the Framingham equations (38). The ASSIGN equations were unable to include ethnicity as their population included few individuals from ethnic minority groups. The ASSIGN equations have not been validated for use in individuals with diabetes.

Diabetes Specific risk calculators

Swedish National Diabetes Register calculator

This is a diabetes specific CVD risk calculator based on data from over 11,000 individuals in the Swedish national diabetes register (42) and includes over 1400

CVD events. However, the calculator was developed using routinely collected data and not via a clinical trial and fails to include any lipid measurements. This inconsistent data collection and no independent verification of CVD events raise questions about the accuracy of the data used. In addition, no external validation has been performed.

United Kingdom Prospective Diabetes Study (UKPDS) Risk Engine

The UKPDS Risk Engine was developed specifically for estimating CVD risk in individuals with type 2 diabetes using data from the UKPDS clinical trial. Version 3 of the Risk Engine (51) calculates the probability of having a CVD event and the probability of dying from a CVD event. Whilst most often used to calculate 10-year risk, the UKPDS Risk Engine can be set to estimate risk over any time period. The UKPDS Risk Engine includes data from 3475 individuals (53,000 patient years) enrolled in the UKPDS study. Participants had newly diagnosed type 2 diabetes and had not had a CVD event when they entered the study allowing the Risk Engine to estimate the probability of a primary CVD event. The Risk Engine includes HbA1c and takes into account duration of known diabetes. It has been successfully validated against data collected from the Collaborative Atorvastatin Diabetes Study (CARDS) (17, 51) but has also been found to underestimate risk in individuals with diabetes from the UK although not to the same extent as the Framingham risk equations (48).

The UKPDS Risk Engine has undergone external validation and has been shown to be more appropriate for use in individuals with diabetes than calculators developed from samples of the general population. The UKPDS Risk Engine has also been found to be capable of ranking CVD risk even in individuals without diabetes. However, it

over estimated risk in individuals without diabetes when compared to the Framingham equations (54).

Risk calculators assist with the identification of individuals at increased CVD risk thus allowing healthcare professionals to initiate risk reduction strategies. Risk calculators vary in their accuracy at predicting risk for an individual but there appears to be reasonable agreement between them in ranking individuals according to risk. The ability of risk calculators to motivate behaviour change aimed at reducing CVD risk has yet to be evaluated.

Table 1: Comparison of commonly used CVD risk calculators

	Framingham risk equations	SCORE	DECODE	QRISK2	ASSIGN	Swedish Diabetes Register	UKPDS Risk Engine
Number of patients	8,491	205,178	25,413	1,535,582	13,297	11,646	3,475
Proportion of female patients	53%	43%	35%	50%	51%	43%	42%
Age range (years)	30-74	19-80	30-74	35-74	30-74	18-70	25-65
Mean age (years)	49	Not reported	Not reported	49 women, 48 men	49	Not reported	59 women, 57 men
Proportion of participants with diabetes	5%	Not reported	9%	2%	1.4%	100%	100%
Number of CVD events	1,174	7,934 deaths	791 deaths	96,709	1,165	1,482	581
Person years of follow-up	Not reported	2,700,000	Not reported	10,925,675	Not reported	58,342	53,000
Average length of follow-up (years)	12	Not reported	4.8-10	Not reported	10-21	5.64	10.3
Only for use in people with diabetes?	No	No	No	No	No	Yes	Yes
Accurate in people with diabetes?	No	No	No	Not known	Not known	Yes	Yes
Externally validated?	Yes	Yes	No	No	No	No	Yes

Chapter 3: Risk Communication

Why talk to people about risk?

One of the key roles of the healthcare professional is to discuss the risks and benefits of a particular treatment or course of action (55, 56). The aim of risk communication is to reduce uncertainty and confusion and to help patients choose a course of action, preferably one that will reduce risk (57). This might include discussing the need for mammography, immunisation, the risks and benefits involved in undergoing an elective surgical procedure, quitting smoking or taking medication as prescribed. In order to do this healthcare professionals need to translate raw data from clinical trials or risk calculators into information that the patient can readily understand and use to make an informed choice (58, 59). Undoubtedly there are challenges in translating scientific data into an acceptable form for patients but if this information is not communicated properly the healthcare professional risks providing information that is misleading or inaccurate (60). Criticism of poor communication between healthcare professionals and patients is the most commonly encountered finding of patient satisfaction surveys and highlights the need for improvements in this area (61). If done well, risk communication provides an ideal opportunity to involve the patient in making decisions about their care particularly when the professional has no clear preference regarding the choice made (62).

Risk communication becomes ever more important with healthcare professionals increasingly being asked to identify individuals at increased risk of developing disease in the future. Often these individuals will have no symptoms and will not be aware that they are at increased risk of future ill health. One current example of this is the government's recently launched vascular risk assessment programme (26) that requires all adults aged 40-70 years to undergo vascular risk estimation and

subsequent management of CVD risk factors. Many individuals are likely to be identified as being at increased risk of vascular disease and will require an explanation as to what this means and what can be done about it.

The area of risk communication is vague and remains poorly researched and even the government has acknowledged that at the moment there is no clear agreement on how best to communicate risk information (26). In addition, risk is in general, poorly understood (63).

What is a risk estimate?

A risk estimate is the probability that an individual will develop a disease at some point in the future or that an event will occur in relation to an existing condition. In many situations the individual at risk will be currently asymptomatic and unaware of their risk.

Certainty and uncertainty

Epidemiology is able to inform us about the rates of disease in a population and also factors associated with increasing or decreasing likelihood of developing a condition or its complications. Epidemiology is not however, able to give us any indication if any one individual is the one in one hundred who develops a certain condition or outcome. This holds true even when the individual has been identified as being at increased risk (60). Communicating the concepts of probability and uncertainty that a particular behaviour or treatment will cause an effect are crucial to effective risk

communication (64). Risks range from the hypothetical, where the risk is possible but there is no evidence of certainty, to the clearly identified where certainty has been established and the level of risk is known (64). However, even when the level of risk is known the chance of an individual patient experiencing this risk remains a probability (64). For example, a healthcare professional discusses the need for statin therapy with a patient with type 2 diabetes. The healthcare professional states that if 100 similar patients take a statin for one year then 0.94 of them will have an acute coronary heart disease event. However, if all 100 patients decide not to take a statin 1.47 of them will have an acute coronary event (17). In addition, 1 in 1,000 patients taking a statin will experience myopathy and there is a hypothetical risk of death from rhabdomyolisis (65, 66). We do not know if the patient sitting in front of us will be one of the patients that will be protected from an acute coronary heart disease event by statin therapy or if they will be one of the minority of patients to develop myopathy or the very rare patient who develops rhabdomyolisis. Communicating this uncertainty is a difficult but key element of risk communication.

Level of risk

The level of risk must be known for an individual in relation to the rest of the population. This can be estimated using simple clinical measures such as waist circumference to estimate CVD risk (37) or from genetic information (67) or most accurately, from risk equations (29, 32, 35, 68).

The effect of risk on the individual

The way in which individuals respond to risk information differs and may not be the same as the healthcare professional. Individuals perceive and react to risk in different ways (69). The effect of risk awareness on an individual may often be quite different from that which the healthcare professional would expect or want. When this is the case, the risk communication consultation should attempt to address this with the aim of helping an individual to make an informed decision. If a particular behaviour (for example continuing to smoke cigarettes) is clearly associated with a hazard (for example lung cancer (70) an individual may choose to continue to smoke despite the evidence presented. In this case the individual should be made aware of the consequences of their decision (64). In addition, it needs to be made clear that in most cases, even with optimal lifestyle or therapy, the individual will still remain at some degree of risk. The healthcare professional needs to explain clearly what is achievable (how much of their risk is reducible). For example, in the case of cardiovascular disease, age (6) and sex (71) are major risk factors and these cannot be altered yet risk can be reduced by treating modifiable risk factors including lowering cholesterol levels (12) and treating high blood pressure (14). However, in the case of quitting smoking, an individual can return to the usual risk of lung cancer for a person of their age and sex after 10 years (70).

Adverse psychological effects of communicating risk

It has been known for over forty years that providing adverse health related information can result in adverse psychological effects. A study in the 1970's demonstrated that informing steel workers that they had high blood pressure resulted

in an 80% increase in illness-related work absenteeism (72). This was seen irrespective of how severe the hypertension was or how much medication was being taken. Researchers have attempted to determine how often and under what circumstances predicting the risk of future illness results in an adverse psychological effect (73). Studies have been conducted in a range of future conditions including CVD and Huntington's disease and have looked at different psychological aspects over the short (<1 month) and long term in individuals receiving both positive and negative results. The results of a total of 54 studies have been pooled in an attempt to shed light on these questions (73). Unfortunately the quality of the studies included varied, making it difficult to draw clear conclusions. For example, only two studies randomised their participants and each study measured psychological distress differently. However, the authors of this overview concluded that when an asymptomatic individual receives adverse information about the future risk of developing a disease, some anxiety and distress is inevitable. This does not appear to persist long-term and can be reduced by interventions aimed at minimising these effects. Interestingly, disease type and severity did not seem to make a difference to the psychological distress experienced with similar results seen for preventable and treatable conditions such as diabetes and CVD as for certain and more debilitating conditions such as Huntington's disease.

The idea that psychological distress is short-lived is supported by a study that investigated anxiety in people three years after informing them if they carried the defective gene for cystic fibrosis or not. Levels of anxiety were no different in those informed they had the gene and those informed that they did not (74). Interestingly, those who were told they did carry the gene reported lower levels of current health

even though they had been told that carrying the gene did not have any implications for their own health.

Recall of risk information

Informing an individual on one occasion that they are at increased risk of disease may be inadequate to motivate behaviour change. It appears that few people are able to remember their risk when asked at a later date. In the study described above, only 43% of negative and 80% of positive for carrying the cystic fibrosis gene adults could correctly recall their cystic fibrosis gene status three years later (74). Recall of risk information has also been found to be poor in individuals with type 2 diabetes who were told their personal risk of future coronary heart disease (75). This apparent failure to retain personalised risk information could harm an individual's ability to make informed decisions.

Tailored risk information

Individually tailored risk information has shown modest success in increasing the uptake of mammography by women. In one study women were sent a questionnaire asking them about risk factors for breast cancer. Once a questionnaire had been returned the information it contained was used to tailor a mammography invitation letter according to each participant's own level of risk (76). This tailored information only increased mammography attendance in those with a family history of breast cancer and not in those identified as being at increased risk for other reasons. The design of this study did however have some problems, and this may have affected the

results. Women who did not return their questionnaire were included in the study and a proportion of women who did return the questionnaire did not actually meet the inclusion criteria for the study (for example because of a personal past history of breast cancer). Personalised information concerning cholesterol levels however, has been shown to be successful at changing behaviours designed to reduce cholesterol levels and was described by participants as "engaging and memorable", "a wake-up call" and "frightening but important" (77). The Department of Health commissioned a review of risk communication and concluded that the provision of personalised risk information was the only risk communication intervention to have been found to work consistently and to have been evaluated in primary and secondary care (62).

Risk factors without symptoms

Communicating CVD risk information can be particularly difficult because many of the risk factors rarely cause specific symptoms, for example high blood pressure (78) or high cholesterol. Studies show that risk factors without symptoms are not considered to be a disease and that people rarely associate a high cholesterol level with risk of cardiovascular disease (79, 80). This is supported by a survey that found that cholesterol levels were viewed as unstable and unpredictable and not perceived as a disease (79).

Understanding the link between behaviour and disease

Psychologists have suggested that motivation to change behaviour depends not only on perceiving a threat (for example, smoking causing increased risk of cardiovascular

disease) but also on understanding the link between the behaviour and the threat, in this case, understanding how smoking damages blood vessels and thus causes cardiovascular disease (81). One study has shown that providing a clear explanation for a relationship without a commonsense mechanism can increase a person's perceived vulnerability to a condition and intention to change behaviour to reduce this risk (81). The researchers wanted to inform women about the link between smoking and cervical cancer. Women who were current smokers were provided with no explanation, a brief explanation or a more comprehensive explanation. The brief and in depth information were equally as successful at increasing perceived vulnerability and intention to quit smoking compared to no information. This is important as these women were unlikely to select smoking cessation as a method of reducing their risk of cervical cancer as no sensible explanation would have previously linked the two. Spending time explaining the relationship between risk factors and disease appears to increase the likelihood of a patient changing their behaviour to reduce risk.

Patients' perceptions of risk

Without proper risk assessment the patient and healthcare professional may have inaccurate views of disease risk. If a risk estimate is not based on objective information (for example blood pressure, cholesterol and age) the healthcare professional may provide a patient with an unrealistically optimistic or pessimistic risk assessment. In addition, if a patient has their own inaccurate estimate of risk of developing a disease it may impact on their health behaviour. For example, if a patient perceives that they are at much lower risk than they actually are, then they may not attend for health screening (for example mammography). However, if a

patient thinks they are at much higher risk than they actually are, this may cause them undue anxiety and distress. Women have been shown to overestimate their own risk of breast cancer by an average of 20% even after they had been told what their risk was (82). Individuals with type 2 diabetes have been shown to be both unaware of and to overestimate their risk of future cardiovascular disease (75, 83) perhaps because they perceive that CVD is related more to stress and hereditary factors than smoking or cholesterol levels (80).

Measuring success

The lack of agreement between researchers on how to measure the success of risk communication techniques makes it hard to draw conclusions about the effectiveness of different techniques. This difficulty has been acknowledged and researchers have attempted to construct standardised measurements for risk communication studies (55). This is an important step forward if the key components of what makes a successful risk communication intervention are to be established. Traditionally researchers have measured a mixture of cognitive and behavioural outcomes that include the ability to correctly recall risk information and the change in risk reducing behaviour, for example compliance with prescribed therapies. It has been recognised that this may not fully describe patient experiences and that other outcomes should also be included such as satisfaction with communication (57).

Can we communicate risk using words instead of numbers?

Studies have shown that patients prefer risk to be expressed in terms of words rather than numbers, but have also shown that there is wide variation in how verbal expressions of risk are interpreted (84, 85). In one study researchers investigated how 22 different expressions of risk were interpreted by patients and doctors. These included words such as “infrequent”, “sometimes”, “often”, “common” and “typical”. For 17 of these words the ways in which they were interpreted varied so much so that they could not be used to communicate risk to patients (86). The European Union has also tried to develop a standardised risk vocabulary (“very common”, “common”, “uncommon”, “rare” and “very rare”) but again patient interpretation did not correspond with the risks they were intended to convey (87). At present, there is no satisfactory method of communicating risks to patients using words instead of numbers.

Numeracy

Numeracy or the ability to do basic mathematics is another important consideration. People can find interpreting decimals and fractions difficult. One study found participants interpreted 1286/10,000 as more risky than 24.14/100 (58). Whilst words cannot replace numbers for the reasons outlined above, healthcare professionals can present risks in different ways to try and aid understanding. For example a risk of 20% could be described as a one in five chance or odds of four to one. However, the way in which risk information is presented has been shown to influence patient decision making (88). Patients are more likely to accept a treatment when risk is presented as a relative risk reduction rather than as a number needed to treat, personal

probability of benefit or absolute risk (88). It is tempting to use relative risks to try and emphasise the need for a treatment. For example a treatment that reduced the risk of a stroke from 2% to 1% would result in a 50% relative risk reduction. However, the initial absolute risk (2%) is so small that a patient may decide it is not worth taking a tablet every day to achieve a 1% absolute risk reduction. The use of relative risks is controversial as some people feel they overinflate numbers and are meaningless unless the underlying rate (absolute risk) is known (59, 60) and suggest the risk of developing a disease (2%) should be compared to the risk of not developing a disease (98%) (60).

Visual representations of risk

A review investigating how best to use graphics to display risk information has concluded that the graphical features that increased understanding were not the same as those that altered behaviour or intentions (89). In general, patients preferred simple graphs even if this was at the expense of accuracy. In addition crowd-charts have been found to be disliked by patients for being confusing, unconvincing and busy (58) and bar charts were similarly unpopular for lacking impact, being too dry, too statistical and too scientific (58). Most graphical representations of risk have been found to require a degree of expertise or instruction in order to aid understanding (89).

Knowledge gaps

Despite the many studies that have been conducted to investigate risk communication, it still remains unclear which individuals are most likely to experience distress as a

result of risk information and under what circumstances (73). It also remains inconclusive how best to frame risk information, the setting in which it should be given and the clinical topics in which it is most effective. Many of the trials that have been conducted are of poor quality and as yet, efficacy has not been shown in routine clinical practice.

How to communicate risk?

In summary, the optimal method of conveying risk information is not known but the provision of personalised risk information is the only intervention to have been found to work consistently and to have been evaluated in primary and secondary care. At present this appears to be the most effective method for communicating risk to individual patients.

Chapter 4: Physical Activity

The benefits of physical activity in preventing CVD have been apparent for over half a century since the initial observation that physically active London bus conductors were less likely to develop coronary heart disease than their sedentary bus driver colleagues (90). Since then evidence has continued to accumulate demonstrating that physically active men and women reduce their risk of CVD by between one third and one half compared to their sedentary counterparts (21). The relative risk of CVD associated with a sedentary lifestyle is similar to that associated with cigarette smoking, hypertension and hypercholesterolaemia (21) and clearly represents an ideal target for CVD risk reduction. However, the capacity of physical activity interventions to prevent CVD events has yet to be born out in outcome studies despite being recommended by international guidelines (91).

Epidemiology

Many epidemiological studies have demonstrated the link between CVD risk factors and physical activity (92-95).

Moderate intensity physical activity

The Australian Diabetes, Obesity and Lifestyle study (AusDiab) investigated associations between physical activity and CVD risk factors in middle-aged adults (mean age 53.4 years) without known diabetes, and found an inverse relationship between time spent engaging in activity of moderate or greater intensity and serum triglycerides (96). This relationship was apparent even after adjusting for age, sex, employment status, alcohol intake, income, education level, smoking status, diet

quality, family history of diabetes and lipid and blood pressure lowering medication use. Ekelund *et al.* have attempted to determine the beneficial effects of physical activity that occur independently of changes in fitness and fatness (97). They demonstrated that an increase in physical activity of approximately 30 minutes of brisk walking per day was independently associated with small reductions (3-5%) in triglycerides, fasting insulin and 2 hour plasma glucose levels.

Sedentary time

Sedentary time has been shown to be associated with CVD risk factors with one study demonstrating an association between time spent watching television and LDL and HDL cholesterol levels (98) and a second study demonstrating that women who watched less than 2 hours of television per day and engaged in more than one hour per week of vigorous activity had an adjusted body mass index of 1.92 kg/m^2 less than women performing no weekly vigorous activity and watching more than four hours of television per day. Reducing sedentary time even by very small amounts has been shown to be associated with improvements in CVD risk factors. Breaks in sedentary time have been shown to be associated with improvements in waist circumference, body mass index, triglycerides and 2-hour plasma glucose (99).

Development of the metabolic syndrome

Studies have examined the influence of physical activity on the development of the metabolic syndrome (100, 101) and have shown that men engaging in three or more hours per week of leisure time physical activity are half as likely as sedentary men to

have the metabolic syndrome. This was seen even after adjustment for major confounders (age, body mass index, smoking, alcohol consumption, socioeconomic status) and mediating factors (plasma insulin, glucose and lipid levels and blood pressure).

All-cause and CVD mortality

Physical activity has also been shown to be beneficial in terms of CVD and all-cause mortality. In one study that followed over 30,000 Finnish adults aged 30-59 years for a median of 20 years, CVD and all cause mortality were 9-21% lower in women and 2-17% lower in men who were moderately or more active during their leisure time (92). A reduction of 21-27% was also seen in men and women who were occupationally active. This is supported by a second study of 707 men aged 61-80 years that demonstrated a doubling of the death rate in men walking less than one mile per day compared with men walking more than two miles per day (93).

No threshold effect of age

There does not appear to be an age cut off above which it is no longer worthwhile increasing physical activity. The Uppsala longitudinal study of adult men investigated men who increased their physical activity between the ages of 50-60 years (102). Whilst they demonstrated higher mortality than men with unchanged high levels of physical activity for the first five years after increasing activity, by ten years their mortality matched that of men with unchanged high physical activity levels (hazard ratio 1.10, 95% CI 0.87-1.38) (102). The reduction in mortality seen in the

men who increased their physical activity compared to men with unchanged low physical activity (0.51, 95% CI 0.26-0.97) was almost equivalent to that seen for smoking cessation in this study (0.64, 95% CI 0.53-0.78).

Individuals at increased CVD risk

The dose-response relationship between physical activity and CVD risk has been noted to be especially steep in those individuals at high CVD (103) risk due to the presence of the metabolic syndrome, type 2 diabetes or obesity (21). In individuals with type 2 diabetes good glycaemic control has been shown to be protective against future CVD events (15). A meta-analysis of physical activity interventions in individuals with type 2 diabetes has shown an overall 0.66% reduction in HbA1c (22). The Multiple Risk Factor Intervention Trial (MRFIT) study conducted in over 12,000 men at increased risk of CVD demonstrated that the third of participants who were least active had excess CVD and all-cause mortality but no increased risk of cancer death (104). Such individuals therefore, would appear to have much to gain from regular physical activity in terms of CVD risk reduction and are an obvious target for lifestyle modification interventions.

Types of physical activity

The impact of the type or intensity of physical activity undertaken on CVD risk remains poorly understood. In a study following 77,743 post-menopausal women aged 50-79 years, walking and vigorous physical activity were associated with similar risk reductions in CVD (95). This result did not vary substantially according to race,

body mass index or age. However, a brisk walking pace and fewer hours sitting also predicted lower risk. In a second study in 39,372 female health professionals active women were shown to have lower rates of coronary heart disease but this association varied according to the intensity of the activity undertaken (105). In this study a reduction in risk was only seen in women walking for at least one hour per week and walking pace was not found to influence coronary heart disease risk.

Mechanism

Lipids

Much of the beneficial effect of physical activity on CVD risk is attributed to an amelioration of plasma lipids. Physical activity has been shown to modulate plasma lipids with improvements seen both acutely (106) and chronically (107), in those with known CVD (108), at high risk of CVD (109) or apparently healthy (110) and in both men and women (21). The improvements occur independently of changes in body weight (107). Physical activity can increase HDL by 5-10% (106, 110) and decrease triglycerides by up to 18% (107). The effect of physical activity on LDL cholesterol and VLDL is less clear cut with both reductions (108, 110, 111) and no change (109) in LDL reported and one study reporting an improvement in VLDL levels (109).

Insulin sensitivity

Physical activity also improves insulin sensitivity. Insulin sensitivity measured by euglycaemic-hyperinsulinaemic clamp has been shown to be strongly associated with

total activity measured by accelerometer in both men and women ($p<0.0001$) (112). Other elements of physical activity measured by accelerometer including sedentary time, time spent undertaking light activity or bouts of moderate or greater intensity physical activity did not impact insulin sensitivity independently of total activity.

Other possible mechanisms

Additional CVD risk reducing mechanisms have also been proposed including improvements in inflammation and endothelial function but the evidence for these remains equivocal (21). However, physical activity remains an independent CVD risk factor even after adjustment for the above factors suggesting the involvement of other mechanisms (21).

Intervention studies

A number of intervention studies have been undertaken in order to confirm the epidemiological and physiological associations seen between physical activity and CVD risk factors.

Diabetes prevention

One systematic review examined studies that had examined the impact of physical activity on the development of diabetes in adults with impaired glucose tolerance. It concluded that whilst a combination of lifestyle modifications has been consistently

associated with a 50% reduction in the risk of developing diabetes the increase in physical activity achieved has been small and therefore the reduction in the risk of developing diabetes is likely to be attributable to other factors including diet and weight loss (113). The authors postulated that current recommendations for physical activity may not be adequate to reduce the risk of diabetes in individuals with impaired glucose tolerance (114). This systematic review included eight studies and the physical activity interventions varied from encouraging 150 minutes of moderate-vigorous physical activity per week with occasional support and encouragement from a healthcare professional to discounted gym membership and even a one month stay at a wellness centre. Others questioned the conclusions of the systematic review and interpreted the findings as showing that physical activity may be better at preventing a worsening of glycaemic control than improving glucose tolerance (115).

Primary prevention of CVD

Whilst some short-term (< 6 months) studies have demonstrated a favourable effect of physical activity interventions on some CVD risk factors (116), no long-term outcome studies to date have been able to demonstrate that a physical activity intervention can prevent CVD events (117). In addition, randomised controlled trials evaluating an exercise consultation with an exercise specialist or a healthcare professional versus no exercise consultation have failed to demonstrate an improvement in CVD risk factors at one year (117).

Summary

There is convincing epidemiological and physiological evidence of the cardiovascular protective effects of physical activity in adults. Disappointingly, intervention studies have yet to demonstrate that interventions designed to increase physical activity can result in a reduction in CVD or a sustained improvement in CVD risk factors. This may be a result of poor interventions, lack of prolonged follow-up or failure of participants to maintain increases in physical activity. Addressing these issues in future studies may achieve a positive result for the benefits of physical activity in preventing CVD.

Chapter 5: Brief Lifestyle Advice

A systematic review of the effectiveness of the provision of brief lifestyle advice in primary care

Introduction

Brief lifestyle advice has been defined as advice delivered in a single consultation (118), often opportunistically, that is usually of only 2-3 minutes duration (118, 119). It is commonly delivered in primary care (118-122) and supported by written information (118, 120, 121). Brief lifestyle advice often addresses a variety of modifiable behaviours including diet, physical activity, alcohol consumption and smoking (120). Interest in brief lifestyle advice has been increasing since it was identified that modifiable lifestyle factors including diet (123-125), smoking (126), alcohol consumption (127) and physical activity (92-95) are associated with risk of future disease. The United Kingdom government has responded to this by introducing financial incentives for general practitioners to deliver lifestyle advice in primary care with the aim of reducing overall risk in the population (128). However, concerns have been raised that public funds may be directed towards interventions for which there is little robust evidence of success (120).

A systematic review published in 1997, of 37 trials investigating the impact of brief and more intensive lifestyle advice versus no advice on physical activity, diet, smoking and alcohol consumption concluded that whilst the results were in general, promising, there was insufficient evidence to conclude that lifestyle interventions could produce substantial change in behaviour (120). Most of the trials included followed participants for at least one year. This systematic review found that the odds ratio for smoking cessation following smoking cessation advice versus no advice was 1.32 (95% confidence interval 1.18-1.48) and that more intensive versus brief advice

had no impact on the success of the intervention (odds ratio 1.07 (0.88-1.29)). For diet, alcohol consumption and physical activity the trials were sufficiently heterogeneous that they could not be compared in this way.

The purpose of this review was to examine the more recent evidence to determine the effectiveness of the provision of brief lifestyle advice in primary care.

Method

Search strategy

A search of the MEDLINE database was conducted including articles published between 1996 and January 2010. Studies from this period were included in order to update the findings of the 1997 systematic review.

Search terms

In order to retrieve studies conducted in primary care the following search terms were used:

- Primary care
- Family practice
- General practice

In order to retrieve studies concerning the provision of brief lifestyle advice the following search terms were used:

- Health promotion
- Lifestyle advice
- Risk factors
- Health behaviour
- Patient education
- Brief lifestyle advice
- Counselling

In order to retrieve studies concerning the provision of physical activity advice the following search terms were used:

- Exercise
- Motor activity
- Physical activity

In order to retrieve studies concerning the provision of dietary advice the following search terms were used:

- Diet
- Diet therapy
- Diet sodium restricted

- Diet protein restricted
- Diet Mediterranean
- Diet carbohydrate restricted
- Diabetic diet
- Diet reducing
- Nutrition therapy

In order to retrieve studies concerning the provision of smoking cessation advice the following search terms were used:

- Smoking
- Smoking cessation
- Tobacco
- Tobacco use cessation

In order to retrieve studies concerning the provision of alcohol consumption advice the following search terms were used:

- Alcohols

Approximately 312 potentially relevant references (including reviews of the literature) were identified through this search strategy. The abstracts for studies were retrieved and the reference lists from review articles were searched. From this initial survey a

set of inclusion criteria was developed and the final selection of trials to be included was made. A total of 16 trials were selected.

Inclusion criteria

The review was restricted to studies published in the English language that investigated the provision of brief lifestyle advice in primary care. Only studies with a randomised design were included. I examined studies that provided advice concerning physical activity, diet, alcohol consumption or tobacco smoking. Studies that included advice on more than one of these behaviours were included. Studies were included if brief advice was compared to either no advice or usual care or to a more intensive intervention. Brief advice was defined being of less than 30 minutes duration, delivered face to face in a single consultation with no further follow up or reinforcement by a person routinely employed in primary care (general practitioner or practice nurse). In general, advice was provided verbally and supported by written materials. Trials were included irrespective of the duration of follow up but needed to include a measure of behaviour change for example change in body weight, blood pressure or physical activity questionnaire score. Studies were excluded if the only outcome measure was thoughts about behaviour change or change in stage of change. Trials were also excluded if the advice was accompanied by a pharmacological agent for example, nicotine gum or patches. The major reasons for excluding trials were:

- Not relevant to review (trial protocols, cost effectiveness analyses, duplicate studies, cross sectional studies of advice given in general practice)
- Non-randomised study design used
- No brief advice intervention arm

- Review articles

Data extraction

I extracted data from the published studies.

Quality assessment

Studies were assessed using the simplified scheme described in the 1997 systematic review described earlier (120, 129). Three dimensions of trial methods were assessed: selection bias at entry to the study (for example was a robust method of randomisation used), selection bias after trial entry (for example were analyses by intention to treat, were rates of follow-up high and similar in all groups) and selection bias in assessing outcomes (for example were individuals collecting and inputting data blinded to an individual's intervention allocation). A score of 3 was awarded if maximal attempts had been made to control bias and 1 if little or no attempts had been made. In some instances the reporting of the study was such that a low score had to be awarded if no information was provided to the contrary.

Data analysis

The trials included reported many different outcomes in a variety of ways. In view of this data was extracted, summarised and tabulated. Outcome measures included self-reported changes in smoking behaviour, physical activity and diet, biochemical measures of smoking cessation including salivary cotinine and objective measures of fitness including a six minute walk test.

Results

Characteristics of trials

A total of 16 trials were included in the review (Table 2). Most physical activity trials recruited sedentary adults and most smoking cessation trials recruited adult smokers irrespective of other health conditions or co-morbidities. A minority of studies recruited healthy adults. The studies included a broad range of ages from 15-80 years old. All studies included both male and female participants. The studies included a mixture of those that compared brief lifestyle advice to no advice or usual care and those that compared brief lifestyle advice to more intensive interventions. In some instances a variety of approaches were tested in the same trial.

In the majority of trials the advice was provided by a general practitioner with fewer studies choosing a nurse to deliver the intervention. Most advice was supplemented by written materials.

Follow up varied between one and 14 months with the majority collecting data for between six and 12 months.

The quality of the studies included was generally good. The commonest reason for being awarded a low score was selection bias after trial entry with many studies reporting high losses to follow up.

Table 2: Characteristics of brief lifestyle advice intervention trials.
Mode of intervention is classified as an intervention addressing a single behaviour (S) or multiple behaviours (M), PA indicates the study addressed physical activity. W indicates that the intervention was supported by written materials. Quality score: low to high score 1-3, A indicates selection bias at entry, B selection bias after entry and C bias assessing outcomes.

Trial	Year	Country	N	Inclusion criteria	Study groups	Intervener	Mode	Duration	Quality
Armit *et al* (130).	2008	Australia	136	Sedentary adults aged 50-70 years	1. Brief GP advice 2. GP & Ex specialist 3. GP & Ex specialist plus pedometer	GP	S (PA) W	6 months	A3, B1, C3
Aveyard *et al* (131).	2003	UK	2471	Adult smokers	1. Leaflet 2. Self help manual 3. Phone intervention 4. Manual plus nurse visits	Nurse	S (smoking) W	6 months	A2, B1 , C3
Bull & Jamrozik (118)	1998	Australia	763	Sedentary adults	1. Brief advice 2. No advice	GP	S (PA) W	12 months	A2, B2, C3
Goldstein *et al.* (132)	1999	USA	355	Sedentary adults	1. Brief activity counselling 2. Standard care	GP	S (PA) W	6 weeks	A3, B3, C3
Grandes *et al* (133).	2009	Spain	4317	Sedentary adults aged 20-80 years	1. Advice 2. Advice and activity prescription 3. Usual care	GP	S (PA) W	6 months	A3, B2, C3

Trial	Year	Country	N	Inclusion criteria	Study groups	Intervener	Mode	Duration	Quality
Harland *et al.* (134)	1999	UK	523	Adults aged 40-64 years	1. One interview 2. Six interviews 3. Exercise vouchers 4. Control group	?GP	M (PA, smoking, diet, alcohol, weight) W	12 months	A3, B2, C3
Jimmy & Martin (135)	2005	Switzerland	161	Individuals aged >15 years old	1. Brief GP advice feeding back a PA questionnaire 2. 45 minute counselling	GP	S (PA)	14 months	A1, B3, C1
Lancaster *et al.* (136)	1999	UK	497	Smokers > 18 years old	1. Brief advice 2. Advice plus follow up counselling from nurse	GP	S (smoking) W	12 months	A3, B2, C3
Little *et al.* (137)	2004	UK	151	Sedentary adults	1. GP advice 2. Nurse counselling 3. Leaflet	GP	S (PA)	1 month	A2, B2, C1
Marshall *et al* (138).	2005	Australia	767	Inactive 40-70 year olds	1. Brief general PA advice 2. No advice	GP	S (PA) W	6 months	A3, B2, C3
Petrella *et al.* (139)	2003	Canada	284	Adults over 65 years old	1. Brief advice 2. Exercise advice and assessment	GP	S (PA)	12 months	A2, B2, C3

Trial	Year	Country	N	Inclusion criteria	Study groups	Intervener	Mode	Duration	Quality
Pieterse *et al.* (140)	2001	Netherlands	530	Adult smokers aged 18-70 years	1. Brief advice 2. Usual care	GP	S (smoking) W	12 months	A1, B2, C3
Sacerdote *et al* (141).	2005	Italy	3186	Healthy adults aged 18-65 years	1. 15 min intervention 2. Sham intervention	GP	S (diet) W	1 year	A2, B2, C2
Steptoe *et al.* (142)	1999	UK	883	Adults with one or more modifiable CVD risk factor	1. Behavioural counselling 2. Standard advice	Nurse	M (diet, smoking, PA)	12 months	A2, B2, C3
Swinburn *et al.* (143)	1998	New Zealand	491	Sedentary adults	1. Brief advice plus written materials 2. Brief advice alone	GP	S (PA)	6 weeks	A1, B2, C3
van Sluijs *et al.* (144)	2005	Netherlands	358	Adults aged 18-70 years with hypertension, hypercholesterolaemia, type 2 diabetes, not physically active in last 6 months	1. Brief advice 2. Physician-based assessment and counselling for exercise (PACE)	GP or nurse	S (PA)	1 year	A3, B3, C3

Effectiveness of brief lifestyle advice

A summary of the results of the 16 studies included in this review is shown in Table 3. Overall in the nine studies that compared brief lifestyle advice with more intensive advice three studies demonstrated that brief advice could be as effective as more intensive advice, five studies showed that brief advice was not as effective as more intensive advice and one study produced an equivocal result. In the seven studies that examined the provision of brief lifestyle advice compared to the provision of usual care or no advice five showed a positive result for the effectiveness of brief lifestyle advice, one showed a negative result and one showed an equivocal result. These results need to be qualified against the fact that in the vast majority of the studies included outcome measures relied on self-reported behaviours. In addition, in many of the studies follow up of participants was not ideal with few studies being able to collect data on more than 80% of participants at follow up. There were also too few studies that examined the impact of the provision of advice concerning more than one behaviour to draw any useful conclusions concerning this approach.

Table 3: Results of brief lifestyle advice intervention trials

Trial	Study groups	Outcome	Problems	Overall effect of brief lifestyle advice
Armit *et al.*	1. Brief GP advice 2. GP & Ex specialist 3. GP & Ex specialist plus pedometer	Increase in self-reported activity in all groups with an average increase of 128 minutes per week (95% CI 79, 177) at 24 weeks. No between group differences in increase in activity but greater proportion in ES and ESP groups meeting activity target (150 minutes per week) at 24 weeks OR 1.14 (0.47, 2.76) and 2.39 (1.01, 5.64) $p<0.01$ in both groups	Sample size not big enough to detect difference as variance larger than expected, self-reported PA, inconsistent delivery, Ex Specialist not blinded	Positive
Aveyard *et al.*	1. Leaflet 2. Self help manual 3. Phone intervention 4. Manual plus nurse visits	Biochemically confirmed sustained quitting (salivary cotinine) at 6 months OR 1.00 p=0.64 1.53 (0.68, 3.42) 1.42 (0.62, 3.21) 1.81 (0.69, 4.73)	Differences in follow up rates between groups	Negative
Bull & Jamrozik	1. Brief advice 2. No advice	No between group difference in self-reported PA at one year, 36% versus 31% physically active at one year	Days of the week randomised rather than individual participants. Self-reported outcomes. Unusual definition of physically active.	Negative
Goldstein *et al.*	1.Brief activity counselling 2. Standard care	Proportion meeting activity recommendations, self-reported (30 minutes 5 days per week) OR=1.37 (0.77, 2.43)	70% of control practices regularly provided PA advice, baseline assessment may have highlighted the need to increase PA	Positive
Grandes *et al.*	1. Brief advice 2. Brief advice and activity prescription 3. Usual care	Self-reported PA, increase of 22.5 minutes per week in participants aged over 50 years, no significant difference in participants under 50 years in advice group compared to control in prescription group results similar	Large numbers lost to follow-up, sub-group analyses	Equivocal

Trial	Study groups	Outcome	Problems	Overall effect of brief lifestyle advice
Harland *et al.*	1. One interview 2. Six interviews 3. Vouchers 4. Control group	Self-reported increases in activity not maintained at one year, improved PA scores seen in 38% versus 16% interventions versus controls p=0.001 at 12 weeks	Self reported PA, 20% drop out rate, baseline assessment may have diluted intervention	Negative
Jimmy & Martin	1. Brief GP advice feeding back a PA questionnaire 2. 45 minute counselling	Self-reported PA about 50% active at 14 months in both groups p=0.95	?Blinding of researcher collecting follow up data, randomisation not equal	Positive
Lancaster *et al.*	1. Brief advice 2. Advice plus follow up counselling from nurse	Biochemically measured smoking cessation (cotinine), quit rates 3.6% versus 4.4%, difference -0.8% (-4.3, 2.6)	25% lost to follow-up	Equivocal
Little *et al.*	1. GP advice 2. Nurse counselling 3. Leaflet	No significant change in 6 minute walk test in single intervention groups	Assessors not blinded	Negative
Marshall *et al.*	1. Brief general PA advice 2. No advice	Proportion physically active at six months 46.8% versus 29.9% p=0.001 OR 2.05 (1.33, 3.16)	Self-reported activity, only one third received written materials	Positive

Trial	Study groups	Outcome	Problems	Overall effect of brief lifestyle advice
Petrella *et al.*	1. Brief advice 2. Exercise advice and assessment	Improvement in VO2max compared to brief advice 22.8 versus 24.9 ml/kg/min p<0.001	Unclear how randomisation of practices performed	Negative
Pieterse *et al.*	1. Brief advice 2. Usual care	Quit rate at 12 months 13.4% versus 7.3%	Self-reported quitting, no biochemical validation, high quit rate in control group ?due to Hawthorne effect, unbalanced groups at baseline in terms of number of cigarettes smoked and level of motivation to quit	Positive
Sacerdote *et al.*	1. 15 min intervention 2. Sham intervention	Net increase in portions of fruit and vegetables per week 1.31 (0.90, 4.39)	Incomplete blinding of GPs, self-reported outcome measures	Positive
Steptoe *et al.*	1. Behavioural counselling 2. Standard advice	Change in number of exercise sessions in last four weeks 3.9 (1.0, 6.8)	High number lost to follow-up, Large differences in recruitment of control and intervention participants	Negative
Swinburn *et al.*	1. Advice plus written materials 2. Advice alone	Proportion of participants who increased their activity 73% versus 63% p=0.02	Recruitment based on those GPs thought would benefit from intervention, self reported activity	Positive
van Sluijs *et al.*	1. Brief advice 2. Physician-based assessment and counselling for exercise (PACE)	Increase in activity in all participants at one year of 61.6 minutes per week (7.5, 115.6), no between group differences	Self-reported activity	Positive

Discussion

The data available to date seem to suggest that there may be some health benefits associated with the provision of brief lifestyle advice and that brief lifestyle advice may be nearly as effective as more intensive regimens. The findings of this review are broadly in keeping with those of The United Kingdom Health Development Agency. In it's evidence briefing for brief interventions aimed at increasing physical activity levels (145) the agency concludes that at the present time the evidence suggests that a single episode of brief tailored advice with some follow-up can increase physical activity at least in the short term (145). This briefing went on to highlight various components that were associated with the greatest likelihood of success. These included the provision of tailored information delivered verbally with written support, setting goals, self-monitoring, exploring beliefs about physical activity, ongoing verbal support, providing occasional reviews, promoting moderate intensity activity such as walking and no requirement for attending a facility (145).

The evidence that brief lifestyle advice may be no less effective than more intensive advice is encouraging for more widespread adoption in routine clinical practice, particularly in primary care. The time pressures on primary care practitioners are increasingly being recognised and there now seems to be an acknowledgement that studies attempting to deliver lifestyle advice in primary care need to develop interventions that can be delivered in just a few minutes (146). In addition more robust studies are being conducted to further evaluate brief lifestyle advice in comparison to a more intensive intervention. One such study has been designed to compare an intensive intervention encompassing risk assessment, risk communication, use of a decision aid and adapted motivational interviewing with a

brief intervention, in adults without known CVD (147). The brief lifestyle advice will be given on a single occasion whereas the intensive intervention will be given over two consultations and one telephone call.

One of the major shortcomings of many of the studies reviewed is the lack of objective measures of behaviour with many relying on self-reported information. There is a clear need for robust objective outcome measures of behaviour to be included in randomised trials of lifestyle interventions and not just intermediate measures for example, intention to change behaviour and thoughts about the need to change behaviour, as have often been used in the past (120). Physical activity can be measured objectively using pedometers or accelerometers. Serum cotinine (148) is a reliable indicator of tobacco smoked and plasma vitamin C provides a robust estimate of fruit and vegetable intake (149).

The methods used to study lifestyle interventions also need to adapt in order to increase the evidence base for the success of lifestyle interventions. Many studies were excluded from this review because they did not use a randomised design.

The 1997 systematic review of lifestyle advice published by Ashenden and colleagues highlighted many of these issues and the inability to draw firm conclusions from the studies conducted up to then (120). Disappointingly, heterogeneous outcome measures, outcomes measured by self-report and non-randomised trial designs still plague this area of research. Future studies need to address these issues in their trial design.

It is possible that over recent years the need to provide lifestyle advice may have diminished because of better knowledge amongst the population about health lifestyle choices. However, despite the government focus on improving the health of the

population in recent years the evidence suggests that public perceptions of what constitutes a healthy lifestyle and which behaviours are unhealthy remain poor. In one United Kingdom questionnaire survey of 512 adults aged 17-45 years, 25% of responders were current smokers yet only 4% recalled being advised to quit smoking (150). When asked what were their main sources of health promotion information 67% of study participants cited magazines and 47% television. In younger patients the internet appears to be an important source of lifestyle advice (151). In another study of 390 adults with and 190 without CVD risk factors, that aimed to determine which factors predict recall of lifestyle advice, those with CVD risk factors, men and older participants were the most likely to recall that they had been given lifestyle advice (152). Those able to recall lifestyle advice were more likely to report a healthier current lifestyle than those who could not recall lifestyle advice. Of concern, 30-50% of responders who reported an unhealthy lifestyle were unaware that it was unhealthy. This study included adults from a wide range of socioeconomic backgrounds. Even in high risk individuals recollection of lifestyle advice can be poor. In a study of over 3000 patients who had been hospitalised with heart failure and received lifestyle advice during their admission only 46% of patients could recall receiving the lifestyle advice (153).

These studies confirm that whilst much effort has been expended on increasing the health of the nation and increasing awareness of what constitutes a healthy lifestyle there remains a significant proportion of the population who are unaware of rudimentary health messages (the benefits of not smoking, participating in physical activity, eating a low-fat, high-fibre diet containing plenty of fruit and vegetables and consuming alcohol in moderation). In view of these findings, it is important that

research continues to be conducted to investigate approaches to educating the population about healthy behaviours.

Conclusion

Despite the shortcomings of the available data as one of the studies concludes (136), brief lifestyle advice appears to be associated with some benefits and therefore is worthwhile as an intervention as it is simple and costs very little to deliver.

Methods & Results

The overall aims of the study were to determine whether or not personalised 10-year CVD risk information or a brief lifestyle advice intervention could motivate behaviour change in individuals at increased risk of CVD. In order to determine who these individuals might be it was first necessary to identify an appropriate risk calculator to be used during the study to estimate personalised CVD risk. It was then necessary to gain a greater understanding of lay perceptions of CVD risk, develop an interface for the risk calculator to best deliver the 10-year personalised CVD risk estimate, design the brief lifestyle advice intervention and to ensure each was comprehensible and acceptable to their target audience. Finally, both the personalised 10-year CVD risk and brief lifestyle advice interventions were tested simultaneously in a pilot 2x2 factorial randomised controlled trial entitled the Understanding Risk (uRisk) study. uRisk participants were recruited from four general practices in Oxfordshire and invited on the basis of being at increased 10-year CVD risk (≥20%) according to the Framingham equations (32).

Chapter 6: Risk calculator selection

Demonstration of the applicability of the UKPDS Risk Engine in a population without diabetes

The decision to use the UKPDS Risk Engine for estimating CVD risk was a somewhat pragmatic decision based on the fact that the Risk Engine was developed in the academic group in which I was studying and the fact that information technology expertise was on hand to enable me to redesign the interface of the Risk Engine based on the findings of the focus groups I conducted. I also anticipated that a significant proportion of individuals recruited for the study would have diabetes or dysglycaemia based on epidemiological evidence suggesting that in the UK most CVD events in men occur in apparently healthy individuals with HbA1c values > 6% (154). However, it was first necessary to assess the utility of the Risk Engine in a non-diabetic population. I was involved with this work as it was integral to my study but it was largely performed by Dr Rebecca Simmons (155).

Subjects

Dr Simmons compared the performance of version 3 of the UKPDS Risk Engine and the 2008 Framingham risk equations in estimating CVD in the EPIC-Norfolk (European Prospective Investigation of Cancer-Norfolk) cohort. EPIC-Norfolk is a prospective study of men and women aged 40-79 years recruited from general practices in Norfolk (156). Over 25,000 individuals were followed for a median of 10.1 years. Diabetes status was determined at entry to the study and from 1995 HbA1c was included in the baseline measurements. CVD events were identified during the study if a participant had a hospital admission and/or died from a CVD event. For these analyses we excluded individuals with CVD at baseline and those with missing data at baseline for the variables needed to estimate CVD risk using the

two calculators. As a result 4,424 men and 5,713 women were included in the analyses.

Materials and methods

The EPIC-Norfolk individuals were divided into three groups: those with known diabetes at entry into the study (n=272), those with non-diabetic hyperglycaemia (defined as HbA1c ≥ 6% with no diagnosis of diabetes, n=906) and those with normal glucose tolerance (no diagnosis of diabetes and HbA1c < 6%, n=8,959).

The performance of the two calculators was assessed by comparing the area under the receiver operating characteristic curve (aROC) (157), by computing a Bayes information criterion (BIC) statistic (158) to assess the global fit of the models and finally, by examining the proportion of men and women who would be reclassified into higher or lower risk categories between the two calculators. This was assessed using the Net Reclassification Improvement (NRI) statistic (159).

Results

Demographics

The baseline characteristics of the EPIC-Norfolk participants used for these analyses are shown in Table 4.

CVD events

The cumulative incidence rate of CVD in the EPIC-Norfolk population was 9.8 per 1,000 person-years.

Over a median of 10.1 years of follow-up there were 69 CVD events in the 272 individuals with diabetes, 160 in the 906 with non-diabetic hyperglycaemia and 732 in the 8,959 with normoglycaemia (Table 4). The estimated CVD 10-year risk in individuals with known diabetes at baseline was 33% and 37% using the UKPDS and Framingham scores respectively (Table 5). In the non-diabetic hyperglycaemia group, estimated CVD risk was 31% and 22% respectively, and for the group with normal glucose tolerance, 20% and 14% respectively.

The aROC for individuals with diabetes in EPIC-Norfolk was 0.72 for the UKPDS score and 0.73 for the Framingham score (Table 5). There was no statistically significant difference in their discrimination (p=0.58). Similarly, the aROC for individuals with non-diabetic hyperglycaemia was 0.68 for the UKPDS score and 0.66 for the Framingham score, with no significant difference in discrimination (p=0.16). For individuals with normal glucose tolerance, the aROC for the UKPDS score was 0.77 and 0.77 for Framingham, with no evidence of a difference in the scores' ability to discriminate between those that had a CVD event or not (p=0.38). The Bayes Information Criterion value was similar for both risk scores in each population sub-group, indicating good global model fit.

Reclassifications are summarised in Table 6. The NRI refers to the net gain in correct reclassification. A positive NRI indicates that the UKPDS score shows an

improvement in classification over the Framingham score, while a negative NRI corresponds to an improvement in classification of the Framingham over the UKPDS risk score. The NRI for the diabetic group was 5.8% (p=0.17), indicating that there was no significant improvement in classification using either score. However, for those with non-diabetic hyperglycaemia (NRI -14.0%, p=0.004) and normoglycaemia (NRI -12.4%, p<0.001), the Framingham risk equations classified more participants correctly than the UKPDS risk score. The goodness-of-fit test statistics were non-significant for all three sub-groups, indicating good calibration in both scores.

Figure 1 shows the ROC curves comparing the UKPDS and Framingham risk scores in each population sub-group. The shapes of each set of ROC curves were roughly similar in each sub-group.

Table 4: Baseline characteristics by population sub-group, EPIC-Norfolk cohort, UK, 1993-2007 (n=10,137)

	Individuals with prevalent diabetes (n=272)	Individuals with non-diabetic hyperglycaemia (n=906)	Normoglycaemic individuals (n=8,959)	P value for difference
Mean age, years (SD)	62.8 (8.6)	62.6 (8.4)	56.6 (9.6)	<0.001
Females, n (%)	129 (47.4)	498 (55.0)	5,086 (56.8)	0.006
Social class, n (%)[1]				
- I - IIIa	156 (58.9)	497 (56.0)	5,485 (61.2)	0.003
- IIIb – V	109 (41.1)	391 (44.0)	3,329 (37.2)	0.990
Caucasian, n (%)	272 (100.0)	904 (99.8)	8,919 (99.6)	<0.001
Mean BMI, kg/m² (SD)	27.8 (5.0)	27.5 (4.5)	26.0 (3.8)	<0.001
Mean total cholesterol, mmol/l (SD)	6.0 (1.2)	6.4 (1.2)	6.1 (1.1)	0.457
Mean HDL, mmol/l (SD)	1.4 (0.4)	1.4 (0.4)	1.5 (0.4)	<0.001
Mean LDL, mmol/l (SD)	3.8 (1.0)	4.1 (1.1)	3.9 (1.0)	<0.001
Mean systolic blood pressure, mm Hg (SD)	141.4 (19.0)	140.8 (17.6)	133.5 (17.9)	<0.001
Statin use, n (%)	10 (3.7)	18 (2.0)	94 (1.1)	<0.001
Current smoker, n (%)	23 (8.5)	155 (17.1)	1,028 (11.5)	<0.001
Mean HbA_{1c}, % (SD)	7.5 (2.0)	6.4 (0.9)	5.1 (0.5)	<0.001
CVD events, n (%)	69 (25.4)	160 (17.7)	732 (8.2)	<0.001

[1] Numbers may not add up to total due to missing values

Table 5: Actual and estimated CVD risk, area under the ROC curve (aROC) and Bayes information criteria (BIC), for the UKPDS and Framingham CVD risk scores in each population subgroup, EPIC-Norfolk cohort, UK, 1993-2007 (n=10,137)

	Individuals with prevalent diabetes (n=272)	Individuals with non-diabetic hyperglycaemia (n=906)	Normoglycaemic individuals (n=8,959)
Actual mean CVD risk, %	25.4	17.7	8.2
Estimated CVD 10-yr risk: UKPDS score, % (95% CI)	33.2 (28.1 to 38.5)	30.5 (25.9 to 35.4)	20.4 (17.0 to 24. 2)
Estimated CVD 10-yr risk: Framingham score, %	36.7	22.3	14.4
aROC (95% CI) for the UKPDS score	0.72 (0.65 to 0.78)	0.68 (0.63 to 0.72)	0.77 (0.76 to 0.79)
aROC (95% CI) for the Framingham score	0.73 (0.66 to 0.78)	0.66 (0.62 to 0.71)	0.77 (0.76 to 0.79)
BIC for the UKPDS score	288	807	4444
BIC for the Framingham score	285	816	4405

Table 6: CVD risk classification comparing the UKPDS and Framingham risk score models (n,%), including the Net Reclassification Improvement (NRI), for each population sub-group, EPIC-Norfolk cohort, UK, 1993-2007

UKPDS risk categories	**Framingham risk categories**			**Total**
Participants with diabetes	**0 to < 10%**	**10 to < 20%**	**≥ 20%**	
0 to < 10%	17 (89.5)	3 (5.9)	0 (0.0)	20 (7.4)
10 to < 20%	2 (10.5)	34 (66.7)	9 (4.5)	45 (16.5)
≥ 20%	0 (0.0)	14 (27.5)	193 (95.5)	207 (76.1)
NRI (%), p-value comparing UKPDS and Framingham models	**5.8%, p=0.171**			
				Total
Participants with non-diabetic hyperglycaemia	**0 to < 10%**	**10 to < 20%**	**≥ 20%**	
0 to < 10%	46 (26.1)	0 (0.0)	0 (0.0)	46 (5.1)
10 to < 20%	122 (69.3)	74 (24.3)	1 (0.2)	197 (21.7)
≥ 20%	8 (4.6)	230 (75.7)	425 (99.8)	663 (73.2)
NRI (%), p-value comparing UKPDS and Framingham models	**-14.0%, p=0.004**			
				Total
Participants with normoglycaemia	**0 to < 10%**	**10 to < 20%**	**≥ 20%**	
0 to < 10%	2,177 (51.3)	10 (0.4)	0 (0.0)	2,187 (24.4)
10 to < 20%	2,002 (47.2)	972 (38.1)	36 (1.7)	3,010 (33.6)
≥ 20%	62 (1.5)	1,570 (61.5)	2,130 (98.3)	3,762 (42.0)
NRI (%), p-value comparing UKPDS and Framingham models	**-12.4%, p<0.001**			

Figure 1: Graph showing area under receiver operating characteristic curves for the UKPDS and Framingham risk score in each population sub-group in the EPIC-Norfolk cohort (1993-2007)

Figure 1a Participants with diabetes

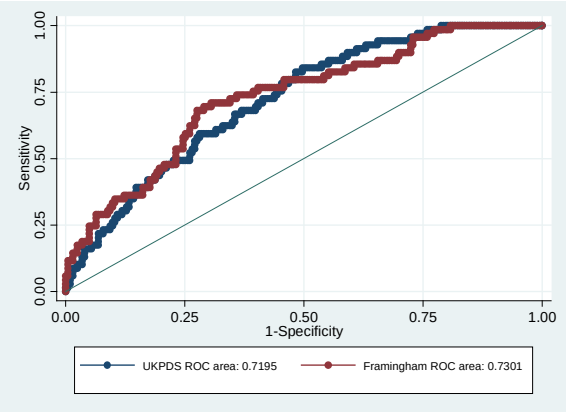


Figure 1b Participants with non-diabetic hyperglycaemia

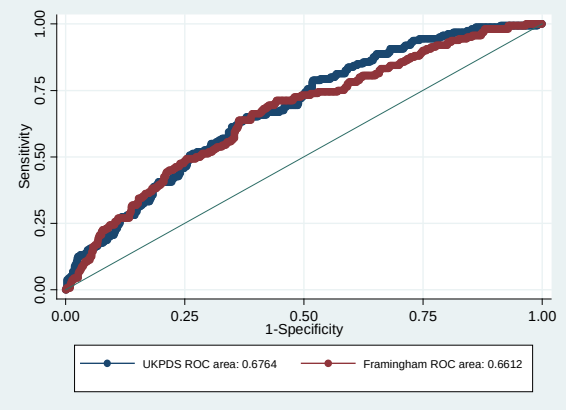
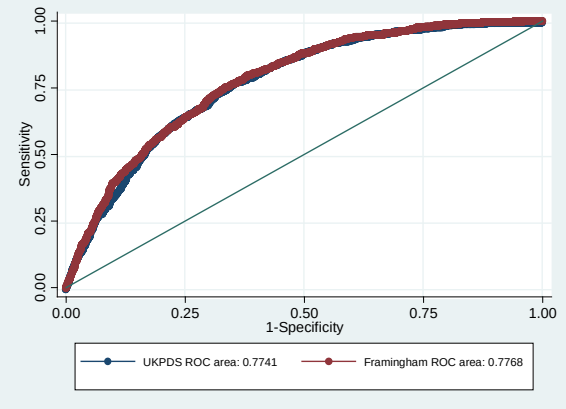


Figure 1c Participants with normoglycaemia



Discussion

In all population subgroups in the EPIC-Norfolk cohort, both the UKPDS Risk Engine and Framingham risk equations were moderately effective for identifying those at high risk (discrimination). Our findings are in keeping with a recent systematic review of cardiovascular risk scores that concluded that many of the commonly used risk scores perform reasonably well at ranking individuals according to CVD risk and are therefore useful in the identification of high risk individuals (160).

Although the risk of a CVD event was overestimated using both risk tools, it was encouraging that the proportion of participants with true-positive results correctly identified (sensitivity) was high in all three subgroups. The Framingham equations performed better in the hyperglycemic and normoglycemic groups as they did not overestimate risk by as much as the UKPDS Risk Engine, and they classified more participants correctly.

These results are unsurprising because the UKPDS Risk Engine was developed specifically for use in those with diabetes, and its use to estimate risk in other populations was exploratory (68). Similarly, the overestimation of the Framingham risk equations confirms previous findings in populations with low disease rates (161). However, the definition of CVD used in this analysis contains fewer end points than the definition given by the Framingham equations, accounting for some of the overestimation.

The predictive ability of both the UKPDS and Framingham risk equations in the EPIC-Norfolk cohort is lower than that reported in the original populations in which

they were developed (28, 68). This is to be expected given changes in the nature and distribution of cardiovascular risk factors over time, both within and between populations. A systematic review of 27 external validity studies showed that the performance of the Framingham risk equations varies considerably among different countries and ethnic groups. Predicted-to-observed ratios ranged from an underprediction of 0.43 in a higher-risk population, to overprediction of 2.87 in lower-risk populations (161). Results from diabetic populations indicate that the Framingham equations underestimates risk by as much as a half (47, 48, 162, 163), contrasting with results from this study in which Framingham equations overestimated CVD risk in individuals with diabetes. This finding may reflect the moderate CVD rates in the relatively healthy Norfolk region. Our results on the discrimination of the Framingham equations in the diabetic subgroup (aROC 0.73) are higher than those of a similar study, which validated the Framingham equations in a cohort of individuals with newly diagnosed diabetes (aROC 0.67) (48).

Measurement error in determining cardiovascular disease outcomes may have been present in our analyses. Four-fifths of the CVD events were nonfatal and were identified by linking records with hospital admission data. Although we could ascertain all deaths in the EPIC-Norfolk cohort, we could not identify all nonfatal cardiovascular events. However, previous validation studies in our cohort indicate high specificity of such case ascertainment (164). Hospital admission data probably underestimate nonfatal CVD events because not all of them result in hospital admission. Nevertheless, this method probably identifies nonfatal events of most clinical importance, e.g., those resulting in hospital admission.

The Framingham and EPIC-Norfolk CVD definitions included angina as an outcome, whereas the UKPDS definition did not. However, the CVD outcomes were largely similar, and this is unlikely to be a large source of bias. In terms of calculating the UKPDS risk equation, we did not have data on atrial fibrillation in the EPIC-Norfolk cohort. Because the number of participants with atrial fibrillation was very low in the UKPDS cohort (~1%), the presence of atrial fibrillation is unlikely to affect our findings.

In this large, population-based cohort, we found that the UKPDS Risk Engine and Framingham risk equations performed reasonably well for identifying those with a high CVD risk (discrimination). However, both equations overestimated risk.

Demonstration of the extent to which the Framingham Risk equations underestimate risk in individuals with diabetes

Having demonstrated the utility of the UKPDS Risk Engine in individuals both with and without diabetes I sought to determine the extent to which a non-diabetes specific risk calculator might underestimate risk in individuals with type 2 diabetes. This was necessary as such individuals represent a high risk group for CVD and it was anticipated that a significant proportion of individuals recruited for the Understanding Risk Study would have type 2 diabetes.

Subjects

I used baseline (pre-randomisation) data from 4,025 of the 4,191 participants recruited into the Lipids in Diabetes Study (LDS) between 1999 and 2001 for whom the requisite data were available. LDS was a lipid-lowering study involving thirty UK centres in which patients were enrolled on the basis that their need for lipid-lowering was uncertain given an absence of known coronary heart disease and an inclusion criterion requiring LDL cholesterol levels to be <4.1 mmol/l. In order to compare the relative performance of two calculators in younger people all participants aged between 40 and 50 years were examined (n=552) in a further analysis.

Materials and methods

Ten-year CVD risks were estimated for each individual using the UKPDS Risk Engine (version 3) (51) and the 2008 Framingham CVD risk equations (28). The

UKPDS Risk Engine defines CVD as fatal or non-fatal myocardial infarction, ischaemic heart disease, sudden cardiac death, fatal or non-fatal stroke or death following peripheral vascular disease. The Framingham equations define CVD as fatal or non-fatal myocardial infarction, angina pectoris, coronary insufficiency or fatal or non-fatal stroke, transient ischemic attack, peripheral vascular disease (intermittent claudication) or heart failure. The conventional risk factors used by both calculators are age, sex, smoking status, total and HDL cholesterol and systolic blood pressure. Only the UKPDS Risk Engine includes atrial fibrillation. The CVD risk estimates calculated using the two methods were compared using the Sign test. The proportions of males, females, and those under 50 years old not eligible for statin therapy were compared using the McNemar test (165).

Results

Demographics

The baseline characteristics of the Lipids in Diabetes Study participants are shown in Table 7.

Table 7: Characteristics of LDS participants.

Data presented are mean (SD), median (IQR)* or percentage.

	LDS participants (n=4025)
Age (years)	60.7 (8.6)
Men	65%
Ethnicity	
White Caucasian	91%
Afro-Caribbean	4%
Asian-Indian	5%
Current smokers	15%
Atrial fibrillation	0.5%
Blood pressure (mmHg)	
Systolic	141 (17)
Diastolic	83 (10)
Total:HDL cholesterol ratio	3.9 (1.0)
Known diabetes duration (years)*	6 (3, 11)
HbA1c (%)	8.0 (7.2, 9.0)

Distribution of 10-year CVD risk estimates

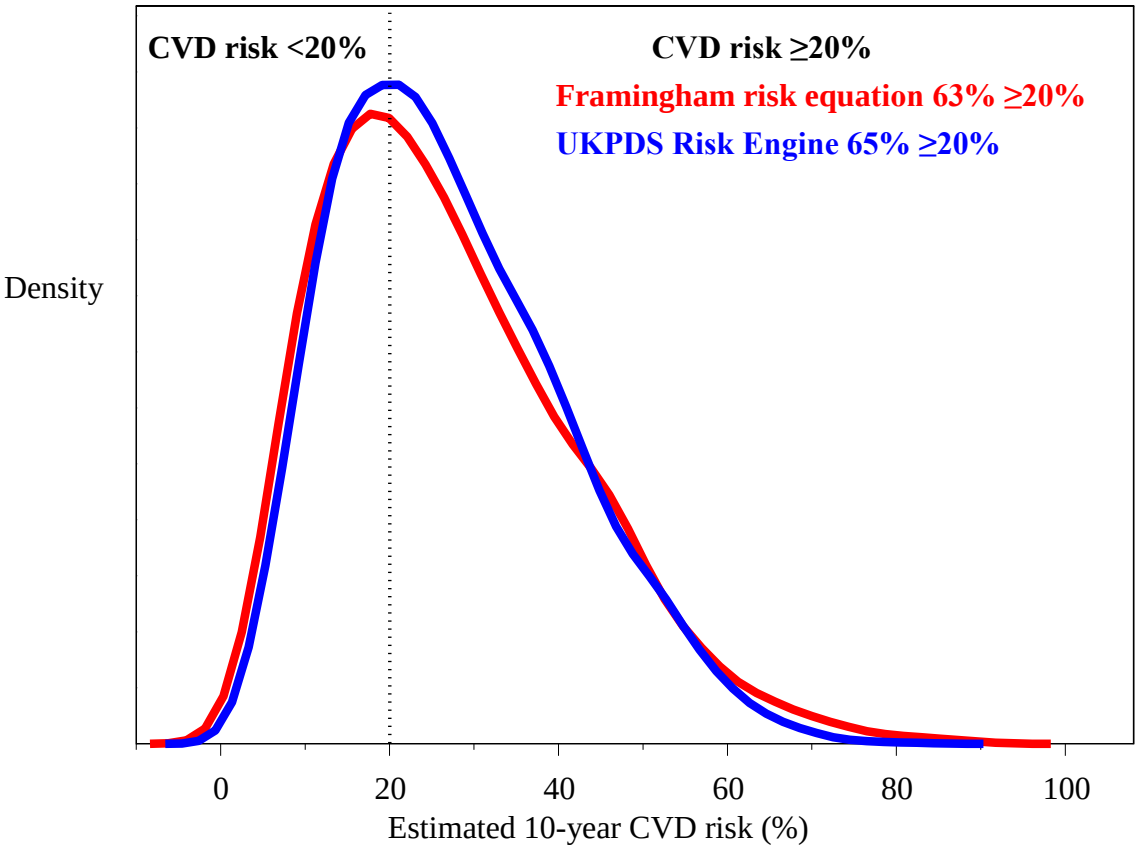
The proportions of patients with an estimated 10-year CVD risk ≥20% using the Framingham risk equations compared with the UKPDS Risk Engine are shown in Table 8 and Figure 2. The findings demonstrate small but significant differences in the proportion of eligible individuals estimated to be at high CVD risk depending on the risk calculator used. In individuals with type 2 diabetes, the differences are particularly pertinent for younger adults and for men. The UKPDS Risk Engine classified 4% more men and 7% more younger adults as being at high CVD risk than the Framingham risk equations.

Table 8: Proportions of patients with estimated CVD risk ≥20% using the UKPDS Risk Engine and Framingham equations.

Results were compared using the McNemar test.

	UKPDS Risk Engine estimated 10-year CVD risk	Framingham estimated 10-year CVD risk	p-value
All participants	65%	63%	p<0.001
Males	82%	78%	p<0.001
Females	34%	34%	p=0.83
Individuals <50 years old	18%	11%	p<0.001

Figure 2: Kernel density plot showing distribution of estimated 10-year CVD risk calculated using the Framingham equations (red) and the UKPDS Risk Engine (blue). The dotted line at 20% denotes a 10-year risk of 20%.



Discussion

I investigated the identification of individuals with type 2 diabetes at increased (≥20%) 10-year risk of CVD using both the UKPDS Risk Engine and the Framingham risk equations. This study found small but significant differences in the proportions of people with type 2 diabetes identified as being at elevated CVD risk depending on the risk calculator used. Two percent fewer people with type 2 diabetes, 4% fewer men with type 2 diabetes and 7% fewer individuals under the age

of 50 years with type 2 diabetes, were estimated to have a 10-year CVD risk ≥20% when using the Framingham equation rather than the UKPDS Risk Engine. This distinction is important as failure to be identified as being at high risk may result in people not receiving appropriate lifestyle advice or being denied statin therapy according to current UK NICE guidelines.

LDS participants were chosen for this initial study as they may not immediately appear to be at increased CVD risk as they had not had any previous CVD events and had LDL-cholesterol values <4.1 mmol/L. However, the LDS study was conducted some years ago and the mean HbA1c of participants is approximately 1% higher than current values (166) and compared with more contemporaneous UK primary care data the subjects included tended to be younger with a longer duration of diabetes (167). As well as population changes in HbA1c and blood pressure, death from CVD has also declined in men (but not women) with diabetes over the last 30 years possibly due to improvements in lifestyle and treatment of CVD (168). The LDS data are not contemporaneous and unlikely to reflect the current ethnic mix of the UK given that the vast majority of LDS subjects were white Caucasian. This is unlikely, however, to alter the conclusions of the study.

The UKPDS Risk Engine version 3 and the 2008 Framingham CVD equations were compared because of their similarities in the definition of CVD and because versions of both have been validated in their respective populations, although the most recent Framingham CVD equation has yet to be validated. The Framingham equation has been shown to underperform in diabetic populations previously (36) and this may in part be because it includes diabetes as a dichotomous variable rather than a continuous

measure of glycaemia. UKPDS Risk Engine CVD risk estimates decrease by approximately 15-20% for each 1% reduction in HbA1c.

Unfortunately, no long-term LDS outcome data are available to compare CVD risk estimates with observed events as the LDS trial was terminated early following withdrawal of cerivastatin for safety reasons (169).

The 2008 Framingham 10-year CVD risk equation estimated a similar proportion of individuals to be at high risk of CVD as the UKPDS Risk Engine. However, the updated Framingham equations require information on antihypertensive treatment that was not available from the LDS data. The numbers shown here assume that the blood pressure measurements at baseline in LDS were untreated, this is likely to be the case given the mean blood pressure in LDS was 141/83 and recruitment took place between 1999-2001. If everyone in the study was receiving blood pressure therapy the proportion of high risk individuals would increase significantly to 77%. The Framingham and UKPDS definitions of CVD are similar with the exception that the Framingham equations include individuals with angina pectoris (brief recurrent chest discomfort for up to 15 min, brought on by exertion and relieved by rest or glyceryl trinitrate)(170) whereas the UKPDS Risk Engine includes those with ischaemic heart disease (based on ECG Minnesota coding) (171). It would be expected that because of the broader definition of CVD used by the Framingham equations they would tend to classify more individuals at high CVD risk but this is not the case.

The differences in 10-year CVD risk estimates are seen predominantly in men and those under the age of 50. The difference in estimated risk seen in males may be due to the failure of Framingham risk equations to show a gradient of risk when total cholesterol in men is <6.2 mmol/L (172). Subsequent studies have demonstrated a

continuous relationship between total cholesterol and CVD risk. In LDS patients the mean (SD) total cholesterol was 4.8 (0.8) mmol/L. Framingham risk equations have also been found to underestimate risk when risk factors are present in severe forms (very elevated systolic BP or total cholesterol) (172). These factors may go some way to explaining the difference in male risk estimates found in this study.

In the UKPDS, 71 individuals under the age of 50 years had a coronary heart disease event. However, in the Framingham study no individual with diabetes under the age of 52 years had a CVD event (173). This difference in the event rates underlying the two equations is likely to explain the underestimation of risk seen in younger people with the Framingham equations.

In individuals under the age of 50 years in this study the Framingham equations classified fewer individuals as being at high CVD risk than the UKPDS Risk Engine ($p<0.0001$). These data illustrate the value of using a diabetes-specific risk calculator to identify the relatively small number of younger people at elevated CVD risk.

In view of the pragmatic reasons already highlighted, the findings from this work and given that our earlier work demonstrated the ability of the UKPDS Risk Engine to correctly rank individuals without diabetes according to their CVD risk, I chose to use the UKPDS Risk Engine to estimate CVD risk for my Understanding Risk Study.

Chapter 7: Development of a risk communication and a brief lifestyle advice intervention

Lay perceptions of CVD risk

Study Design

In January 2008 three focus groups (group interviews) were held with 21 adults in Oxford. Focus groups were chosen in order to encourage discussion amongst participants in the groups rather than responding only to direct questions from the moderator. My approach was designed to identify themes during data collection, rather than test predetermined hypotheses.

Training in qualitative methods

Prior to conducting the focus groups I attended two courses at the University of Surrey in order to ensure that I had the appropriate skills to conduct and analyse this type of research. The courses were entitled "Introduction to focus groups" and "Introduction to qualitative analysis". Mentoring in this area was also provided by Dr Simon Griffin who has considerable expertise in this field.

Participants

Participants were recruited from a database of individuals expressing interest in taking part in research studies. All participants gave written informed consent and the study received approval from the local Milton Keynes Research Ethics Committee.

Data Collection

The tape-recorded focus groups were held in seminar rooms at the Oxford Centre for Diabetes, Endocrinology and Metabolism. Each focus group lasted approximately 90

minutes. Participants received no financial incentive for taking part but were reimbursed their travelling expenses and were given drinks and light refreshments during the sessions.

Topics discussed

A question map of open-ended questions was used during the groups (Appendix 1). The topics discussed included:

- Concern about having a heart attack
- Own perceptions of heart attack risk
- Knowledge of CVD risk reduction strategies
- Level of heart attack risk that would cause concern
- Effect of physical activity on heart attack risk
- Sources of knowledge regarding heart attack risk

Data Analysis

Preliminary analyses began as each focus group transcript was completed. After completion of three focus groups I recognised that a level of data saturation had been reached as comments were becoming repetitive. Once all three focus groups had been completed an in-depth analysis of the data collected began. Analysis was thematic (174). The tape recordings were listened to and the transcripts read repeatedly.

Codes were then developed and the transcripts were coded line by line but a qualitative data indexing software package was not used. New codes were generated during this process as required. Following coding, recurring themes, similar patterns and distinctions were sought and supportive quotations were identified. Themes were not predetermined and were not referred back to the focus group participants but they were invited to take part in the pilot study using the interventions developed as a result of the focus group findings. No formal statistical analyses took place.

Results

Participants

The 21 participants were mean (SD) age 66 (1.3) years. 62% were males, median (IQR) age at leaving full time education was 18 (16-22). Sixteen had type 2 diabetes and none had a prior history of CVD. All participants were of White Caucasian ethnicity.

Lay perceptions of heart attack risk

Varying concern about having a heart attack.

Participants' concerns about having a heart attack varied widely (Box 1). Some participants viewed death from a heart attack as preferable to other causes of death whereas others were more worried. A ten year CVD risk of 10% or above seemed to be an arbitrary level that participants considered as 'high risk'.

Box 1: Quotations supporting the theme of varying concern regarding having a heart attack

Participant 1 “To be honest I worry more about things like prostate cancer…than heart attacks.”

Participant 2 “I basically couldn’t give a bugger about heart attack as long as it’s fatal”

Participant 2 “I look at it this way, you’ve got to leave this mortal coil somehow…and I can’t think of a better way than a heart attack”

Participant 3 “You don’t want to have a heart attack no, be it fatal or otherwise”

Participant 4 “Something less than 10% I’m thinking ok, that’s fine. Obviously in the 20’s and so on I’m really getting it…10% is my sort of arbitrary, I think I’m ok.”

Barriers to physical activity.

Participants tended to focus on the barriers to physical activity and persistently highlighted the possible dangers of increasing physical activity (Box 2).

Box 2: **Quotations supporting the theme of barriers to physical activity**

Participant 5 "I don't know quite, what the sort of safe level of exercise is? Bearing in mind the footballer who collapsed on the field a week or so ago."

Participant 6 "Just a warning about exercise, I used to be a brisk walker and a keen gardener, and through my keen gardening I slipped a disc and overnight I could neither walk nor garden"

Participant 6 "I approached my doctor some time ago and said would it be a good idea for me to join a gym and take regular you know, exercise with gymnasium equipment. And rather alarmingly he looked at me and said 'I should stick to walking if I were you'. As if you say, there's a limit to what you can achieve at your age."

Sources of knowledge and information.

All participants were aware that having a heart attack would adversely affect their health but few understood the links between CVD risk factors and heart attacks (Box 3). Participants' explanations included that such information probably had been explained to them at some point in the past by a healthcare professional but they had forgotten it. If participants wanted to know more about heart attack risk then in general they would visit their healthcare professional. A minority would consult the lay press or the internet. For many the internet was viewed with suspicion as a source of quality health information. Information published by the lay press and government agencies was largely considered a poor source of information with confusing or conflicting messages. In all groups awareness of CVD was strongly influenced by

real life, including their own experiences and anecdotal observations. In summary participants were sceptical about risk information particularly that emanating from the government, but had much more faith in information provided by general practitioners.

Box 3: Quotations supporting the theme of sources of knowledge and information

Participant 1 “You know, those who smoke are obviously are more risk, I say obviously without having the faintest idea why”

Participant 4 “I’ve got a deep suspicion anyway that there is so much out there that is unfiltered and all the rest of it and sort of trying to interpret it yourself that’s the last thing. I’d want to go and see my…GP”

Participant 7 “Every day there’s something new in the newspapers that says ‘that’s bad for you’ or ‘that’s good for you’ you get so muddled!”

Participant 3 “My doctor should know me and know my records….does Gordon Brown know that? Can he tell me what to do to help me keep alive?”

Participant 7 “Anything to do with the government dear can go away”

Participant 4 “If I go into a pub and I see someone who’s obviously quite young with an enormous belly and is smoking….and drinking copious quantities of lager…I think ‘I am so far removed from that’ I think instinctively ‘I’m all right’.”

Participant 8 “My mother died at 79 she was gardening and she dropped dead without any previous health things”

Participant 9 “Thinking of a member of the family who looks like a sitting heart attack who smoked and drank and so on but dies at the age of 92 whereas a much healthier cousin, thin and fit and healthy…died at 40 of a heart attack”

Discussion

The findings from the three focus groups held demonstrated that the benefits of a healthy lifestyle were well known amongst older adults from Oxfordshire and whilst this supports a previous study (175) this has not universally been the case when lay perceptions of a healthy lifestyle have been investigated (150). Interestingly, despite their apparent knowledge, participants consistently expressed barriers to physical activity particularly expressing a concern that it may "do more harm than good". The gathering of such information is useful when designing interventions aimed at increasing physical activity in late middle-aged UK adults which may need to address this issue specifically if they are to be effective.

I have also demonstrated that interest in the risk of future ill health is variable and is influenced by personal and anecdotal evidence that tends to equate health events to luck or chance. Participants also varied in their level of concern about having a heart attack. In general however, participants were keen to reduce their risk to below average, particularly if their estimated risk of having a heart attack was greater than 10% over the next ten years. This seems to reflect a concern with both peer comparisons and a somewhat arbitrary absolute level of risk and reflects a previous similar study (175).

Knowledge among focus group participants that type 2 diabetes is a major risk factor for CVD was poor in keeping with other evidence (176). A minority of participants thought they may have been told this at the time of diagnosis (two participants) and others maintained they had never been informed of this link (five participants). There was also a view that this was something the general practitioner should take care of and that the patient's role was to take the medication prescribed rather than request an

explanation for the rationale behind the prescription. Lack of awareness about major CVD risk factors has been noted previously (77).

Participants' explanations about CVD risk factors and the benefits of lifestyle choices often contained inaccuracies and this was irrespective of educational background. Providing patients with more detailed information about CVD risk may not necessarily impact on their underlying beliefs but in this study participants were actively seeking more detailed and complex explanations about the links between CVD risk factors and CVD. A balance needs to be struck between providing adequate explanatory information yet not providing such complex explanations that few patients can understand.

Throughout the focus groups advice given by a healthcare professional was considered of high quality and important. Participant's viewed their healthcare providers as an important source of honest, reliable, non-biased information and underlined the importance of the role of the healthcare provider as a patient educator. Interestingly, advice issued by the government was viewed with the same scepticism as information found in the lay press or on the internet. This information could also be useful in designing health interventions or even public health campaigns.

The focus group findings are limited in that they were collected from a small sample of the general population from a limited geographical area. Focus group participants also tended to be well educated and were recruited through a database of individuals willing to take part in research. All were of White Caucasian ethnicity. Unfortunately I am unable to further describe the characteristics of focus group participants as the data presented is all the demographic information that was collected from these participants. In addition, the majority of participants had type 2

diabetes as a result, the findings of the focus groups may be more applicable to individuals at increased CVD risk due to type 2 diabetes than for other reasons. These issues may limit the generalisibility of the findings and as such they may not be truly representative of the late middle-aged British population. However, interest in the topic could be considered high given that the response rate to invitations to take part in the focus groups was 30%. In order to confirm the findings the focus groups could be repeated with individuals from a broader range of educational backgrounds and include individuals from a variety of ethnic groups. In addition, this study is liable to bias because the focus groups were transcribed and analysed by one person without the aid of a suitable software package. The results are however, in keeping with another similar study (175). Ideally the findings from the focus group should have been triangulated with others who have also read the focus group transcripts although this is not an absolute requirement of data analysis (174). This is a limitation of my study. The failure to use a software package was viewed favourably by the reviewers of the journal to which the focus group results manuscript was submitted and subsequently published (177). The reviewers said it was refreshing that a software package had not been used as analysing the data by hand allowed more subtle themes to be identified.

Focus groups are also unable to glean the detailed personal information that can be obtained by conducting individual interviews with participants. However, their advantage is that they allow lively discussion and participant interaction.

The focus groups described here have allowed a better understanding of lay perceptions of, and underlying assumptions about, CVD risk. Individually tailored information appears to be an important determinant in engaging patients in a

discussion of their risk. Participants expressed interest in knowing they were at high risk of CVD, particularly if interventions could be initiated with a view to lowering that risk. Detailed explanation was considered important in understanding how risk reduction strategies work. These findings may assist with improving physician-patient discussions of CVD and along with well designed, evidence-based tools may help to motivate behaviour changes aimed at reducing CVD risk.

Use of focus groups to develop methods to communicate cardiovascular disease risk and potential for risk reduction

A question map of open-ended questions was used during the groups (Appendix 1). Participants were the same as those involved in the focus groups described above. Risk communication aids were discussed in the second part of the focus groups following the discussions concerning CVD risk.

To compare participants' reactions to commonly used visual risk communication material, examples were provided to each participant approximately one week prior to the group meeting. Although some of the examples were interactive computer-based tools they were not demonstrated during the focus groups but a brief explanation of how each worked was given.

The scenarios provided included a 65 year old man (178), a 60 year old man (179) and a 54 year old woman (180), all with an estimated 10-year CVD risk of 13% calculated using the Framingham risk equations (32). Participants were also shown images of The Paling Perspective Scale©, crowd charts depicting 100 faces with colours indicating the proportion of individuals affected (58), New Zealand CVD risk charts (181) and British Hypertension Society risk charts (182). They were also shown a simple bar chart shaded from blue to red (through green, yellow and orange) to represent lowest and highest possible risk for an individual of that age and sex with a second bar next to it to represent current personal risk (183).

Participants were provided with a draft version of a CVD risk reduction brief lifestyle advice intervention based on self-regulation theory (184), and their opinions regarding its content and likelihood of motivating behaviour change were sought (Appendix 2).

The intervention focused on four target behaviours: increasing physical activity, increasing fruit and vegetable intake, reducing alcohol intake and smoking cessation.

Development of Brief Lifestyle Advice and UKPDS Risk Engine interface

The interpretations of these data were used to refine the brief lifestyle intervention and to design an interactive display version of the UKPDS Risk Engine that could illustrate potential reductions in CVD risk. The interface was not tested again prior to its incorporation as an intervention into the uRisk study.

Results

Three recurring themes emerged. The first is that being less numerate is common and that for many people numbers are incomprehensible (Box 4). This was particularly true of older women focus group participants.

Box 4: Supportive quotations for the theme of being less numerate

Participant 1 “Numbers defeat me”
Participant 2 “I prefer words to numbers”

The second theme was that CVD risk reduction is important (Box 5). Participants expressed a wish to be at or below average risk and were willing to modify behaviour to achieve this even if it meant only a modest reduction in absolute risk. The idea of

personalised risk information was appealing and preferred over more general information but needed to be accompanied by risk reduction strategies.

Box 5: Supportive quotations for the theme of the importance of CVD risk reduction

Participant 3 "Yes, but then he could say to me 'well look, you're here if you worked harder on your blood pressure by doing a bit more exercise or blah blah blah then we could bring it down to here, but look if you took the statins then you could bring the risk this way a bit' and so I think…it is useful"

Participant 4 "I've been doing this, that and that it should have come down, it's giving you something to…to aim for"

Moderator "If you were 13% and your GP said 'right, if you drink a little bit less, do that 30 minutes walking a day and come back and see me in 6 months and you'll be 9%'. You would consider that something worth doing?...Even though 4% might not sound very much, that would be enough to make you do it?"

Participant 5 "But it's not 4% is it, cos, it's actually nearly 50%."

The third theme concerned the visual representation of risk (Box 6). Participants felt a clear visual representation of risk aided comprehension particularly when demonstrating how risk is accumulated. The ability to use sliders and option buttons to demonstrate the impact of changes (for example reducing blood pressure) on 10-year CVD risk was popular. A traffic light system of colours was considered a universally comprehensible method of conveying risk information. The size of any

graphical interface should be such that it fills the entire computer screen on which it is displayed.

Box 6: Supportive quotations for the theme of visual representation of risk

Participant 6 “What I’d like to know is, how much does that factor contribute to the risks?”

Participant 3 “By putting the sliders up and down…people could see…how much the risk factors affected their outcome”

Participant 7 “That’s the more usual arrangement where red for danger, green for you know, go.”

Participant 7 “Green for good and red for bad…..it’s just that it’s a convention that everybody knows and everybody understands and you don’t have to explain”

Participant 6 “A traffic light system then, 3 colours”

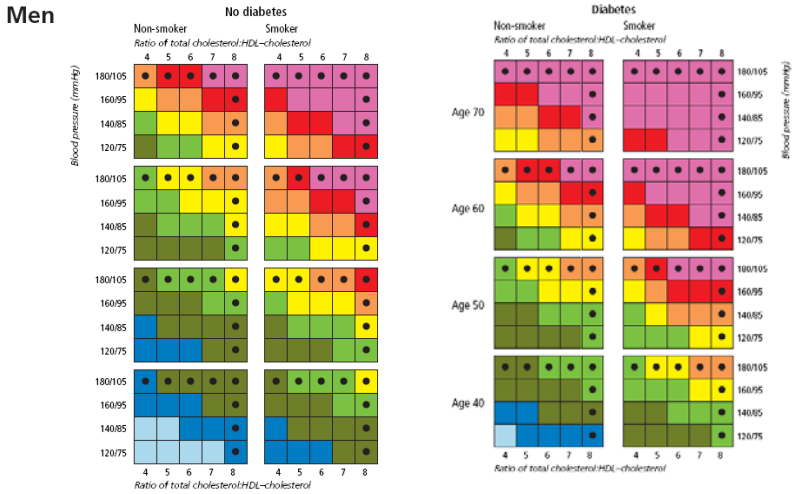
Participant 8 “It’s too small! Can’t even read it. I won’t even bother trying.”

Participant 4 “If those are going to be used they’ve got to be larger.”

Responses to Visual Representations of Risk (Box 7)

New Zealand Risk Charts

Figure 3: New Zealand Risk Charts



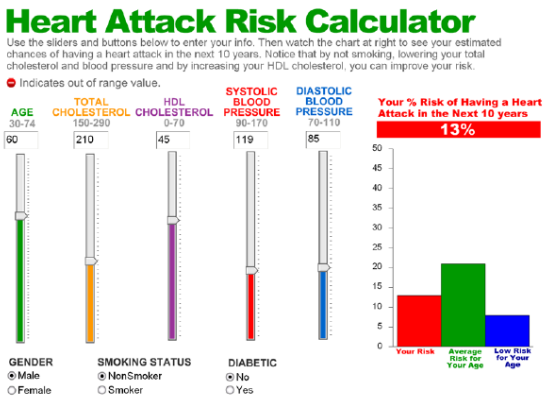
Risk level 5 year cardiovascular risk (non-fatal and fatal)		Benefit Cardiovascular events prevented per 100 treated for 5 years*	Benefit Number needed to treat for 5 years to prevent 1 event*
Very high	>30%	>10	<10
	25-30%	9	11
	20-25%	7.5	13
High	15-20%	6	16
Moderate	10-15%	4	25
Mild	5-10%	2.5	40
	2.5-5%	1.25	80
	<2.5%	<0.8	>120

Cells with this marker (●) indicate that in patients with very high levels of total cholesterol (> about 8.5–9 mmol/L) or blood pressure (> about 170/100 mmHg), the risk equations may underestimate the true risk.
* Assumes that cholesterol reduction of about 20% in patients with total cholesterol > 5.0–5.5 mmol/L or blood pressure reduction of about 12/6 mmHg in patients with BP > 140–150/90 mmHg produces an approximate 30% reduction in cardiovascular disease risk, whatever the pretreatment absolute risk.

These were disliked by the majority of participants. Participants explained that although consisting of 16 different boxes only one would be relevant to any one individual. The colour scheme was also unpopular with a strongly held view that the highest risk boxes should be shaded red and not pink.

The Heart Attack Risk Calculator

Figure 4: The Heart Attack Risk Calculator



This was viewed more positively. The comparison to other people of the same age was popular.

Crowd Chart

Figure 5: Crowd Chart

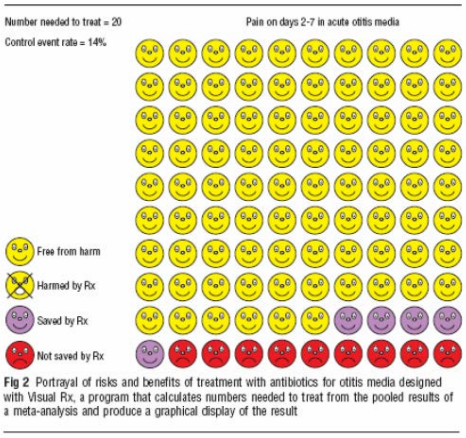
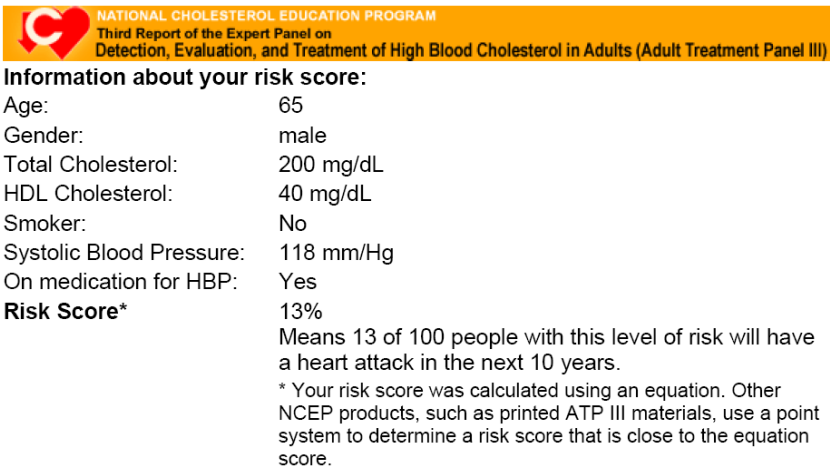


Fig 2 Portrayal of risks and benefits of treatment with antibiotics for otitis media designed with Visual Rx, a program that calculates numbers needed to treat from the pooled results of a meta-analysis and produce a graphical display of the result

This was very unpopular. It did not resonate with any of the participants. It was considered to be confusing and incomprehensible.

The National cholesterol education risk score/The British Hypertensive Society charts/Healthlink

Figure 6: The National cholesterol education risk score



NATIONAL CHOLESTEROL EDUCATION PROGRAM
Third Report of the Expert Panel on
Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III)

Information about your risk score:

Age:	65
Gender:	male
Total Cholesterol:	200 mg/dL
HDL Cholesterol:	40 mg/dL
Smoker:	No
Systolic Blood Pressure:	118 mm/Hg
On medication for HBP:	Yes
Risk Score*	13% Means 13 of 100 people with this level of risk will have a heart attack in the next 10 years.

* Your risk score was calculated using an equation. Other NCEP products, such as printed ATP III materials, use a point system to determine a risk score that is close to the equation score.

Figure 7: The British Hypertension Society charts

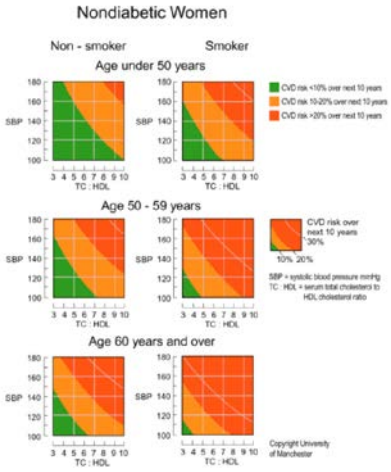


Figure 8: Healthlink

Your Chances of Heart Disease

Your chances of having a heart disease (including heart related chest pain, heart attack, and sudden death) in the next 10 years is **27%**.

The following graph is provided to help gauge your chances of having a heart disease in the next 10 years. The arrow indicates your chances. According to most doctors, Green means that you have a low chance of heart disease (<5%), while Red means that you have a high chance (>10%).

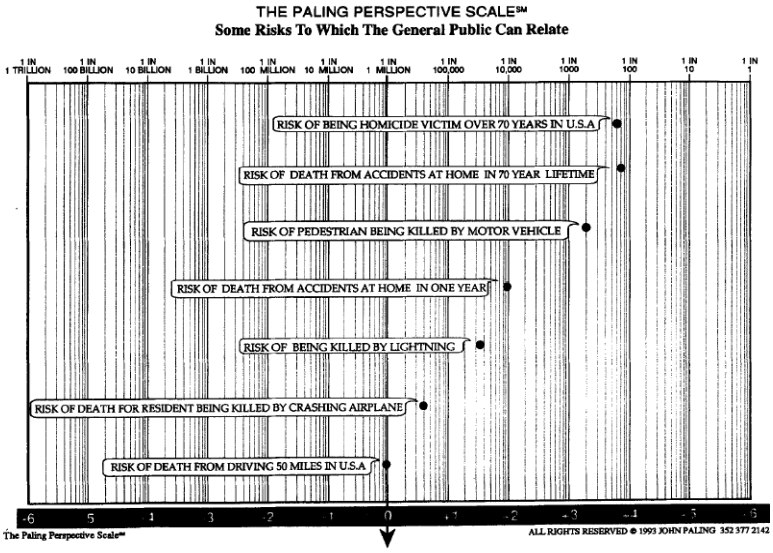
Overall risk(%)

For comparison, a 68 year old male with no risk factors has a 13% average chance of having a heart disease **sometime in the next 10 years.**

These visual representations generated few comments.

The Paling Perspective Scale

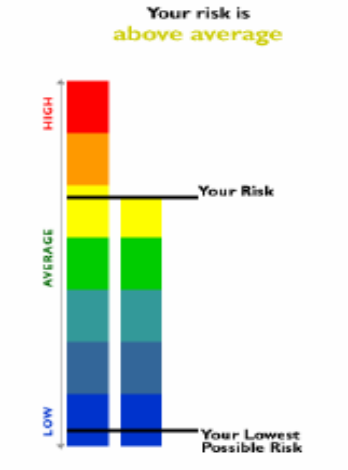
Figure 9: The Paling Perspective Scale



The Paling Perspective Scale was disliked by all. It was considered confusing and irrelevant.

Your disease risk bar charts

Figure 10: Your disease risk bar charts



The bar charts used by your disease risk provoked varied responses. Some liked the colour scheme but other preferred the standard traffic light scheme. Many commented on the unnecessary second bar present.

Box 7: Supportive quotations for the opinions regarding existing representations of risk

New Zealand Risk Charts

Participant 6 “You don’t want 16 squares on there when only one applies to you”

Participant 8 “I would strongly support the view that red should be the highest”

The Heart Attack Risk Calculator

Participant 2 “The heart attack calculator. I thought that was particularly good”

Crowd Chart

Participant 7 “I didn’t understand the one with all the faces on”

The Paling Perspective Scale

Participant 4 “I thought that was rubbish”

Participant 4 “Risk of death from resident being killed by crashing aeroplane, I’ve got a job to even think about that. Risk of being killed by lightening well, again I can’t really see the relevance”

Box 7 continued

The Paling Perspective Scale

Participant 9 "What is a trillion, how do you get your head around that?"

Your disease risk bar charts

Participant 10 "It sort of strikes you as, more accurate, it goes from blue up to red"

Participant 3 "Except that the second bar…is functionless, why is the second bar there? The first one was fine."

Responses to draft brief lifestyle advice intervention

The participants largely felt more comfortable with the information contained in the brief lifestyle advice intervention than they did with the CVD risk material (Box 8).

Participants felt the health messages contained within the intervention were well known and considered to be true. They felt the intervention did not contain any confusing or conflicting health messages. Participants did not however, like rigid targets for exercise and fruit and vegetable intake. Instead they wanted an intervention that encouraged them to do as much as they can. There was also a strong feeling in all the groups that the intervention should acknowledge each individual's own circumstances that may make following the lifestyle advice more difficult for

example family commitments limiting time for exercise or financial constraints restricting fruit and vegetable intake.

Five of the 16 participants with diabetes were unaware of the link between diabetes and heart attacks and wanted more explanation as to why this is the case.

There was also concern that, in its present state, the intervention assumed everyone was smoking or drinking too much alcohol which may not always be the case.

Box 8: Supportive quotations for the opinions regarding the draft brief lifestyle advice intervention

Participant 1 “This stuff is lovely. I can get to grips with this.”

Moderator “Do you think that that recommendation to walk for 30 minutes a day. Was that something that you’d heard of before?”

Participant 11 “Yes”

Moderator “So none of it was really new to you in the information?”

Participant 11 “No, no.”

Participant 12 “There was a lot of it I think that we have heard.”

Participant 1“Absolutely”

Participant 13 “To have some general guidelines that…eating fruit and…going walking whenever you can instead of saying it has to be for 30 minutes and you have

Box 8 continued

to be sweating…that puts people off"

Participant 9 "With diet have your 5 a day etc. etc. Can you afford to? Can you walk to the shops to buy it? Have you got transport? Have you got enough money? You know…there are lots of other factors"

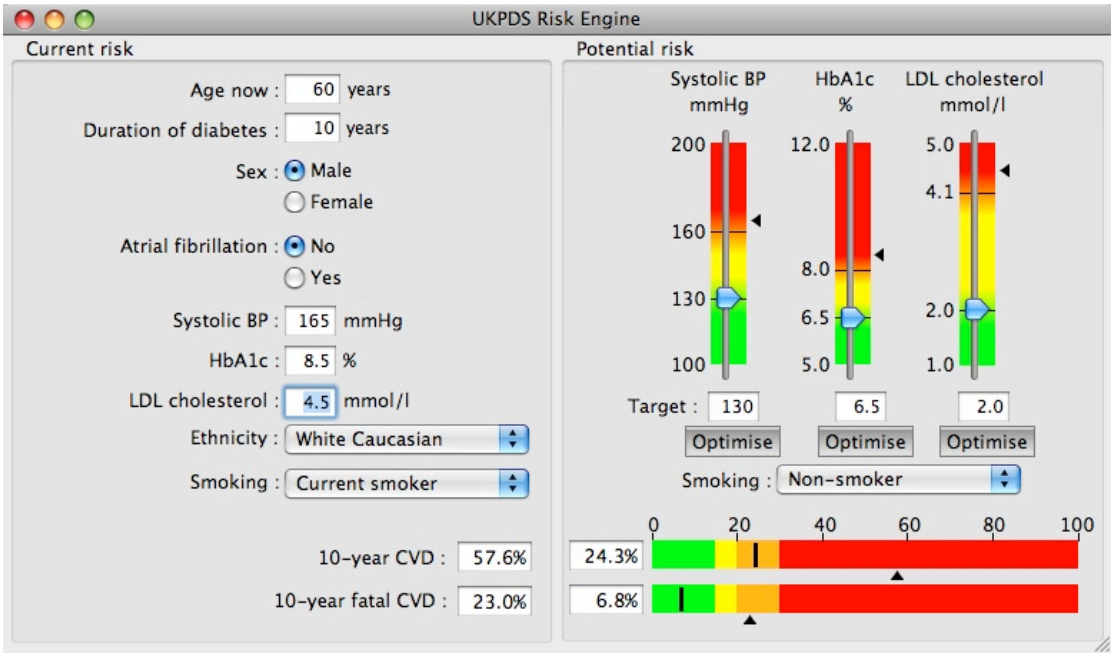
Participant 5 "There's a little line which I thought was very empowering which said something about, yes, fruit and veg, fresh fruit and chilled, canned and 100% juice all count as do dried fruit and veg. That's great. That's really useful."

Participant 4 "So why can't you have a page on what you're just saying (link between diabetes and CVD), it's there in black and white for everybody to realise exactly what is happening inside you"

Participant 14 "It does make the assumption that everybody is drinking too much alcohol…we might not be"

The focus group findings were used to inform the design of a simple graphical method (Figure 11) for illustrating likely risk reductions and a brief lifestyle advice intervention (Appendix 2). The UKPDS Risk Engine interface chosen was that which best reflected the most common requirements, including the incorporation of sliders to demonstrate the accumulation of risk and a traffic-light colour scheme.

Figure 11: The animated interactive version of the UKPDS Risk Engine developed using focus groups



The Risk Engine interface was divided into two panels. The left hand panel concerned the estimation of current risk and the right hand panel the estimation of "achievable" or potential risk. In order to estimate current risk, age, duration of diabetes, systolic blood pressure, HbA1c value and LDL cholesterol value were typed into the interface. Option buttons were then used to select sex and presence of atrial fibrillation. Finally, ethnicity and smoking status were selected from drop down menus. Ethnicity options included White Caucasian, Asian-Indian and Afro-Caribbean and smoking status options current, ex or never. Once these parameters were all entered the Risk Engine automatically estimated current 10-year CVD risk. The right hand panel was then used to demonstrate potentially achievable reductions in 10-year CVD risk. The sliders allowed systolic blood pressure, HbA1c and LDL-cholesterol values to be scrolled up and down. As this was done, potential 10-year CVD risk automatically adjusted accordingly. In addition, clicking an optimise button

set a risk factor value to its target level and the smoking menu allowed smoking status to be set to ex for those who were current smokers. The small black triangles displayed current risk factor values.

Discussion

The focus group findings contained key messages that aided the development of a personalised 10-year CVD risk estimate intervention and a brief lifestyle advice intervention. Findings included views that being less numerate is common, CVD risk reduction is important, and clear visual representations of risk aid comprehension. Incorporation of these findings into each intervention should have resulted in the production of interventions that had high acceptability and comprehension by their target audience.

Some of the risk communication examples discussed were interactive computer-based tools and I assumed a degree of familiarity with computers in participants. This is not unreasonable as data from the United States shows 55% of adults aged 60-64 years have access to a home computer (185) although this does decline with advancing age falling to 16% of those aged over 90 years. A study in the United States has also shown that with appropriate training older adults are able to successfully play complex strategic computer games (186) suggesting that the interface developed could be used by its target audience with some instruction although any risk communication tool will not be universally acceptable to all (187).

Participants received the risk communication examples in advance of the focus groups. This allowed participants the opportunity to familiarise themselves with the

materials before the focus groups but may have influenced their opinions of risk communication materials compared to not having seen any examples in advance. I could have shown some groups the materials in advance and not other groups to ensure that this did not impact on participant opinions.

In the development of the brief lifestyle advice intervention, I incorporated the findings from the focus groups that rigid targets are unhelpful but that general guidelines are acceptable and useful. Any reference to government health policy was avoided and the intervention was designed to be delivered by a healthcare professional as they represented the most trusted source of healthcare information. An acceptance of individual circumstances was also included to acknowledge that lifestyle choices are influenced by many other factors (finances, family commitments etc.), besides a desire to be healthy and protect oneself against future disease events. The health messages contained within the lifestyle intervention were well known and it was accepted that following the recommendations would be advantageous to health. As in an earlier study I also found that the concepts of luck and fate play a role in individual's perceptions about future ill health (175) and so the intervention specifically addresses modifiable CVD risk factors to emphasise that behaviour changes can reduce risk.

Focus groups were required to design a new interface for the UKPDS Risk Engine as there is a paucity of data regarding the effectiveness of differing forms of numerical presentation for conveying risk information. Similarly a need has been identified to develop and test such interventions with their target group in order to assess applicability and interpretation as few of the many decision aids available have been evaluated (188). Trials indicate that decision aids improve knowledge and realistic

expectations, enhance active participation in decision making, lower decisional conflict, decrease the proportion of people remaining undecided, and improve agreement between values and choice. However, their long-term effectiveness and cost-effectiveness have yet to be evaluated (188). Other work has highlighted the benefits of personalised information and has promoted the idea of using online or interactive formats allowing real-time presentation of individual risk and an interactive discussion of risk (187).

Clear messages emerged from focus group participants concerning risk communication. Participants felt very strongly about the colour scheme that should be used to communicate risk and clearly felt that deviation from the accepted traffic light colour scheme was unhelpful to patients. This colour scheme was duly incorporated into the UKPDS Risk Engine interface. In addition, it was clear that the font size of the interface would need to be large in order to facilitate understanding. Finally, participants expressed a wish to visualise the accumulation of risk and viewed the use of interactive buttons and sliders that demonstrated the accumulation of risk favourably. These findings are likely to be applicable to many clinical situations requiring a discussion of risk and may assist others wishing to design a user-centred risk communication tool.

The findings from this study and the subsequent Risk Engine interface are largely in keeping with the recommendations from the International Patient Decision Aid Standards Collaboration concerning the production of risk communication materials (189). The UKPDS Risk Engine interface developed complies with the majority of the checklist, including the ability to compare outcome probabilities using the same denominator, time period and scale and allowing individuals to view probabilities

based on their own situation. It also includes multiple methods of viewing probabilities including numbers and graphics and uses a traffic light colour scheme.

A risk communication tool and brief lifestyle advice intervention were developed with the aid of focus groups and other published evidence and were subsequently tested in a 2x2 factorial randomised controlled trail to determine the ability of each intervention to motivate individuals to adopt lifestyle changes aimed at reducing their CVD risk.

Chapter 8: The Understanding Risk Study

Primary objectives

To determine the efficacy of a personalised 10-year CVD risk estimate for increasing physical activity at one month compared with CVD risk factor values and to determine if a brief lifestyle advice intervention versus no lifestyle advice could increase physical activity at one month.

Secondary Objectives

To determine the efficacy of a personalised 10-year CVD risk estimate and a brief lifestyle advice intervention in modifying estimated 10-year CVD risk and the following CVD risk factors: smoking status (as measured by serum cotinine), fruit and vegetable intake (as measured by plasma vitamin C), self-reported alcohol consumption, fasting and 2-hour post-challenge plasma glucose, fructosamine, waist circumference, body weight, BMI, total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides, systolic and diastolic blood pressure and body fat percentage.

Study Design

This was a pilot 2x2 factorial randomised controlled trial with 46 participants in each cell (Figure 12). The 2x2 factorial design was considered to be the most appropriate and efficient method of answering the research question posed. Each participant received a personalised 10-year CVD risk estimate or CVD risk factor values plus a standardised brief lifestyle advice intervention or no lifestyle advice intervention.

Ethical approval was granted by the Milton Keynes Local Research Ethics Committee in September 2007 and the study was carried out in accordance with the Declaration of Helsinki and good clinical practice guidelines.

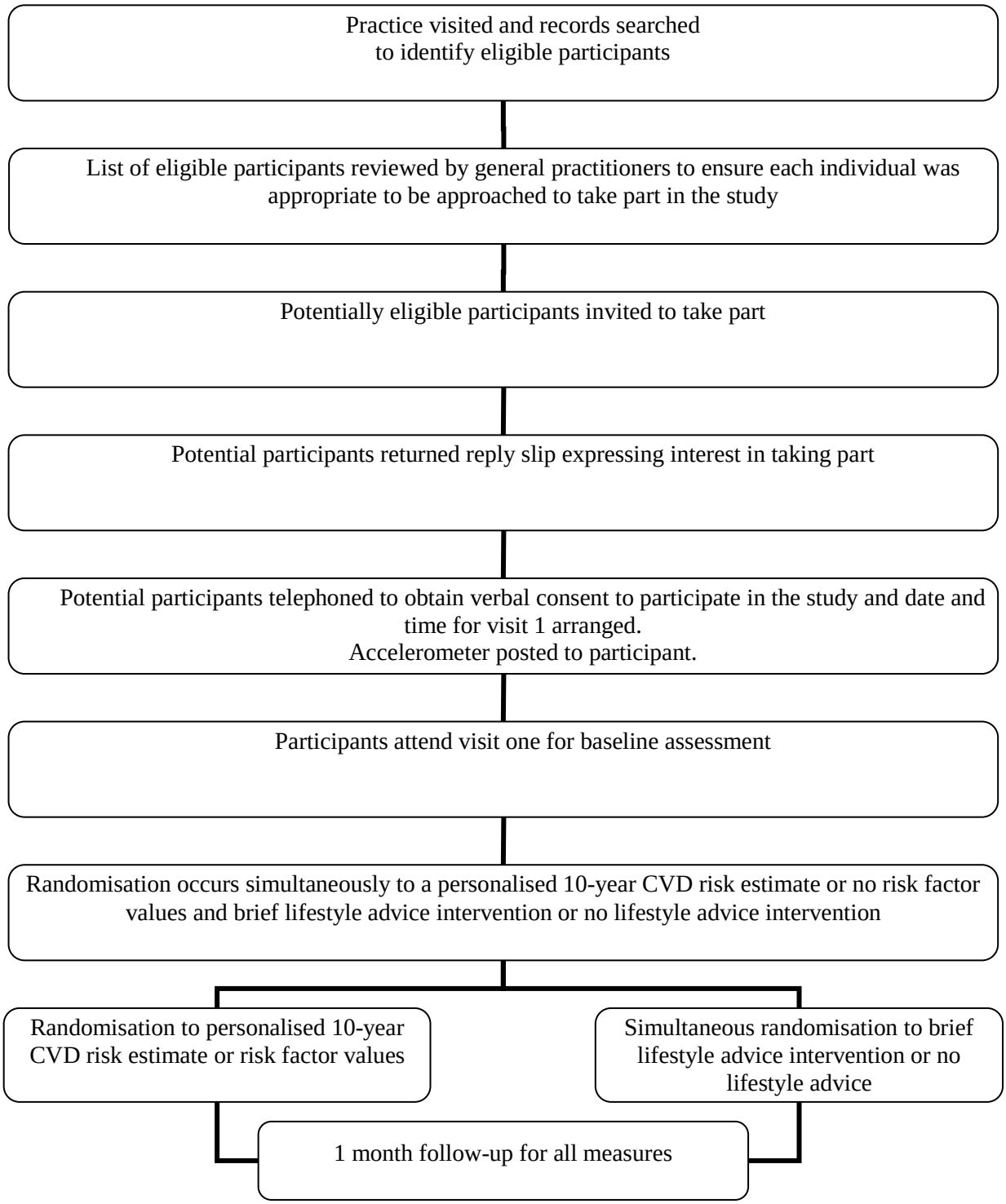
Physical activity and clinical information were collected before randomisation and one month after delivery of the intervention. A personalised 10-year CVD risk estimate and brief lifestyle advice was provided to all participants at the end of 4 weeks.

A summary of the study from recruitment to follow-up at one month is shown in figure 13.

Figure 12: 2x2 factorial study design

		10-year CVD risk estimate		
		Yes	**No**	
Brief lifestyle advice intervention	**Yes**	46	46	92
	No	46	46	92
		92	92	**184**

Figure 13: Study flow chart from recruitment to completion at one month



Study population

Participant eligibility criteria were

- Adults aged 40-70 years
- Estimated Framingham-derived 10-year CVD risk ≥ 20%
- No known cardiovascular disease as defined by a history of myocardial infarction, other incident ischaemic heart disease, stroke, coronary or peripheral revascularisation, or transient ischaemic attack
- No known physical disability or other condition reducing the ability to walk
- Able to read and write English
- Able to comply with the trial protocol

Practice recruitment

I approached practices directly by telephoning or emailing the practice manager or one of the general practitioners. Those that expressed interest were sent further information regarding the study and a date arranged for me to visit the practice to undertake a search of the practice electronic patient records database. In total, participants were recruited from four Oxfordshire general practices. The number of practices required was not specified *a priori*. It was my intention to stop recruiting practices when participant recruitment had been completed.

Participants

I searched each practice's electronic patient records database. Three of the participating practices used the Egton Medical Information Systems (EMIS) clinical system (EMIS, Leeds, UK) and one practice used Vision (In Practice Systems LtD, London, UK). I received training on how to search using both systems from practice managers. Once a list of potentially eligible participants had been constructed using the inclusion criteria each general practitioner in each practice was asked to review the list and remove any individual they felt would not be able to comply with the trial protocol. This could be for any reason including but not exclusive to, severe mental or physical illness. Once the list of potentially eligible participants had been finalised, participant invitation packs were sent our randomly in batches of 60. Each pack contained an invitation letter, a patient information leaflet, a reply slip and a prepaid envelope. The invitation letter was printed on practice headed notepaper and signed electronically by the senior partner or signed by myself on behalf of the practice.

Non-responders

At the end of the study I returned to each practice to collect age and gender information for individuals who had been invited to participate in the study but had not expressed interest in doing so.

Telephone contact

Once a potential participant had expressed interest in taking part in the study by returning a reply slip in a prepaid envelope or by email or telephone I telephoned the potential participant to confirm that they met the inclusion criteria for the study and to obtain verbal consent to participate in the trial. The date verbal consent was given was recorded on the electronic data capture system. I then arranged a date and a time for their first study visit. I mailed accelerometers (Figure 14) to recruited participants approximately one week prior to visit 1. Accelerometers were mailed in order to reduce the number of study visits required and to reduce the potential effect of measurement on baseline physical activity. Simple instructions on how to use the device were provided including a photograph demonstrating how the accelerometer should be worn (Figure 15). Participants were asked to wear the accelerometer on an elastic belt around the waist and to remove it for sleep, bathing, showering and swimming. Participants were asked to wear the accelerometer for seven days in total over a mixture of week and weekend days. Prior to mailing the accelerometers I programmed each device with the participant's unique identification number and a starting date and time for the recording to begin. Participants were informed of this date and time in the accompanying letter.

Figure 14: Actigraph^{TM} GT1M monitor (3.8 x 3.7 x 1.8 cm; 27 grams)

Figure 15: Photograph demonstrating correct positioning of accelerometer

Written informed consent

Verbal consent was taken at entry to the study and written informed consent was collected at the first study visit. The consent forms were held in the clinical research unit and each participant was given a photocopy of their signed consent form.

Baseline assessment

Baseline clinical assessment was conducted in the clinical research unit. Medical history, demographic details, age at leaving school and electoral ward were collected. Electoral ward was used to derive an index of multiple deprivation score for each participant. A 75 mg anhydrous oral glucose tolerance test (0 and 120 minute glucose sampling) was conducted and fasting blood samples taken for total, LDL and HDL cholesterol, triglycerides, HbA1c, serum cotinine, plasma vitamin C and fructosamine assessment. Anthropometric measurements were taken (resting blood pressure, height, body weight, waist circumference, body fat percentage). Smoking status, current medication and self-reported alcohol intake was recorded. An ECG was

performed to ascertain presence or not of atrial fibrillation. Once these data had been collected the participant was randomised and any interventions delivered at this study visit.

Randomisation

Computer randomisation was used to allocate participants to each of the interventions in blocks of four.

Data entry

I trained the nursing staff in the trial protocol and wrote an operational manual to assist with the day to day running of the study. Departmental standard operating procedures were followed to ensure consistent data collection.

Data were recorded using a web-based electronic data capture platform (MACRO v3; Infermed, London, UK) with electronic transfer of laboratory results. I wrote the specification for the electronic database. Nursing staff who were inputting data were trained in how to use the electronic database and each user assigned a unique username and password. The data capture platform recorded each time study personnel logged into the system and was also able to record who entered each piece of data and an audit trail if any data was altered after it had been initially entered. If any data were not available for a participant this was recorded along with the reason for the missing data. The database included pre-specified rules for particular parameters to try to minimise the collection of any discrepant data. For example, a

waist circumference could only be entered if it was in the range 73-130 cm for men or 65-130 cm for women. The electronic case report forms (eCRFs) used are shown in the appendix.

Outcome assessment

Follow-up at four weeks occurred for all measures (with the exception of HbA1c) including oral glucose tolerance test, blood samples, anthropometric measurements, smoking status, current medication and alcohol intake. Physical activity was again measured by accelerometer for seven days in the week before the second study visit.

The interventions

Personalised 10-year CVD risk intervention

For the purposes of the study 10-year CVD risks were estimated using the UKPDS Risk Engine (51). The UKPDS Risk Engine interface used displayed both current and 'achievable risk' for an individual. Achievable risk was that calculated assuming current target levels for systolic blood pressure (130 mmHg), LDL cholesterol (2 mmol/L) and HbA1c (6.5 %) were met (27) with smoking cessation if applicable. Each participant randomised to receive a 10-year CVD risk estimate sat beside me at a computer whilst I inputted their data into the UKPDS Risk Engine. The participant was then able to see where their individual risk factor results lay in relation to target values and to see their overall 10-year CVD risk. Following this, I used the optimise

buttons to reset their risk factor values to target values and the UKPDS Risk Engine calculated their achievable risk and displayed this in relation to their current risk. The participant was then able to spend time themselves using the Risk Engine sliders and optimise buttons to more fully understand their risk. This process lasted approximately 10-15 minutes. A print out of current and achievable 10-year risks was provided to participants randomised to receive personalised risk estimates at the time the intervention was delivered. General practitioners were only provided with risk estimates once a participant had completed the study. The control group were given a print out of their fasting plasma glucose, blood pressure and LDL cholesterol values and informed if any of these were elevated according to current guidelines (27).

Brief lifestyle advice intervention

The brief lifestyle advice intervention was a computerised slide show that participants worked through themselves whilst I sat beside them to clarify any points that the slides raised. The intervention aimed to motivate behaviour changes designed to reduce CVD risk and was informed by self-regulation theory (184).

The adoption of medical advice designed to reduce a health threat requires an internalisation process through which the individual transforms external advice into a potential goal (190). This forms the basis of self-regulation theory (184). Self-regulation is defined as "a systematic process of human behaviour that involves the setting of personal goals and steering behaviour towards the achievement of established goals" (190). Self-regulation encourages the individual to assume an active role in their healthcare and encourages a collaborative philosophy to empower

the individual to do this. This is important as self-efficacy and self-determination have been shown to be a powerful predictor of initiation and maintenance of behaviour change in healthy populations (190). Leventhal's self-regulatory theory describes the response of an individual to a health threat and involves identifying the threat, the time-line of the threat, the cause of the threat, the consequences of the threat and the cure or control of the threat (184). Provision of health threat information initially causes fear which then results in either denial of the health threat or motivation to change behaviour and this in turn may result in eventual behaviour change.

A successful intervention designed to change behaviour needs therefore, to facilitate goal-setting, self-monitoring, self-evaluation and self-reinforcement (190).

The brief lifestyle advice intervention involved the setting of goals and the steering of behaviour towards their achievement. Goal setting was encouraged to fit in with other factors in participants' lives including family and financial constraints. Whilst the slides encouraged participants to consider barriers to achieving lifestyle change and to set their own goals these were not discussed with me. It took approximately15 minutes for each participant to work through the presentation.

The intervention stressed that even small changes in behaviour were beneficial to health and focused on increasing physical activity, fruit and vegetable consumption, decreasing alcohol intake and smoking cessation if necessary. The physical activity goal was 30 minutes of brisk walking per day in line with current guidelines (191) and the fruit and vegetable goal five portions per day (192). A reduction in alcohol consumption was advised if current intake was above UK government

recommendations (not more than 3-4 units per day for men and 2-3 units per day for women) (193).

At the end of the computer presentation participants were given a leaflet repeating the advice they had been given. Those not randomised to receive the brief lifestyle advice intervention received no intervention and no written materials.

Quality assurance

I delivered all interventions personally to ensure standardised delivery. Source data verification was performed by monitors from the University of Oxford Clinical Trials and Research Governance department.

Biochemical and clinical assessments

Plasma, whole blood and serum samples were taken immediately to the Diabetes Trials Unit laboratory, which has clinical pathology accreditation and participates in the UK National External Quality Assessment Scheme (Wolfson EQA Laboratory, Birmingham, UK) and the Welsh External Quality Assessment Scheme (Quality Laboratory, Cardiff and Vale NHS Trust, Cardiff, UK).

HbA1c

HbA1c was measured by high-performance liquid chromatography (Bio-Rad Variant II Automated Glycosylated Hemoglobin Analyzer, Bio-Rad Laboratories, Hemel

Hempstead, UK), normal range 4.5–6.2%, and certified by the National Glycohaemoglobin Standardisation Programme.

Plasma lipids

Other biochemical analyses were performed on an Olympus AU400 automated chemistry analyser (Olympus Optical, Southall, UK). Total cholesterol was measured by an enzymatic colorimetric endpoint method (CHOD-PAP method) using cholesterol oxidase and esterase and a peroxidase-catalysed reaction for production of quinoneimine. LDL cholesterol was measured directly using a Genzyme kit (Biostat, Stockport, UK) with lipoproteins other than LDL disrupted and removed enzymically. HDL cholesterol was measured directly with anti-human beta lipoprotein antibody to bind to lipoproteins other than HDL cholesterol (LDL cholesterol, very-low-density-lipoprotein-cholesterol and chylomicrons) using the Olympus system HDL cholesterol kit. Triglycerides were measured using the enzymatic, colorimetric, GPO-PAP method with hydrolysis by lipases and quinoneimine as the indicator.

Plasma glucose

Plasma glucose was measured by an enzymatic UV test (hexokinase method) using hexokinase and glucose-6-phosphate dehydrogenase for production of NADH.

Plasma fructosamine

Fructosamine was measured using a calorimetric assay based on ketoamine reduction of nitrotetrazolium-blue to formazen.

Plasma vitamin C and serum cotinine

Serum samples for cotinine assay and plasma samples for vitamin C assay were stored at -80 ºC prior to being couriered in one batch at -20 ºC to external laboratories. Vitamin C was measured using a fluorometric assay. Normal range 34-114 μmol/L. Serum cotinine was measured on the BEST 2000 (Launch Diagnostics, Kent, UK) by ELISA using the Cozart EIA cotinine kit (Cozart, Oxfordshire, UK). Normal range <5 ng/ml negative, 5-10 ng/ml equivocal, >10 ng/ml positive.

Anthropometric measures

Blood pressure was measured with an automated sphygmomanometer (Omron 705CP-II, Omron Healthcare, Kyoto, Japan) and body fat percentage using a body composition analyser (Biostat 1500, Biostat, Isle of Man, UK). Electrocardiograms were performed using an electrocardiograph (CP 100, Welch Allyn, Skaneateles Falls, NY) to determine the presence or not of atrial fibrillation. Body mass index (BMI) was calculated as weight (kg) divided by the square of the height (m).
Socioeconomic status was estimated using the Index of Multiple Deprivation Score (IMDS) 2004 based on electoral ward (194).

Sample size

Sample-size calculations assumed that provision of a personalised 10-year CVD risk estimate would increase physical activity by $30x10^3$ total accelerometer count per day compared with the control intervention. This equates approximately to a ten percent increase in physical activity or an additional ten minutes of brisk walking per day. A total of 184 participants were required to achieve 80% power (α=5%) to detect this difference. To allow for a drop-out rate of up to 5% 194 participants were randomised.

Statistical analyses

Statistical analyses used SPSS 17.0 (SPSS Inc., Chicago, IL).

Recruited and non-recruited participants

The gender of recruited and non-recruited participants was compared using frequency counts and the χ^2 test and the age of recruited and non-recruited participants using medians/inter-quartile range (IQR) and the Mann-Whitney U test.

Descriptive statistics for recruited participants

Demographic and clinical data were summarised for randomised patients using appropriate measures of central tendency and dispersion or number (%). Mean (standard deviation) was used if data followed a normal distribution and median (IQR) if the data did not follow a normal distribution. The Kolmogorov–Smirnov test

was used to determine if data followed a normal distribution. Missing values were not imputed for. Tables and graphical summaries were then constructed.

Change in variables with time

The analysis was by intention to treat. The percentage change in variables with time from randomisation was determined and the Mann-Whitney U test used to compare the intervention and control arms. Within group changes were determined using the paired Student's t test. Missing values were not imputed for.

Interaction testing

A univariate analysis of variance was used to determine if an interaction was seen between the effects of the brief lifestyle advice intervention and the provision of the personalised CVD risk estimate with respect to changes in accelerometer count.

Net effect of interventions

Comprehensive meta-analysis (Biostat Inc., USA) software was used to determine the net effect of each intervention. This was then displayed as a forest plot.

Ten year CVD risk estimates

Ten year CVD risk was estimated for each participant using version 3 of the UKPDS Risk Engine from age, duration of diagnosed diabetes, sex, self-reported ethnicity, smoking status, HbA1c, systolic BP and the total to HDL cholesterol ratio. Achievable risk was estimated for each participant using version 3 of the UKPDS Risk Engine assuming target values for systolic blood pressure, HbA1c and LDL cholesterol were met and assuming smoking cessation.

Accelerometer data

Accelerometer data were reduced, cleaned and analysed using MAHUffe software (www.mrc-epid.cam.ac.uk). Non-wear time was identified as continuous zero movement lasting longer than 20 minutes. Only data from individuals who accumulated at least 500 minutes per day of activity for at least four days were analysed.

Outcome variables included time (minutes/day) spent at different activity intensity categories averaged per day over the measurement period. Intensity thresholds for moderate (1952-5724 counts/minute) and vigorous intensity activity (>5725 counts/minute) were defined according to Freedson *et al.* (195) and Ekelund *et al.* (196). A single variable, activity of moderate or greater intensity (MVPA), was constructed by combining accumulated time in moderate and vigorous intensity activity. Sedentary behaviour was defined as <100 counts/minute.

Adverse events

All adverse events during the study were documented and reported to the Thames Valley Primary Care Research Partnership. The frequency of adverse events in the intervention and control arms was compared using the χ^2 test with Yates' correction applied where observed frequencies were <5 (197).

Ethics, funding and indemnity

Ethical approval

Ethical approval was granted by the Milton Keynes Local Research ethics Committee in September 2007. Following this permission to conduct the study was granted by the Thames Valley Primary Care Research Partnership.

Project funding and indemnity

The study was supported by a personal Diabetes Trials Unit Fellowship and a grant from the Insulin Dependent Diabetes Trust. Indemnity was provided by the University of Oxford.

Study documentation

A protocol detailing the background, design, aims methods and outcomes for the study was written. The protocol contained details of all of the tasks that were required to complete the study both clinical and administrative. A system was put in place to

allow any telephone messages to be taken on my behalf and forwarded on to me and a dedicated email address (understanding_risk@dtu.ox.ac.uk) was created to ensure participants were able to contact me rapidly if necessary.

The operational manual was provided to all staff working with me on the study. It provided a simple reference to the study to ensure the protocol was followed correctly. The manual contained a summary of the protocol along with more practical information including the number and type of blood tests required at each visit, the standard operating procedures for measuring blood pressure, waist circumference, body weight and height along with information on the interventions to be delivered. A copy was available in the clinical research unit throughout the study.

Information for general practices, participant information leaflets, invitation letters and appointment letters were created specifically for use in this study. A folder for each participant was kept in a locked filing cabinet in the clinical research unit for the duration of the study. This contained contact details for the participant along with their signed consent form, ECG and paper copies of their laboratory results. No other documentation specifically no case report forms, were kept in these folders because electronic data capture was used.

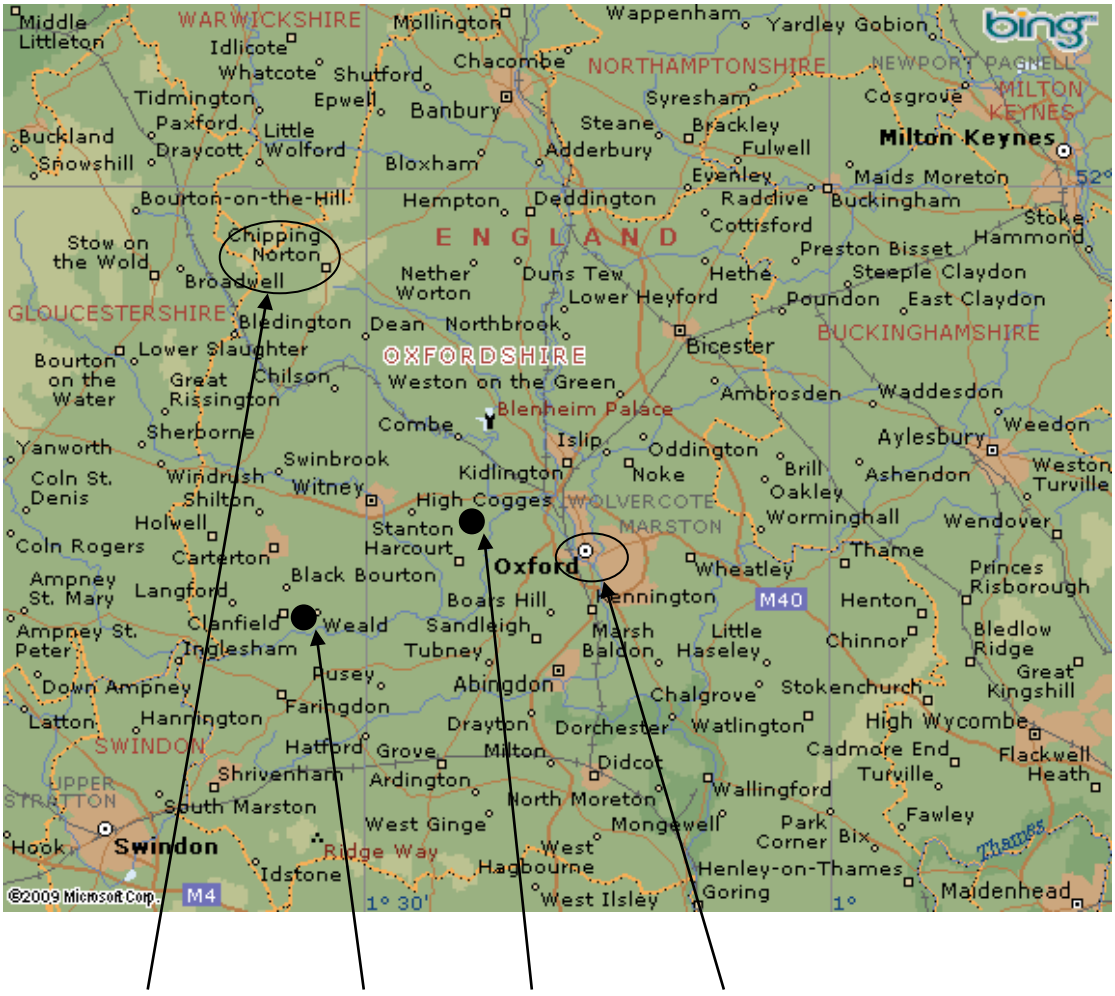
Results

Practices & Participants

Practices

The four recruited general practices were Bartlemas Surgery in Oxford, Bampton Medical Practice, The White House Surgery in Chipping Norton and The Eynsham Medical Group. Figure 16 shows the locations of recruited practices within Oxfordshire.

Figure 16: Map (198) indicating locations of recruited practices



Participants

The 4 general practices had 37,145 registered patients (Table 9) of whom 15,063 were aged 40-70 years. Of the 1,333 potentially eligible for inclusion in the study and invited to take part, 238 (18%) people expressed interest. The number of participants who responded per practice ranged from 11 to 112. Of the 238 expressing interest, 9 did not meet the inclusion criteria, 12 were no longer interested in taking part and 23 were not randomised as recruitment had been completed.

Table 9: Recruitment of participants within practices

	Registered patients	Potentially eligible	Invited to participate	Responded	Recruited
Bampton	8199	252 (3%)	252	55 (27%)	54 (21%)
Bartlemas	8216	89 (1%)	89	11 (12%)	10 (11%)
White House Surgery	7639	740 (10%)	740	112 (15%)	95 (13%)
Eynsham	13092	578 (4%)	269	60 (22%)	35 (13%)
TOTAL	**37145**	**1659 (4%)**	**1333**	**238 (18%)**	**194 (14%)**

Non-recruited participants

For the 1095 (82%) who were invited but did not respond to the invitation only age and gender information was available. They differed from those who took part (Table 10) in that they were younger and included a smaller proportion of males.

Table 10: Demographic characteristics of non-recruited and randomised participants. Data presented as median (IQR) and n (%).

	Randomised participants (n=194)	Non-recruited participants (n=1095)	p-value
Age (years)	62.3 (54.9, 66.1)	60.4 (53.4, 65.0)	<0.001
Males	130 (67%)	668 (61%)	<0.001

Withdrawals

Nine participants withdrew from the study, 4 were male and 5 female. The reasons given for withdrawing from the study are given in Table 11.

Table 11: Reasons for withdrawal from study

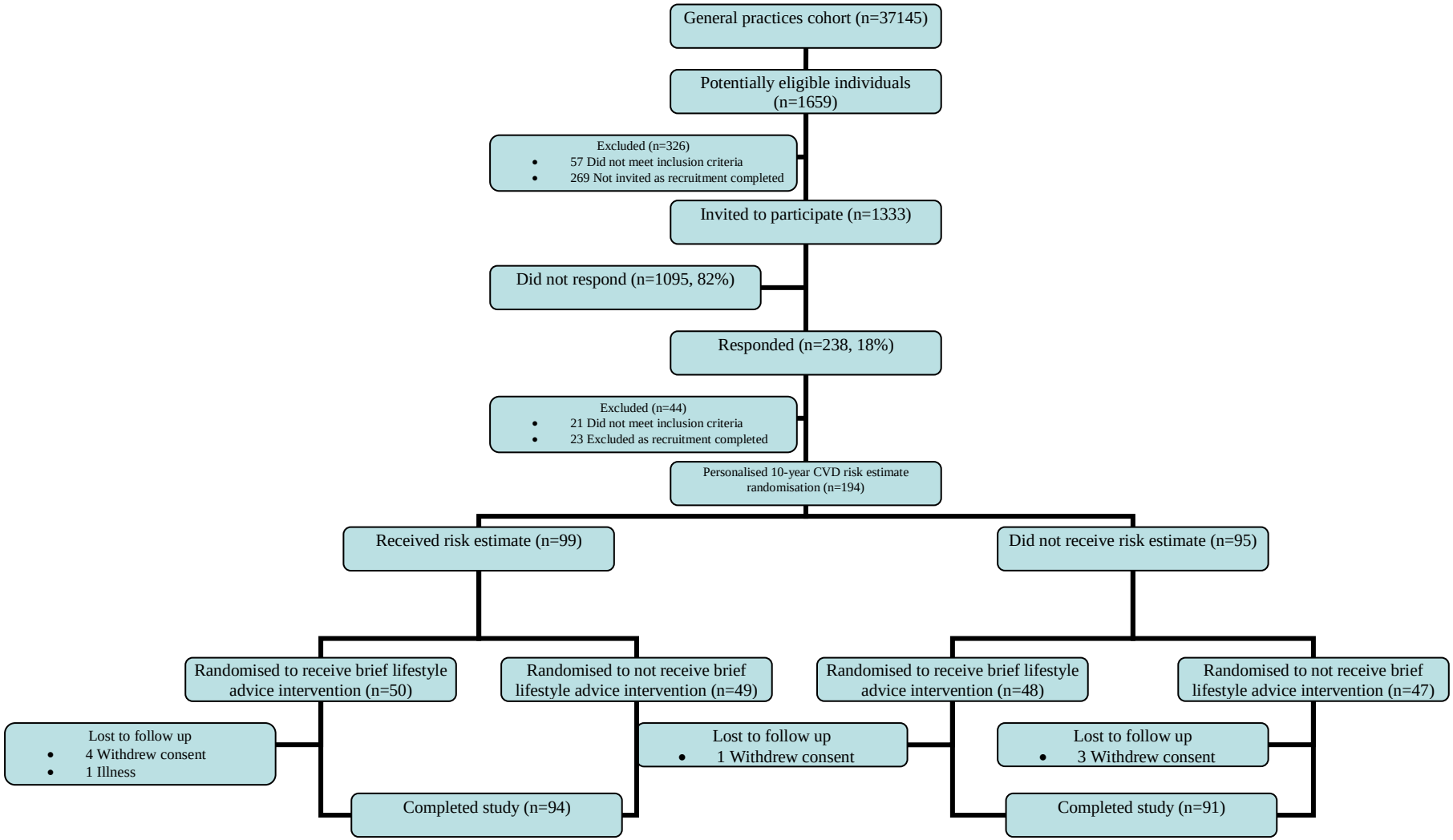
Participant	Reason for withdrawal from study
1	Did not want second oral glucose tolerance test
2	Emigrating
3	Failed to attend appointments
4	New job
5	Unable to get time off work to attend appointment
6	Declined to give a reason
7	Lumbar disc prolapse
8	Declined to give a reason
9	Declined to give a reason

Personalised 10-year CVD risk estimate intervention

Baseline characteristics

Participant flow through the study is shown in Figure 17.

Figure 17: Participant flow through the study (risk estimate intervention)



One hundred and ninety four eligible participants were randomised, 99 to receive a personalised 10-year CVD risk estimate and 95 to receive the control intervention (Table 12). There were no statistically significance between group differences at baseline (all p>0.15).

Overall participants were median (IQR) age 62.3 (54.9, 66.1) years (Table 12). There were 67% men and 19% had known diabetes. Mean (SD) blood pressure was 140/81 (18/11) mmHg, total cholesterol 5.0 (1.1) mmol/L, LDL cholesterol 3.1 (0.9) mmol/L and HDL cholesterol 1.23 mmol/L (0.29) in men and 1.53 mmol/L (0.37) in women. Median (IQR) triglycerides were 1.4 mmol/L (1.0, 1.9) and body mass index 28 kg/m^2 (26, 31).

Median (IQR) estimated 10-year CVD risk was 48% (34%, 60%) in men and 31% (22%, 43%) in women. Potential absolute reductions in estimated CVD risk assuming participants could achieve target modifiable risk factor levels, were -10% (-17%, -5%) in men and -9% (-15%, -5%) in women. Baseline CVD risk stratified by sex and diabetic status is shown in Table 13.

Lipid lowering drugs, blood pressure lowering drugs and anti-platelet agents were taken by 20%, 52% and 11% respectively of those without diabetes and 70%, 59% and 32% respectively of those with diabetes. Of those with diabetes glucose-lowering drugs were taken by 81%.

Valid baseline accelerometer data were available for 148 participants. Mean (SD) total accelerometer count per day was $297x10^3$ ($110x10^3$) with activity of moderate or greater intensity undertaken for 53 (22) minutes per day. At baseline, individuals with diabetes were performing less daily physical activity than those without diabetes (Table 14).

Table 12: Demographic, clinical and biochemical characteristics of all randomised participants according to their risk intervention allocation

Data presented as n (%), mean (SD) or median (IQR)*. 10-year CVD risk was estimated using the UKPDS Risk Engine version 3. There were no significant differences between groups at baseline (all p>0.15). Achievable risk calculated assuming all risk factors meet target values†.

	All participants	Received risk estimate (± lifestyle advice)	
		Yes	No
	(n=194)	(n=99)	(n=95)
Age (years) *	62.3 (54.9, 66.1)	62.3 (54.2, 66.2)	62.4 (56.0, 65.9)
Males	130 (67%)	63 (64%)	67 (71%)
White Caucasians	189 (97%)	97 (98%)	92 (97%)
Proportion with known diabetes	37 (19%)	17 (17%)	20 (21%)
Known diabetes duration*	9.0 (4.5, 17.0)	9.0 (5.5, 15.0)	8.0 (4.3, 17.5)
Newly discovered dysglycaemia			
Type 2 diabetes	15 (8%)	7 (7%)	8 (8%)
Isolated impaired fasting glucose (IFG)	23 (12%)	12 (12%)	11 (12%)
Isolated impaired glucose tolerance (IGT)	22 (11%)	11 (11%)	11 (12%)
IFG & IGT	14 (7%)	9 (9%)	5 (5%)
Index of multiple deprivation score*	13.8 (7.0, 15.5)	15.5 (7.0, 15.5)	9.6 (5.2, 15.5)
Age left school (years) *	17 (16, 21)	17 (16, 21)	16 (16, 21)
Waist (cm)			
Men	102 (10)	104 (11)	101 (10)
Women	92 (13)	90 (12)	94 (12)
Smoking status			
Current	71 (19%)	21 (21%)	16 (17%)
Ex	86 (44%)	50 (51%)	36 (38%)
Never	37 (37%)	28 (28%)	43 (45%)
Proportion taking alcohol	146 (75%)	72 (73%)	74 (78%)
Alcohol intake per week (units)*	14 (6, 25)	16 (8, 30)	14 (6, 21)

	All participants	Received risk estimate (± lifestyle advice)	
		Yes	No
	(n=194)	(n=99)	(n=95)
Atrial fibrillation	6 (3%)	3 (3%)	3 (3%)
Body weight (kg) *	82.9 (72.8, 92.6)	81.4 (71.3, 92.7)	83.9 (74.4, 92.5)
Body mass index (kg/m^2) *	28.0 (25.6, 31.4)	27.8 (24.9, 32.1)	28.0 (25.8, 30.9)
Body fat (%)			
Men*	29.3 (26.7, 31.9)	29.6 (26.5, 32.7)	28.8 (26.7, 31.7)
Women*	43.0 (36.9, 47.8)	42.1 (34.7, 46.7)	44.3 (37.6, 48.8)
Blood pressure (mmHg)			
Systolic	140 (18)	140 (20)	141 (22)
Diastolic	81 (11)	83 (12)	79 (10)
Lipids			
Total cholesterol (mmol/L)	5.0 (1.1)	5.1 (1.1)	5.0 (1.1)
LDL cholesterol (mmol/L)	3.1 (0.9)	3.2 (0.8)	3.0 (1.0)
HDL cholesterol (mmol/L)			
Men	1.23 (0.29)	1.19 (0.26)	1.26 (0.31)
Women	1.53 (0.37)	1.46 (0.35)	1.63 (0.38)
Triglycerides (mmol/L) *	1.4 (1.0, 1.9)	1.4 (1.1, 1.9)	1.4 (0.9, 1.9)
Total:HDL cholesterol	4.0 (1.1)	4.1 (1.0)	3.9 (1.1)

	All participants	Received risk estimate (± lifestyle advice)	
		Yes	No
	(n=194)	(n=99)	(n=95)
Participants with known diabetes (n=37)			
HbA1c (%)*	7.1 (6.6, 8.0)	6.9 (6.6, 8.0)	7.2 (6.4, 8.1)
Fasting plasma glucose (mmol/L) *	9.2 (7.1, 10.4)	7.7 (6.8, 10.4)	9.5 (7.9, 10.4)
2-hour plasma glucose (mmol/L) *	17.5 (14.5, 22.1)	17.4 (14.5, 21.1)	17.6 (14.5, 28.5)
Fructosamine (μmol/L) *	269 (239, 303)	256 (234, 303)	273 (245, 310)
Participants without known diabetes (n=157)			
HbA1c (%)*	5.5 (5.3, 5.8)	5.5 (5.3, 5.8)	5.5 (5.3, 5.9)
Fasting plasma glucose (mmol/L) *	5.8 (5.5, 6.2)	5.8 (5.4, 6.1)	5.9 (5.6, 6.2)
2-hour plasma glucose (mmol/L) *	6.4 (5.3, 7.8)	6.4 (5.2, 7.8)	6.4 (5.5, 7.8)
Fructosamine (μmol/L) *	225 (212, 235)	225 (210, 236)	225 (213, 234)
Plasma vitamin C (μmol/L)	61.8 (21.2)	62.4 (19.9)	61.1 (22.6)
Current smokers serum cotinine* (ng/ml)	56 (49, 62)	59 (48, 62)	53 (48, 62)
Participants with diabetes (n=37)			
Glucose lowering drug use	30 (81%)	12 (71%)	18 (90%)
Lipid lowering drug use	26 (70%)	12 (71%)	14 (70%)
Blood pressure lowering drug use	22 (59%)	9 (53%)	13 (65%)
Anti-platelet agent use	12 (32%)	7 (41%)	5 (25%)
Participants without diabetes (n=157)			
Lipid lowering drug use	32 (20%)	20 (24%)	12 (16%)
Blood pressure lowering drug use	81 (52%)	40 (49%)	41 (55%)
Anti-platelet agent use	18 (11%)	12 (15%)	6 (8%)

	All participants	Received risk estimate (± lifestyle advice)	
		Yes	No
	(n=194)	(n=99)	(n=95)
Physical activity			
Time sedentary (minutes/day)	1165 (53)	1167 (74)	1167 (76)
Time light activity (minutes/day)	168 (37)	169 (48)	168 (56)
Time moderate or vigorous activity (minutes/day)	53 (22)	53 (31)	53 (32)
Total accelerometer counts (x1000 per day)	297 (110)	298 (162)	296 (148)
Estimated 10-year CVD risk (%)			
Men*	48.3 (34.2, 59.8)	50.5 (32.7, 61.8)	48.2 (36.5, 58.1)
Women*	30.7 (22.2, 42.7)	30.9 (22.2, 43.1)	30.7 (22.2, 39.8)
Estimated 10-year CVD risk reduction potentially achievable (%)†			
Men*	-10.3 (-17.4, -4.5)	-11.1 (-17.5, -5.3)	-9.6 (-16.4, -4.0)
Women*	-9.4 (-14.9, -4.8)	-9.2 (-14.9, -4.8)	-10.6 (-15.2, -4.8)

Table 13: Baseline estimated 10-year CVD risk for participants with valid data (n=193) by sex and diabetic status

	Estimated 10-year CVD risk (%)
Participants with diabetes (n=36)	
Men (n=27)	30.0% (24.1%, 38.5%)
Women (n=9)	16.0% (9.5%, 22.7%)
Participants without diabetes (n=157)	
Men (n=102)	54.7% (46.1%, 61.4%)
Women (n=55)	30.3% (23.8%, 37.6%)

Table 14: Baseline physical activity for participants with valid accelerometer data (n=148) by diabetic status

Physical activity	Participants without diabetes (n=115)	Participants with diabetes (n=33)	p-value
Time sedentary (minutes/day)	1158 (61)	1192 (69)	0.006
Time light activity (minutes/day)	173 (42)	151 (50)	0.012
Time moderate or vigorous activity (minutes/day)	57 (27)	39 (22)	0.001
Total accelerometer counts (x1000 per day)	317 (135)	226 (104)	<0.001

One month data

One hundred and eighty five (95%) participants completed the study. Of the nine participants who withdrew from the study, four were male and five female (p=0.74), five received a personalised 10-year CVD risk estimate and four received no estimate (p=0.74). Within group differences at one month are shown in Table 15.

Valid baseline and follow-up accelerometer data were available for 125 (64%) participants, of whom 69 received and 56 did not receive a personalised 10-year CVD risk estimate (p=0.24). Overall there was a non-significant net 0.5% ($8x10^{-3}$ total counts per day) greater increase in accelerometer counts (p=0.56) in those receiving personalised CVD risk estimates (Table 16 and Figure 18) with 21 (30%) of those who received a personalised 10-year CVD risk estimate and 16 (29%) of whom did not receive a risk estimate increasing their physical activity by $30x10^3$ total counts per day (p=0.41).

No significant between group differences seen in estimated 10-year CVD risk (p=0.52 for men and p=0.64 for women).

No significant between group differences were seen in blood pressure or HDL cholesterol. A net 4.5% decrease in total cholesterol (p=0.01) and a net 7.4% decrease in mean LDL cholesterol (3.2 mmol/L at baseline) (p=0.004) were seen in the intervention group with similar increases in new prescriptions for lipid lowering therapies in the intervention group (4) and in the control group (5) (p=0.74). The 7.4% net reduction in LDL cholesterol comprised a 4.5% decrease in LDL cholesterol in the risk estimate group and a 3% increase in the control group. When these analyses were repeated excluding the 15 participants who had a change in their drug

therapy during the course of the study the net reduction in LDL cholesterol was essentially unchanged at 7.8% ($p<0.001$).

No significant within or between group differences were seen in waist circumference, body weight, BMI, body fat percentage, triglycerides, fasting or 2-hour plasma glucose, fructosamine alcohol consumption, plasma vitamin C or serum cotinine (in smokers).

Table 15: Within group percentage change at one month from randomisation in clinical and biochemical variables (risk estimate arm)

Data are presented as mean (95% CI). Differences were analysed using the Student's t test.

	Risk estimate ± lifestyle advice (n=94)	p-value	No Risk estimate ± lifestyle advice (n=91)	p-value
Waist (cm)				
Men	-0.52 (-2.1, 1.1)	0.68	0.25 (-0.8, 1.3)	0.85
Women	-0.30 (-3.5, 2.9)	0.39	1.6 (-1.0, 4.2)	0.31
Alcohol intake per week (units)	4.0 (-10.2, 18.1)	0.04	-1.2 (-14.0, 11.7)	0.09
Weight (kg)	-0.23 (-0.6, 0.1)	0.06	-0.13 (-0.4, 0.2)	0.26
Body mass index (kg/m^2)	-0.26 (-0.6, 0.1)	0.04	-0.26 (-0.6, 0.1)	0.26
Body fat (%)				
Men	-1.9 (-8.7, 4.8)	0.55	1.3 (-5.0, 7.6)	0.39
Women	-5.3 (-13.0, 2.5)	0.59	2.2 (-3.1, 7.5)	0.35

	Risk estimate ± lifestyle advice (n=94)	p-value	No Risk estimate ± lifestyle advice (n=91)	p-value
Blood pressure (mmHg)				
Systolic	-2.1 (-4.3, -0.0)	0.01	-1.9 (-3.9, 0.1)	0.16
Diastolic	-1.6 (-3.8, 0.6)	0.06	-0.64 (-2.6, 1.3)	0.33
Lipids				
Total cholesterol (mmol/L)	-3.2 (-5.2, -1.2)	<0.001	1.3 (-1.1, 3.7)	0.49
LDL cholesterol (mmol/L)	-4.5 (-7.1, -1.8)	<0.001	3.0 (-0.5, 6.4)	0.21
HDL cholesterol				
Men (mmol/L)	-1.3 (-4.3, 1.8)	<0.001	-5.8 (-8.4, -3.2)	0.01
Women (mmol/L)	-3.6 (-7.7, 0.5)	0.55	3.7 (-6.4, 13.9)	0.38
Triglycerides (mmol/L)	-0.66 (-6.4, 5.1)	0.24	0.73 (-5.1, 6.5)	0.79
Total:HDL cholesterol	-0.20 (-2.7, 2.3)	0.40	4.3 (1.7, 6.9)	<0.001

	Risk estimate ± lifestyle advice (n=94)	p-value	No Risk estimate ± lifestyle advice (n=91)	p-value
Fructosamine (μmol/L)	-3.6 (-4.8, -2.5)	<0.001	-1.9 (-3.9, 0.10)	0.01
Fasting glucose (mmol/L)	-0.80 (-3.6, 2.0)	<0.001	-3.8 (-6.8, -0.8)	<0.001
2-hour glucose (mmol/L)	-2.1 (-7.0, 2.9)	<0.001	-4.5 (-11.4, 2.4)	<0.001
Estimated 10-year CVD risk (%)				
Men	-2.6 (-8.1, 2.9)	0.78	-9.9 (-16.1, -3.7)	0.05
Women	-0.6 (-11.1, 10.0)	0.27	-4.4 (-18.2, 9.4)	0.92
Plasma vitamin C (μmol/L)	3.0 (-4.3, 10.2)	0.47	8.4 (-1.0, 17.8)	0.45
Smokers serum cotinine (ng/ml)	-1.5 (-23.4, 20.4)	0.05	-22.0 (-46.7, 2.7)	0.59

	Risk estimate ± lifestyle advice (n=94)	p-value	No Risk estimate ± lifestyle advice (n=91)	p-value
Physical activity				
Time sedentary (minutes/day)	0.5 (-1.2, 3.1)	0.22	1.6 (-1.6, 4.1)	0.45
Time light activity (minutes/day)	-7.8 (-15.4, -0.8)	0.02	-6.4 (-12.4, 6.0)	0.01
Time moderate or vigorous activity (minutes/day)	-7.1 (-21.1, 12.7)	0.37	-5.5 (-23.8, 19.0)	0.16
Total accelerometer counts (x1000 per day)	-3.0 (-16.8, 10.2)	<0.001	-3.5 (-18.0, 10.5)	<0.001

Table 16: Net between group percentage change at one month from randomisation in clinical and biochemical variables (risk estimate intervention)

Data are presented as mean net difference. Between group differences were analysed using the Wilcoxon test.

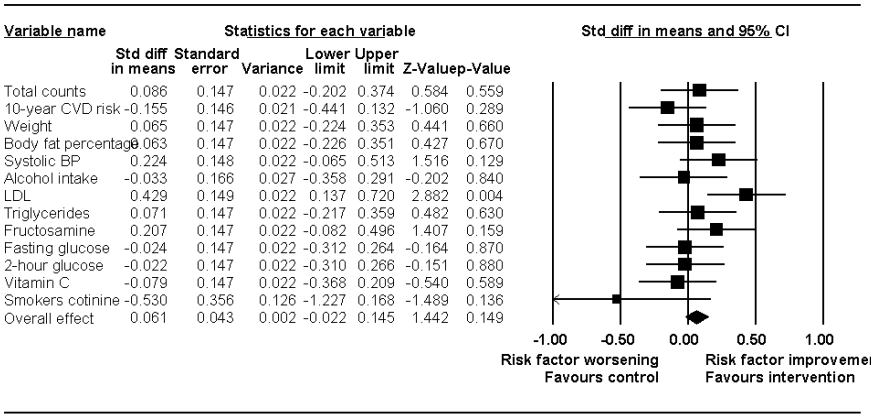
	Net difference (%) (95% CI)	Net difference	P-value	Risk factor change
Waist (cm)				
Men	-0.74 (-1.3, -0.23)	-0.75 cm	0.61	Decrease
Women	-1.9 (-2.5, -1.3)	-1.8 cm	0.22	Decrease
Alcohol intake per week (units)	5.1 (-13.8, 24.1)	0.71 units	0.84	Increase
Body weight (kg)	-0.09 (-0.53, 0.34)	-0.07 kg	0.66	Decrease
Body mass index (kg/m^2)	-0.13 (-0.56, 0.31)	-0.04 kg/m^2	0.54	Decrease
Body fat (%)				
Men	-3.2 (-3.7, -2.8)	-0.94 %	0.40	Decrease
Women	-7.5 (-9.9, -5.0)	-3.2 %	0.95	Decrease

	Net difference (%) (95% CI)	Net difference	P-value	Risk factor change
Blood pressure (mmHg)				
Systolic	-0.23 (-0.4, -0.08)	-0.32 mmHg	0.09	Decrease
Diastolic	-1.0 (-3.9, 1.9)	-0.81 mmHg	0.13	Decrease
Lipids				
Total cholesterol (mmol/L)	-4.5 (-7.6, -1.4)	-0.23 mmol/L	0.01	Decrease
LDL cholesterol (mmol/L)	-7.4 (-11.7, -3.2)	-0.23 mmol/L	0.004	Decrease
HDL cholesterol (mmol/L)				
Men	4.5 (4.1, 4.9)	0.06 mmol/L	0.96	Increase
Women	-7.3 (-13.3, -1.3)	-0.11 mmol/L	0.66	Decrease
Triglycerides (mmol/L)	-1.3 (-9.4, 6.8)	-0.02 mmol/L	0.63	Decrease
Total:HDL cholesterol	-4.5 (-8.1, -0.96)	-0.18	0.02	Decrease

	Net difference (%) (95% CI)	Net difference	P-value	Risk factor change
Fructosamine (μmol/L)	-1.7 (-4.0, 0.52)	-3.9 μmol/L	0.16	Decrease
Fasting plasma glucose (mmol/L)	3.1 (-0.93, 7.1)	0.19 mmol/L	0.87	Increase
2-hour plasma glucose (mmol/L)	2.4 (0.44, 4.4)	0.17 mmol/L	0.88	Increase
Plasma vitamin C (μmol/L)	-5.4 (-7.6, -3.3)	-3.3 μmol/L	0.59	Decrease
Current smokers serum cotinine (ng/ml)	20.5 (17.7, 23.3)	11.5 ng/ml	0.14	Increase
Physical activity				
Time sedentary (minutes/day)	-1.1 (-15.5, 11.7)	-12.8 minutes/day	0.35	Decrease
Time light activity (minutes/day)	-1.4 (-6.2, 4.4)	-2.4 minutes/day	0.24	Decrease
Time moderate or vigorous activity (minutes/day)	-1.6 (-6.6, 3.6)	-0.85 minutes/day	0.93	Decrease
Total accelerometer counts (x1000 per day)	0.5 (-0.6, 1.8)	1.5 x1000 per day	0.56	Increase

	Net difference (%) (95% CI)	Net difference	P-value	Risk factor change
Estimated 10-year CVD risk (%)				
Men	7.3 (1.6, 8.7)	3.5 %	0.29	Increase
Women	3.8 (-4.8, 5.9)	1.2 %	0.60	Increase

Figure 18: mean net percentage change from baseline to one month following a personalised 10-year CVD risk estimate



Overall at one month, 11 individuals had received 17 new prescriptions for CVD risk reducing therapies in those randomised to receive a personalised 10-year CVD risk estimate and four individuals five new prescriptions in those who did not receive a risk estimate (Table 17). A significant difference was seen in the number of new prescriptions between the groups (p=0.01) but not in the number of individuals receiving new prescriptions (p=0.07).

Table 17: Newly prescribed CVD risk reducing therapies (risk estimate intervention)

Data presented are frequencies.

CVD risk reducing therapies	Received 10-year CVD risk estimate		p-value
	Yes	No	
Anti-platelet agents	2	0	0.16
Blood pressure lowering agents	8	0	0.005
Glucose lowering agents	3	0	0.08
Lipid lowering agents	4	5	0.74
Total	**17**	**5**	**0.01**

No interaction was seen between the effects of the brief lifestyle advice and provision of the personalised CVD risk estimate with respect to changes in accelerometer count (p=0.268).

Adverse events that occurred in more than 5% of participants are shown in Table 18.

Table 18: Adverse events occurring in more than 5% of participants (risk estimate intervention)

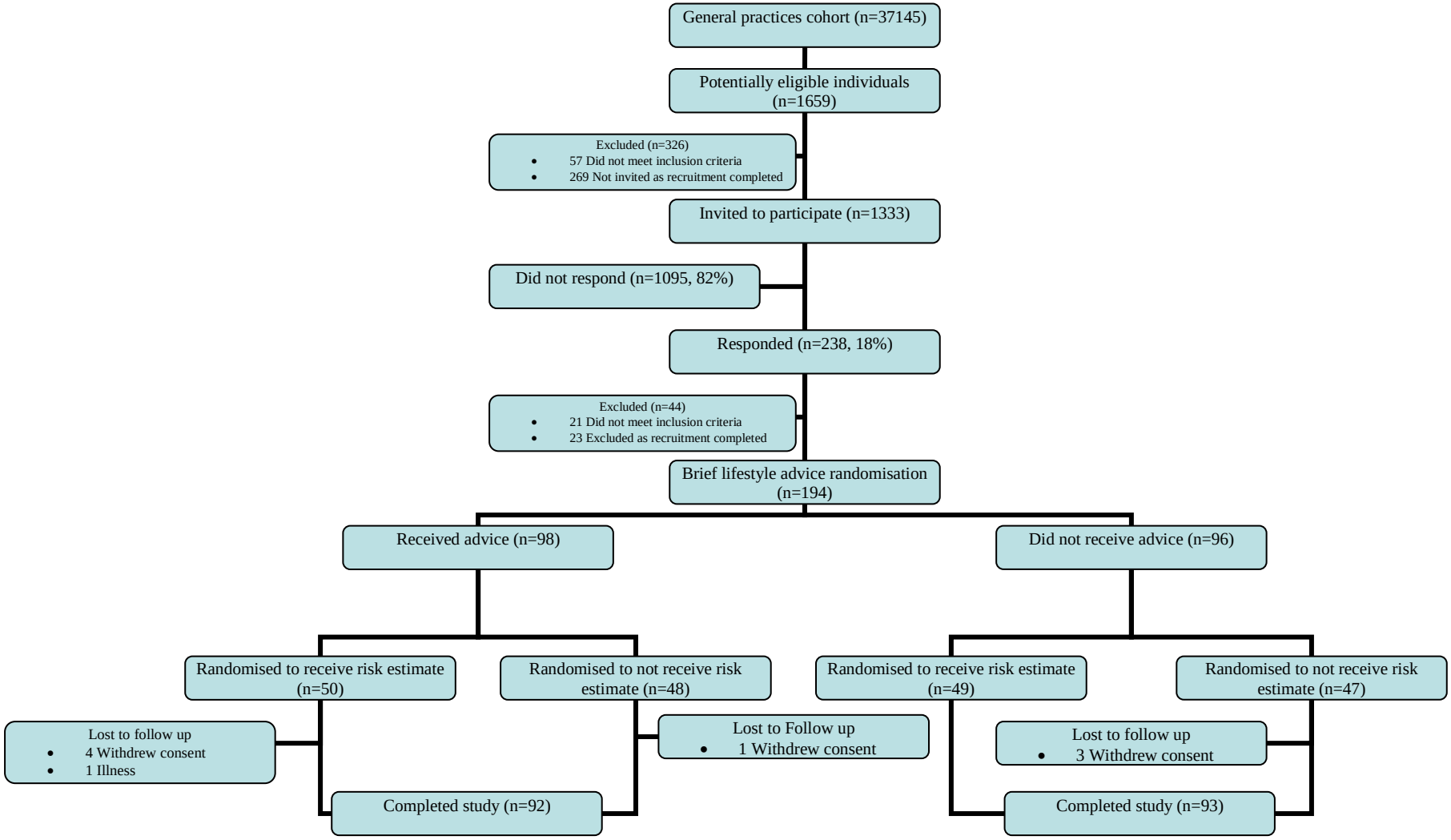
Data presented are frequency (%).

	All participants (n=194)	Risk estimate ± lifestyle advice (n=99)	No Risk estimate ± lifestyle advice (n=95)	p-value
Musculoskeletal pain	13 (7%)	5 (5%)	8 (8%)	0.46
Upper respiratory tract infection	18 (9%)	8 (8%)	10 (11%)	0.53

Baseline characteristics

Participant flow through this arm of the study is shown in Figure 19.

Figure 19: Participant flow through study (brief lifestyle advice intervention)



One hundred and ninety four eligible participants were randomised, 98 to receive the brief lifestyle advice intervention and 96 to receive no intervention (Table 19). There were no statistically significant between group differences at baseline (all $p>0.15$).

Table 19: Demographic, clinical and biochemical characteristics of all randomised participants according to their brief lifestyle advice intervention allocation

Data presented as n (%), mean (SD) or median (IQR)*. 10-year CVD risk was estimated using the UKPDS Risk Engine version 3. There were no significant differences between groups at baseline (all p>0.15). Achievable risk calculated assuming all risk factors meet target values†.

	All participants (n=194)	Received brief lifestyle advice (± risk estimate)	
		Yes (n=98)	No (n=96)
Age (years) *	62.3 (54.9, 66.1)	62.6 (54.9, 66.2)	62.1 (54.7, 66.0)
Males	130 (67%)	66 (67%)	64 (67%)
White Caucasians	189 (97%)	95 (97%)	94 (98%)
Proportion with known diabetes	37 (19%)	21 (21%)	16 (17%)
Known diabetes duration*	9.0 (4.5, 17.0)	8.0 (4.0, 17.0)	9.0 (7.0, 21.3)
Newly discovered dysglycaemia			
Type 2 diabetes	15 (8%)	7 (7%)	8 (8%)
Isolated impaired fasting glucose (IFG)	23 (12%)	10 (10%)	13 (14%)
Isolated impaired glucose tolerance (IGT)	22 (11%)	10 (10%)	12 (13%)
IFG & IGT	14 (7%)	9 (9%)	5 (5%)
Index of multiple deprivation score*	13.8 (7.0, 15.5)	15.5 (7.0, 15.5)	10.4 (7.0, 15.5)
Age left school (years) *	17 (16, 21)	17 (16, 21)	16 (16, 21)
Waist (cm)			
Men	102 (10)	103 (11)	102 (10)
Women	92 (13)	94 (12)	90 (13)
Smoking status			
Current	71 (19%)	19 (19%)	18 (19%)
Ex	86 (44%)	44 (45%)	42 (44%)
Never	37 (37%)	35 (36%)	36 (38%)

	All participants (n=194)	Received brief lifestyle advice (± risk estimate)	
		Yes (n=98)	No (n=96)
Proportion taking alcohol	146 (75%)	72 (75%)	74 (76%)
Alcohol intake per week (units)	14 (6, 25)	14 (6, 25)	16 (9, 25)
Atrial fibrillation	6 (3%)	4 (4%)	2 (2%)
Body weight (kg) *	82.9 (72.8, 92.6)	83.2 (74.1, 92.6)	82.0 (70.5, 92.8)
BMI (kg/m^2) *	28.0 (25.6, 31.4)	27.9 (25.5, 31.5)	28.0 (25.7, 31.3)
Body fat (%)			
Men*	29.3 (26.7, 31.9)	28.8 (26.5, 31.8)	29.5 (27.0, 32.0)
Women*	43.0 (36.9, 47.8)	42.1 (37.2, 48.8)	44.3 (36.9, 47.5)
Blood pressure (mmHg)			
Systolic	140 (18)	139 (16)	141 (16)
Diastolic	81 (11)	80 (10)	80 (11)
Lipids			
Total cholesterol (mmol/L)	5.0 (1.1)	4.9 (1.0)	5.1 (1.1)
LDL cholesterol (mmol/L)	3.1 (0.9)	3.0 (0.9)	3.2 (0.9)
HDL cholesterol (mmol/L)			
Men	1.23 (0.29)	1.22 (0.28)	1.24 (0.31)
Women	1.53 (0.37)	1.57 (0.39)	1.49 (0.35)
Triglycerides (mmol/L) *	1.4 (1.0, 1.9)	1.3 (1.0, 1.9)	1.5 (1.1, 1.9)
Total:HDL cholesterol	4.0 (1.1)	3.9 (1.1)	4.1 (1.0)
Participants with known diabetes (n=37)			
HbA1c (%)*	7.1 (6.6, 8.0)	7.1 (6.6, 7.9)	7.1 (6.5, 8.5)
Fructosamine (μmol/L) *	269 (239, 303)	269 (234, 292)	268 (243, 323)
Fasting plasma glucose (mmol/L) *	9.2 (7.1, 10.4)	8.6 (6.9, 10.2)	9.3 (7.2, 10.7)
2-hour plasma glucose (mmol/L) *	17.5 (14.5, 22.1)	16.7 (13.9, 21.3)	18.2 (15.0, 23.6)

	All participants (n=194)	Received brief lifestyle advice (± risk estimate)	
		Yes (n=98)	No (n=96)
Participants without known diabetes (n=157)			
HbA1c (%)*	5.5 (5.3, 5.8)	5.5 (5.3, 5.8)	5.6 (5.2, 5.9)
Fructosamine (μmol/L) *	225 (212, 235)	227 (213, 235)	224 (211, 239)
Fasting plasma glucose (mmol/L) *	5.8 (5.5, 6.2)	5.8 (5.5, 6.1)	5.9 (5.5, 6.2)
2-hour plasma glucose (mmol/L) *	6.4 (5.3, 7.8)	6.6 (5.4, 7.8)	6.3 (5.3, 7.6)
Plasma vitamin C (μmol/L)	61.8 (21.2)	60.2 (21.3)	63.4 (21.1)
Current smokers serum cotinine (ng/ml)	56 (49, 62)	56 (50, 62)	54.5 (44, 62)
Participants with known diabetes (n=37)			
Glucose lowering drug use	30 (81%)	17 (81%)	13 (81%)
Lipid lowering drug use	26 (70%)	15 (71%)	11 (69%)
Blood pressure lowering drug use	22 (59%)	12 (57%)	10 (63%)
Anti-platelet agent use	12 (32%)	8 (38%)	4 (25%)
Participants without known diabetes (n=157)			
Lipid lowering drug use	32 (20%)	18 (23%)	14 (18%)
Blood pressure lowering drug use	81 (52%)	41 (52%)	40 (51%)
Anti-platelet agent use	18 (11%)	12 (16%)	6 (8%)
Physical activity			
Time sedentary (minutes/day)	1165 (53)	1166 (75)	1165 (75)
Time light (minutes/day)	168 (37)	167 (52)	169 (51)
Time moderate or vigorous (minutes/day)	53 (22)	51 (30)	56 (33)
Total accelerometer counts (x1000 per day)	297 (110)	286 (157)	308 (152)
Proportion meeting physical activity recommendations	77%	72%	81%
Estimated 10-year CVD risk (%)			
Men*	48.3 (34.2, 59.8)	48.1 (32.7, 61.8)	49.3 (39.3, 57.5)
Women*	30.7 (22.2, 42.7)	31.1 (21.5, 39.9)	30.2 (24.2, 44.4)
Estimated10-year CVD risk reduction potentially achievable (%)†			
Men*	-10.3 (-17.4, -4.5)	-9.8 (-17.5, -3.7)	-10.3 (-17.1, -4.9)
Women*	-9.4 (-14.9, -4.8)	-6.7 (-12.1, -4.2)	-12.1 (-16.0, -6.8)

One month data

One hundred and eighty five (95%) participants completed the study. Of the nine participants who withdrew from the study, four were male and five female p=0.74), six participants received brief lifestyle advice and three no brief lifestyle advice (p=0.32).

Within group differences at one month are shown in Table 20.

Valid baseline and follow-up accelerometer data were available for 125 participants of whom, 62 received and 63 did not receive the brief lifestyle advice intervention. Overall there was a non-significant net 6% decrease in physical activity in those receiving the brief lifestyle advice intervention (p=0.71) (Figure 20 and Table 21) with 14 (23%) of those who received the brief lifestyle advice intervention increasing their physical activity by $30x10^3$ total counts per day and 23 (37%) of those who did not receive the brief lifestyle advice intervention (p=0.14).

No significant between group differences were seen in estimated 10-year CVD risk (p=0.72 for men and p=0.78 for women).

No significant between group differences were seen in systolic (p=0.61) or diastolic (p=0.71) blood pressure or total (p=0.54), LDL (p=0.96) or HDL cholesterol (p=0.27 for men and p=0.58 for women).

A net 10.2% decrease in triglycerides (p=0.02) was seen in the intervention group with similar increases in new prescriptions for lipid lowering therapies in the intervention group (2) and control group (7) (p=0.10). The 10.2% net reduction in triglycerides comprised a 5.1% decrease in the intervention group and a 5.2% increase in the control group. When these analyses were repeated excluding the 15

participants who had a change in their drug therapy during the course of the study the net reduction in triglycerides was similar at 13.1% (p=0.002).

A net 2.6% reduction in waist circumference was seen in the intervention group in men (p=0.006) but not in women (p=0.13).

No significant between group differences were seen in body weight (p=0.89) or BMI (p=0.98).

A net 7.9% reduction in serum cotinine in smokers (p=0.028) was seen in the intervention group but no differences were see in plasma vitamin C (p=0.61) or alcohol intake per week in those consuming alcohol (p=0.16).

Table 20: Within group percentage change at one month from randomisation in clinical and biochemical variables (brief lifestyle advice intervention)

Data are presented as mean (95% CI). Differences were analysed using the Student's t test.

	Lifestyle advice ± risk estimate (n=92)	p-value	No Lifestyle advice ± risk estimate (n=93)	p-value
Waist (cm)				
Men	-1.4 (-3.1, 0.2)	0.07	1.2 (0.0, 2.5)	0.06
Women	-2.0 (-5.6, 1.6)	0.30	0.01 (-2.0, 2.0)	0.20
Alcohol intake per week (units)	0.44 (-15.6, 16.5)	0.01	2.2 (-8.6, 12.9)	0.40
Weight (kg)	-0.23 (-0.5, 0.1)	0.07	-0.12 (-0.4, 0.2)	0.24
Body mass index (kg/m^2)	-0.14 (-0.4, 0.2)	0.05	-0.15 (-0.5, 0.2)	0.23
Body fat (%)				
Men	-0.07 (-7.1, 6.9)	0.45	-0.94 (-7.7, 5.9)	0.47
Women	3.9 (-4.2, 12.0)	0.83	-0.12 (-1.7, 1.5)	0.42
Blood pressure (mmHg)				
Systolic	-0.88 (-2.7, 0.9)	0.02	-1.2 (-3.1, 0.8)	0.07
Diastolic	-1.3 (-3.3, 0.7)	0.12	-1.0 (-3.1, 1.2)	0.16
Lipids				
Total cholesterol (mmol/L)	-1.3 (-3.4, 0.8)	0.09	-0.68 (-3.1, 1.8)	0.36
LDL cholesterol (mmol/L)	-0.21 (-3.3, 2.9)	0.36	-1.4 (-4.6, 1.8)	0.17
HDL cholesterol (mmol/L)				
Men	-3.3 (-6.2, -0.4)	0.02	-2.6 (-5.9, 0.7)	<0.001
Women	-1.0 (-5.8, 3.7)	0.12	-2.1 (-8.6, 4.5)	0.92
Triglycerides (mmol/L)	-5.1 (-10.0, -0.2)	<0.001	5.2 (-1.2, 11.5)	0.43
Total:HDL cholesterol	1.4 (-1.0, 3.8)	0.62	2.6 (-0.2, 5.3)	0.30

	Lifestyle advice ± risk estimate (n=92)	p-value	No Lifestyle advice ± risk estimate (n=93)	p-value
Fructosamine (μmol/L)	-2.4 (-4.3, -0.5)	<0.001	-3.2 (-4.4, -1.9)	<0.001
Fasting glucose (mmol/L)	-2.7 (-5.5, 0.1)	<0.001	-1.9 (-4.9, 1.2)	0.16
2-hour glucose (mmol/L)	-4.8 (-11.0, 1.3)	<0.001	-1.7 (-7.5, 4.2)	0.57
Estimated 10-year CVD risk (%)				
Men	-4.8 (-1.0, 7.7)	0.92	3.1 (-14.2, -1.6)	0.63
Women	-2.6 (-14.6, 9.3)	0.81	-1.9 (-14.0, 10.1)	0.42
Plasma vitamin C (μmol/L)	7.2 (1.4, 13.0)	0.19	16.5 (-12.0, 45.1)	0.70
Smokers serum cotinine (ng/ml)	-7.4 (-31.6, 16.8)	0.60	0.57 (-41.5, 42.6)	0.05
Physical activity				
Time sedentary (minutes/day)	1.2 (-0.7, 3.3)	0.05	0.5 (-1.5, 3.8)	0.75
Time light activity (minutes/day)	-6.7 (-14.0, 1.0)	0.01	-6.3 (-15.5, 2.9)	0.02
Time moderate or vigorous activity (minutes/day)	-4.9 (-23.5, 8.8)	0.43	-9.4 (-23.1, 24.9)	0.15
Total accelerometer counts (x1000/day)	-6.8 (-22.2, 7.9)	0.10	-0.8 (-15.3, 11.5)	0.60

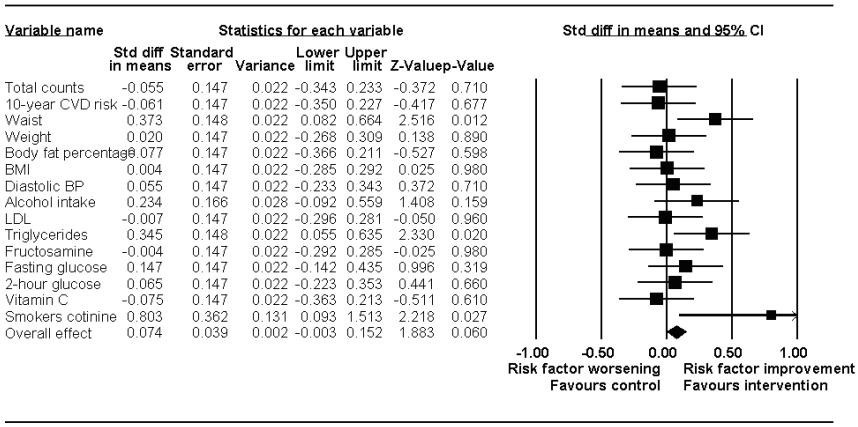
Table 21: Net between group percentage change at one month from randomisation in clinical and biochemical variables (brief lifestyle advice intervention)

Data presented as mean net difference. Between group differences were analysed using the Mann-Whitney U test.

	Net difference (%) (95% CI)	Net difference	P-value	Risk factor change
Waist (cm)				
Men	-2.6 (-3.1, -2.2)	-2.7 cm	0.006	Decrease
Women	-2.0 (-3.6, -0.39)	-1.8 cm	0.13	Decrease
Alcohol intake per week (units)	-1.7 (-20.6, 17.2)	-0.24 units	0.16	Decrease
Body weight (kg)	-0.11 (-0.12, 0.10)	-0.09 kg	0.89	Decrease
Body mass index (kg/m^2)	-0.11 (-0.55, 0.32)	-0.03 kg/m^2	0.98	Decrease
Body fat (%)				
Men	0.87 (0.66, 1.1)	0.25 %	0.82	Increase
Women	4.0 (-2.5, 10.5)	1.7 %	0.35	Increase
Blood pressure (mmHg)				
Systolic	0.27 (0.08, 0.47)	0.38 mmHg	0.61	Increase
Diastolic	-0.24 (-3.1, 2.7)	-0.19 mmHg	0.71	Decrease

	Net difference (%) (95% CI)	Net difference	P-value	Risk factor change
Lipids				
Total cholesterol (mmol/L)	-0.56 (-3.7, 2.6)	-0.03 mmol/L	0.54	Decrease
LDL cholesterol (mmol/L)	1.2 (-3.2, 5.6)	0.04 mmol/L	0.96	Increase
HDL cholesterol (mmol/L)				
Men	-0.61 (-1.1, -0.33)	-0.01 mmol/L	0.27	Decrease
Women	1.0 (-0.77, 2.8)	0.02 mmol/L	0.58	Increase
Triglycerides (mmol/L)	-10.2 (-18.2, -2.3)	-0.14 mmol/L	0.02	Decrease
Total:HDL cholesterol	-1.1 (-4.7, 2.5)	-0.04	0.16	Decrease
Fructosamine (μmol/L)	0.77 (-1.5, 3.0)	1.8 μmol/L	0.98	Increase
Fasting plasma glucose (mmol/L)	-0.94 (-5.0, 3.1)	-0.06 mmol/L	0.32	Decrease
2-hour plasma glucose (mmol/L)	-3.1 (-3.4, -2.8)	-0.21 mmol/L	0.66	Decrease
Plasma vitamin C (μmol/L)	-9.3 (-32.1, 13.4)	-5.8 μmol/L	0.31	Decrease
Current smokers serum cotinine (ng/ml)	-7.9 (-25.8, 9.9)	-4.4 ng/ml	0.028	Decrease
Physical activity				
Time sedentary (minutes/day)	0.7 (-0.18, 1.4)	8.2 minutes/day	0.47	Increase
Time light activity (minutes/day)	-0.4 (-1.8, 0.94)	-0.67 minutes/day	1.0	Decrease
Time moderate or vigorous activity (minutes/day)	4.5 (-9.4, 17.7)	2.4 minutes/day	0.69	Increase
Total accelerometer counts (x1000 per day)	-6.0 (6.0, 6.3)	-17.8 x1000 per day	0.71	Decrease
Estimated 10-year CVD risk (%)				
Men	3.1 (-1.66, 7.7)	1.5 %	0.63	Increase
Women	-0.7 (-15.1, 14.4)	-0.21 %	0.60	Decrease

Figure 20: mean net percentage change from baseline to one month following a brief lifestyle advice intervention



Overall at one month, six individuals had received six new prescriptions for CVD risk reducing therapies in the intervention group and nine individuals 16 new prescriptions in the control group (Table 22). A significant difference was seen in the number of new prescriptions between the groups (p=0.03) but not in the number of individuals receiving new prescriptions (p=0.44).

Table 22: Newly prescribed CVD risk reducing therapies (brief lifestyle advice intervention)

Data presented are frequencies

CVD risk reducing therapies	Received brief lifestyle advice		p-value
	Yes	No	
Anti-platelet agents	2	0	0.16
Blood pressure lowering agents	2	6	0.16
Glucose lowering agents	0	3	0.08
Lipid lowering agents	2	7	0.10
Total	**6**	**16**	**0.03**

No interaction was seen between the effects of the brief lifestyle advice and provision of the personalised CVD risk estimate with respect to changes in accelerometer count (p=0.268).

Adverse events that occurred in more than 5% of participants are shown in Table 23.

Table 23: Adverse events occurring in more than 5% of participants (brief lifestyle advice intervention)

Data presented are frequency (%)

	All participants (n=194)	Lifestyle advice ± risk estimate (n=98)	No Lifestyle advice ± risk estimate (n=96)	p-value
Musculoskeletal pain	13 (7%)	4 (4%)	9 (9%)	0.46
Upper respiratory tract infection	18 (9%)	6 (6%)	12 (13%)	0.53

Discussion

The results of the 2x2 factorial randomised controlled trial demonstrated that whilst both interventions were associated with some health improvements neither was able to significantly increase physical activity in adults at increased risk of CVD.

In individuals who did receive a personalised 10-year CVD risk estimate and those that did not receive a risk estimate the proportion of participants increasing their daily activity by $>30x10^3$ accelerometer counts was very similar (30% versus 29%). No change either was seen in estimated 10-year CVD risk at one month or the modifiable risk factors used to make this estimate except for a net 7.4% reduction in LDL cholesterol. Similar numbers of patients received additional CVD risk reducing therapies but significantly more prescriptions were given to the personalised 10-year CVD risk estimate intervention group.

Similarly, a brief lifestyle advice intervention did not increase physical activity at one month in adults at increased risk of CVD. The intervention was however, associated with small but significant improvements in some of the CVD risk factors measured. A 10.2% reduction was seen in triglycerides and in men, a 2.6% reduction in waist circumference. Among smokers, serum cotinine was reduced by 7.9%.

Strengths

Strengths of this study include its rigorous design, intervention development and the inclusion of objective measures of behaviour. The brief lifestyle advice intervention was based on sound psychological theory and developed with input from the target group. Each intervention was one off and brief to increase their applicability to

routine clinical practice and were universally delivered as per protocol. Follow up of participants was high suggesting the interventions were acceptable. Whilst the primary objective was not met some small but significant improvements in some CVD risk factors were seen.

Limitations

Diagnosis of diabetes and dysglycaemia

The rates of newly diagnosed type 2 diabetes and dysglycaemia quoted in this study are based on a single oral glucose tolerance test result measured at entry to the study. The diagnostic glucose values used are in accordance with the World Health organisation criteria for the diagnosis of diabetes and dysglycaemia (199) (type 2 diabetes indicated if fasting plasma glucose >7.0 mmol/L or post-challenge glucose >11.1 mmol/L, impaired glucose tolerance if post challenge glucose >7.8 but <11.1 mmol/L and impaired fating glucose if fasting plasma glucose >6.1 but <7.0 mmol/L). However, the World Health organisation requires that the diagnosis is confirmed with a second oral glucose tolerance test. In this study the diagnosis was not confirmed on a second oral glucose tolerance test as the second oral glucose tolerance test was performed one month after an intervention that may have altered the results of the test. This is a weakness of the study and may mean that the rates of newly diagnosed diabetes and dysglycaemia quoted under or over estimate (200) the true prevalence in this population.

Impact of multiple testing

The p-values quoted for change in parameters measured over time were not corrected for multiple testing. Statistical advice was sought as to whether or not this was required in this study. Based on the fact that each parameter was tested separately and only once in each group it was deemed that this was not required. In addition, a common method of taking into account multiple testing is to increase the level of significance required in order to determine that a result is statistically significant (201) (for example only accepting a p value of <0.01 rather than the conventional <0.05) (The Bonferroni method). In this study the results quoted as being statistically significant would remain so.

Clinical significance of results

Whilst the results for LDL cholesterol lowering in the 10-year personalised risk estimate arm and triglyceride results in the brief lifestyle advice arm achieved statistical significance this must be balanced against the clinical significance of the results. The individuals participating in this study were all at increased risk of CVD and as such would be entitled to lipid lowering therapy with statin drugs according to NICE guidance. A large meta-analysis of statin therapy has demonstrated that for every mmol/L reduction in LDL cholesterol a reduction of approximately one fifth is seen in the 5-year risk of having a major coronary event, coronary revascularisation or stroke (202). In the 4-S study the average reduction seen in LDL cholesterol following treatment with 20mg Simvastatin for 6 weeks was approximately 2 mmol/L (13). These data indicate that the clinical significance of the lipid lowering impact of

the interventions used in this study is modest when far greater reductions could have been achieved with the use of appropriate pharmacotherapies.

I attribute the reduction in LDL cholesterol and triglycerides seen to improved adherence to prescribed medication as there was an improvement in lipids despite no increase in physical activity and the improvement was seen even after those prescribed lipid lowering therapy during the study were excluded. Unfortunately no measure of adherence to prescribed medication was used in this study and so I am unable to substantiate this claim with objective evidence.

Population

The participants in this study were identified on the basis that they were at increased CVD risk. The high median level of risk of the participants (48% in men and 31% in women) was perhaps greater than I anticipated finding when I began recruiting participants. It was also surprising to find that given that it is relatively straightforward to estimate CVD risk using commonly used general practice computer software so few of these individuals (particularly those without diabetes) were currently prescribed proven CVD risk reducing therapies (for example only 20% were taking lipid lowering medication). I expected to find individuals with treated risk factors with some degree of residual modifiable risk that would be amenable to reduction through lifestyle modification. This was not the case and therefore it could be argued that prescribing study participants proven CVD risk reducing therapies would have achieved far greater reductions in estimated CVD risk (203) than either of the interventions used in this study. However, it must be remembered that the primary objective of the study was to increase physical activity. An alternative

approach may have been to stratify the interventions according to level of risk with brief lifestyle advice being offered to those at lower estimated risk and more intensive advice and drug therapy being offered to those at higher risk.

Furthermore, the high levels of previously unrecognised elevated CVD risk in this population would seem to support the proposal that all adults over the age of 55 years be prescribed a "polypill" consisting of a combination of lipid and blood pressure lowering agents, aspirin and folic acid in order to substantially reduce the incidence of CVD events in the population (204). This approach as opposed to the one advocated in my study based on estimated 10-year CVD risk, would also overcome the recent finding that commonly used risk calculators often fail to identify the majority of those who will go on to have a CVD event (205, 206). Whilst accepting these findings, the purpose of my study was to determine if the provision of CVD risk information could motivate behaviour change (specifically an increase in physical activity) rather than to determine the optimal approach to reducing the burden of CVD risk in the population.

In my study the proportion of individuals identified as being at increased CVD risk varied substantially between the practices included in the study (between 1 and 10%). Whilst this may in part reflect demographic differences between the practice population I think it is more likely to represent missing risk factor values. The CVD risk equations built into general practice software can only estimate CVD risk if information is available on all of the parameters required to make the risk estimation (systolic blood pressure, lipid values, presence of diabetes etc.). It is most likely that much of the variation seen in the proportion of high risk individuals identified represents differences in the rates of missing data. It was not possible to determine the number of individuals in a practice for whom the requisite risk factor values required for CVD risk estimation were not available. It is also possible that some of

the individuals with missing data would be at high risk because they have failed to engage with healthcare services and those with risk factor information available are motivated to attend their primary care service and undergo testing for CVD risk factors.

Accelerometer data

A major limitation of this study was the less than anticipated accelerometer data collected. Valid baseline and follow up accelerometer data was only available for 125 (64%) participants. The missing data was overwhelmingly due to technical problems with the accelerometer devices mostly due to battery failure. This may have occurred due to the mailing of accelerometers to participants in advance of their study visits. This failure to collect adequate accelerometer data was not anticipated as other studies that have used accelerometers have not reported device failure rates (195, 196). However, near complete data was available for CVD risk factors and risk estimates.

Adjustment for baseline differences between groups

The between group comparisons made in this study were not adjusted for baseline differences between groups as there were no statistically significant differences between groups at baseline. This approach is acceptable if there is no imbalance between groups at baseline (207).

Trial design and bias

I used a 2x2 factorial design in order to test two separate interventions in one trial. This design allows the effect of each intervention on physical activity to be determined as well as any interaction between the two interventions. Given that it appears that interventions that attempt to achieve behaviour modification seem to be more successful if they combine threat information (in this case estimated CVD risk) with strategies to reduce the threat (in this case following a brief lifestyle advice intervention) this trial design may not have been the most appropriate. It may have been more suitable to test the effect of combining a risk estimate and brief lifestyle advice against the provision of neither a risk estimate nor lifestyle advice. My trial was not sufficiently powered to make this comparison but a post hoc analysis demonstrated that the combination of the two interventions versus no interventions (double placebo group) demonstrated similar improvements in lipids to those seen with each single intervention. However, a small (2%) reduction in fasting and 2-hour plasma glucose was seen with the combined interventions versus no interventions. Throughout the trial several participants would attend on the same day. During the morning participants would sit together in the clinical research unit and at the end of the morning when each had received any intervention to which they were randomised they would sit together and be given a light meal. This gave participants the opportunity to discuss with each other what had occurred during each intervention and thus contaminate the effect of the interventions. Given that participants were supervised throughout by trial staff I do not feel this occurred to any great extent but it does introduce the possibility of bias. One way in which this could have been avoided would have been to cluster randomise (208) the participating practices so that all

participants attending on any one day would have been randomised to the same intervention.

In addition, I took part in the measurement of clinical parameters at both the baseline and follow up visits. Given that I was aware of the intervention to which each individual had been randomised this is another possible source of bias. The possibility of such measurement bias (209) could have been reduced by different trial staff members measuring clinical parameters at baseline and follow up. However, given the limited number of staff and the requirement for me to be intimately involved in data collect for my D.Phil studies this would have been difficult to have achieved practically.

Brief lifestyle advice intervention

The brief lifestyle advice intervention was a computerised slide show that participants worked through themselves whilst I sat beside them to clarify any points that the slides raised. Whilst the slides encouraged participants to consider barriers to achieving lifestyle change and to set their own goals these were not discussed with me. This may have contributed to the failure of the lifestyle advice intervention to achieve an increase in physical activity. In addition, it took 15 minutes for each participant to work through the presentation. It may have been more appropriate to have delivered the brief lifestyle advice intervention in groups of 4-6 participants. This would have increased the duration of the intervention and allowed discussion between participants regarding goal setting and barriers to achieving lifestyle change. The focus groups conducted during the development of the trial suggest this may have

been more effective as during the focus groups participants discussed such goal setting and barriers (Box 2 and Box 8).

Participant lifestyle at baseline

Examination of the baseline characteristics of the participants in this study revealed that whilst they were at increased CVD risk they were following a healthy lifestyle and perhaps there was little scope for improving their healthy behaviours and instead CVD risk reducing drug therapy may have been a more appropriate method of reducing CVD risk in this group. Baseline levels of physical activity were far higher than anticipated and a mean plasma vitamin C level of 62 μmol/L indicates that participants were well nourished with fruit and vegetables even prior to participating in the study. In a study in which UK adults were randomised to a brief intervention to encourage fruit and vegetable intake baseline levels of vitamin C were almost half those seen in this study (34 μmol/L) (210). Unfortunately I did not include a measure of self-reported fruit and vegetable intake in the study to determine the quantities of fruit and vegetables consumed by study participants. It would have been interesting to determine the number of portions of fruit and vegetables consumed in order to achieve such high levels of plasma vitamin C.

The individuals who participated in this study were more physically active at baseline than expected with the mean minutes per day of moderate or greater intensity physical activity being almost twice that anticipated. A previous study in younger adults (aged 30-50 years) at risk of diabetes and CVD found that their mean (SD) activity of moderate or greater intensity was 30 (18) minutes per day in men and 24 (16) minutes

per day in women (196) compared with the 53 (22) minutes seen in my study. One explanation is that my study participants were largely from affluent communities and an association between physical activity and higher socioeconomic status has been recognised previously (211). Given that more than three quarters of participants were meeting currently recommended levels of physical activity at baseline this could have resulted in false reassurance (212) and the view that they did not need to increase their level of activity further. False reassurance describes a situation of reassurance despite ongoing risk. Seasonality is a second explanation but this is unlikely to have impacted on the results of this study. One might expect levels of physical activity to fall during the winter months but participant recruitment took place between March and October.

A further possible explanation for the lack of increase in physical activity is that the inclusion of robust objective measures of physical activity and CVD risk factors may have had a greater effect than that of the intervention itself. The duration of study visits was at least 2 hours in order for each participant to undergo an oral glucose tolerance test with the intervention itself lasting for only 15 minutes of this time. The duration of study visits was independent of intervention allocation. Spending two hours having CVD risk factor information collected and measured yet not receiving an intervention may account for the greater proportion of control subjects compared to brief lifestyle advice intervention subjects, increasing their activity by $30x10^3$ counts per day as control participants may have overestimated the amount of daily physical activity being recommended by the brief lifestyle advice intervention. This dilution of the effect of an intervention by baseline measurements has been recognised in previous similar studies (132, 134). In addition, all participants were aware from the invitation letter and patient information leaflet that this was a study investigating

physical activity and CVD risk and that they had been invited to take part on the basis that they had been identified as being at high CVD risk. This may also have provided some impetus to adopt behaviour changes aimed at reducing CVD risk.

Socioeconomic status of participants

Although the participants in this study and my earlier focus group work were largely of high socioeconomic status it does not necessarily mean that the results are not applicable to a wider population. Focus group research carried out in Ireland (213) has shown that perspectives regarding CVD and its associated risk factors are similar across socioeconomic groups in particular that motivation to change behaviours to reduce CVD is low. In addition, a study from Germany (211) found that 20% of adults have specific barriers to exercise and those that do participate in health promoting activities do so in order to stay young rather than to reduce CVD risk. This homogeneity in underlying beliefs and barriers to CVD risk reduction strategies may help to explain the results of the current study and suggests the minimal impact of providing 10-year personalised CVD risk estimates on physical activity would have been similar if our study had been conducted in participants from a broader range of social backgrounds.

Bias in participant recruitment

Those that responded to the invitation were by definition, more motivated and interested in reducing CVD risk than those who did not and the greater number of individuals in the control group compared to the brief lifestyle advice intervention

group who received new CVD risk reducing therapies during the study may have occurred because the control individuals had been made aware of their increased CVD risk and perhaps felt that they were "missing out" by not receiving the brief lifestyle advice intervention and so instead sought CVD risk reduction advice from their general practitioner.

Reinforcement of intervention

The brief lifestyle advice intervention used in this study was expected to result in an increase in physical activity based on the available evidence at the time of its development. It was brief, delivered by a healthcare professional and supported by written materials (118, 120, 121, 145, 214). In addition, it targeted walking rather than other activities and had a sound theoretical basis (145). The age of the participants should not have impacted on its success as similar interventions have been successful at increasing physical activity in adults over the age of 50 years (145). Reinforcing the advice through repeated contact with a healthcare professional or referral to an exercise specialist for more tailored exercise advice may have secured the success of the intervention (145) as some interventions that have achieved sustained increases in physical activity have been of at least six months duration (215) and have shown benefit for at least two years although this has not universally been the case (214). Increasing the contact time during the delivery of the intervention may have helped (216) but again this has not been replicated in other studies (214). However, a study in UK adults with impaired glucose tolerance that randomised participants to a three hour educational programme or an advice leaflet (control group) designed to increase physical activity was able to successfully increase

physical activity in the intervention compared to the control group at one year although no significant increase in activity was seen at three or six months (217).

Intervention addressing multiple behaviours

A further reason for the inability of participants to increase their physical activity may have been that the brief lifestyle advice intervention used targeted several other behaviours in addition to physical activity with advice on fruit and vegetable intake, smoking cessation and avoidance of excessive alcohol consumption. Limiting the intervention to one single factor may have been more successful (145). There is however, evidence to suggest that interventions addressing multiple behaviours are no less effective than those addressing a single behaviour (120).

Biofeedback

The accelerometers used in this study did not provide participants with any immediate feedback on what levels of physical activity they were achieving. In a recent study that also attempted to increase physical activity in order to improve glucose tolerance in UK adults with impaired glucose tolerance participants were randomised to receive a three hour educational programme with either pedometer step count goals or time based goals or an advice leaflet (control group). Significant improvements in glucose tolerance were seen in the pedometer group compared to the control group (217). The results of this study would suggest that providing individuals with immediate biofeedback through the provision of a simple pedometer device can successfully be

used to increase physical activity. The failure to include such feedback in my study may have contributed to the failure to increase physical activity.

Smoking cessation

The reduction in serum cotinine seen in the brief lifestyle advice group compared to those who did not receive the brief lifestyle advice would seem to suggest that the intervention was successful in reducing tobacco consumption. The half life of cotinine is approximately 24 hours and levels can fluctuate according to the timing of the last cigarette smoked (218). Levels are lowest in the morning because of minimal exposure to cigarette smoke overnight. However, smokers with a fairly constant smoking pattern should have a steady state serum cotinine level. Participants were asked to attend study visits having fasted overnight. They were also advised to abstain from smoking during the fasting period. The advice given was identical for both study visits. However, it is possible that the impact of the being involved in a CVD risk study was such that participants were more likely to refrain from smoking prior to the second compared to the first study visit.

Risk estimate confidence intervals

In this study participants were provided with a point estimate of their CVD risk. The UKPDS Risk Engine produces 95% confidence intervals for each point estimate it produces (51). For simplicity and ease of understanding participants (and their general practitioners) were not provided with the confidence limits for their estimate. Confidence intervals for the UKPDS Risk Engine tend to average ±8% of the point

estimate. Thus a participant provided with a point estimate of 22% could in fact have a risk somewhere between 14% and 30%. Providing participants and there general practitioners with these confidence intervals may have influences the way in which the point estimate was interpreted. For example, in the example given above a general practitioner or participant may decide that statin therapy is not indicated in case the participants risk is really 14% and not the 22% quoted.

Baseline estimated CVD risk in participants with and without diabetes

This study demonstrated that at baseline, participants with diabetes had lower estimated 10-year CVD risk than participants without diabetes. Indeed, some of the female diabetic participants when their risk was re-estimated after CVD risk factors had been measured at baseline in the study were not at increased estimated risk (≥20%). This may have occurred as a result of using historical data for the risk calculations completed in each practice as outlined above. It could be argued that these women should have been excluded from the trial but this discrepancy was only detected at the end of the study as these women were not randomised to a CVD risk estimate in the study and so their inclusion was unintentional. Given the relatively small number of female participants with diabetes (n=9, <5% of study participants) it is unlikely that their inclusion altered the overall conclusions of the study.
The discrepancy in risk between those participants with and without diabetes is an interesting finding. Individuals with diabetes are know to be at 2-4 times greater CVD risk than individuals without diabetes (6) perhaps it is this awareness amongst physicians that results in them being prescribed risk reducing therapies. Indeed the rates of prescriptions of CVD risk reducing therapies seen at baseline in this study

were much greater in individuals with diabetes than in individuals without diabetes. This is an important finding and again highlights the need to use risk calculators to identify those individuals who would not immediately appear to be at increased risk of CVD because their individual risk factor levels do not ring alarm bells. The vascular screening programme should identify such individuals and trigger the initiation of risk reducing strategies.

Sampling Frame

The practices and participants who took part in this study are unlikely to be representative of the general UK adult population given their healthy lifestyles at baseline and high socioeconomic status. I obtained a list of general practices in Oxfordshire and contacted them by telephone or email. Those that expressed interest in taking part were subsequently recruited. Only one practice was located in central Oxford, the others were in rural Oxfordshire. Recruitment from the city centre practice was much poorer than from the rural practices. In particular, despite this practice having a significant number of registered patients from black and minority ethnic groups I was able to recruit only a tiny number of such patients. This was disappointing particularly because of the recognition that studies should include participants from lower socioeconomic groups and from black and minority ethnic groups (219). Producing study invitation letters in a variety of languages and providing appointments outside of normal office hours may have helped recruitment of such individuals. Alternatively, the study could be replicated in a variety of different populations.

Despite the shortcomings outlined above it is likely that an overwhelming predominance of White Caucasians is representative of the late middle-aged UK population as a whole and represent those most likely to attend a screening programme.

Explanation of findings

CVD risk lower than anticipated by participants

One explanation for the inability of my participants to increase their physical activity despite the potential 10% reduction in absolute 10-year CVD risk offered, may be that participants were anticipating that they would be at higher CVD risk than they actually were and so were reassured. In a study of individuals at moderate and high CVD risk participants consistently overestimated their own CVD risk often by more than 20% (220). This discrepancy in higher perceived than actual risk may in part explain why participants felt that they did not need to adopt CVD risk reducing behaviours. This is supported by work that has shown that high risk individuals need to perceive a threat and have a coherent model linking their behaviour to the threat before they will start to change their behaviour (81). A further possible explanation is that participants did not consider a 10% reduction in 10-year CVD risk to be sufficiently adequate to encourage them to increase their physical activity.

Improvement in plasma lipids

The reduction in lipids seen at the end of the study in all participants could have occurred because individuals were invited to take part on the basis that they were

identified as being at increased CVD risk. This alone may have provided the impetus to adopt behaviour changes aimed at reducing CVD risk.

The net 10.2% reduction in triglycerides seen in individuals receiving the brief lifestyle advice intervention was seen despite similar increases in the number of new prescriptions for lipid lowering therapies in both groups (4 versus 5, p=0.74) and despite no increase in physical activity. One possible explanation for this reduction is that it is associated with the reduction in tobacco smoking demonstrated in this study by a reduction in serum cotinine levels. Previous studies have demonstrated higher triglyceride levels in smokers compared with non-smokers or former smokers and have concluded that smoking is an independent risk factor for hypertriglyceridaemia (221, 222).

Findings in context of other studies

The provision of a personalised CVD risk estimate intervention used in this study was in keeping with earlier work that had been successful. My intervention included information regarding absolute risk (59, 60), provided instruction on how to interpret risk (89) and included an individualised risk estimate (62). Such estimates have been shown to be associated with larger effect sizes compared to other types of risk communication intervention (62).

The duration of the current study may not have been adequate to achieve an increase in physical activity. Interventions that have achieved sustained increases in physical activity have been of six months duration (215) and have shown benefit for at least two years. However, this was a pilot study designed to demonstrate proof of principle rather than ongoing benefit.

The significant reduction in serum cotinine seen in this study among participants randomised to receive the brief lifestyle advice intervention suggests that the brief lifestyle advice intervention was successful at reducing tobacco smoking. This is in keeping with a systematic review that found that the odds ratio for smoking cessation having received smoking cessation advice compared with not receiving advice was 1.32 (95% confidence interval 1.18-1.48) (120). As smoking continues to be the leading cause of preventable death in the developed world (223) it is reassuring that brief advice can be effective.

Implications of findings

Large numbers of individuals at unrecognised risk

The UK government vascular screening programme is likely to identify large numbers of individuals at previously unrecognised high CVD risk. Processes need to be put in place in order to provide ongoing management for these patients aimed at preventing the development of CVD. In addition, my findings demonstrate that many individuals identified as being at increased CVD risk are also likely to have previously unrecognised dysglycaemia.

Improving adherence to prescribed therapies

Provision of a personalised 10-year CVD risk estimate was associated with a clinically significant reduction in lipids and an increase in the number of CVD risk reduction therapies prescribed but no increase in physical activity or reduction in estimated CVD risk. Once individuals have been identified as being at increased CVD risk then attention should be focused on the prescription of proven CVD risk

reduction therapies including antihypertensive drugs and statins (12, 14). Personalised 10-year CVD risk information may be helpful in demonstrating the benefits of such therapies allowing individuals to make informed decisions about committing themselves to life long drug treatments. The increase in prescriptions for CVD risk reducing therapies was seen in this study even though only participants and not their general practitioners were provided with CVD risk estimates initially. This may be particularly pertinent in the case of statin drugs in view of their extensive poor coverage in the lay press (224). Adherence to medication has been acknowledged as an important factor in achieving LDL cholesterol goals (225). Improved compliance can be achieved through a variety of methods including increased provision of information and education and improved communication between health care professionals and patients (226). Successful methods to date however, have largely been complex and labour intensive (226). A need for innovative methods to improve compliance has been acknowledged (226). Providing a personalised 10-year CVD risk estimate and demonstrating the reduction in risk achievable with therapies may be one option for improving compliance or indeed emphasising the need for medication in the first instance. Improved adherence to prescribed medication may explain the reduction in LDL cholesterol seen in this study despite no significant increase in either physical activity or lipid lowering drug prescriptions.

Hard to reach individuals

Those who chose not to take part were younger, more likely to be female and more likely to live in an inner city area with a high ethnic mix as reflected by the low response rate from an inner city practice with a high proportion of ethnic minority

patients. This is not an unexpected finding and has been found before when looking at non-responders to screening programmes (227, 228). When embarking on a national screening programme plans need to be in place to target these hard to reach individuals. Participants in this study were seen in a clinical research unit based in a local hospital. All appointments took place during normal office hours. Providing appointments at weekends or outside normal office hours may assist in recruiting working age individuals. Providing a choice of venues may encourage more people to take part. In this study, invitation letters and patient information leaflets were only published in English and we excluded individuals who could not read and write English. Providing materials in other languages may be helpful. The UKPDS Risk Engine is being developed to run in a variety of different languages.

I would also liked to have included more individuals from more deprived backgrounds as they have been demonstrated to perform less physical activity than those in higher socioeconomic groups and hence would have more to gain from a physical activity intervention (211).

Population level change

This is not the first study to fail to show that a brief lifestyle intervention can result in an increase in physical activity (214). This is despite robust underlying psychological theory and using an evidence-based approach to the design of the intervention. The failure of brief interventions like the one used in this study, and the failure of more intensive interventions delivered face to face or over the telephone, indicates that these approaches should not routinely be used to try and increase physical activity in adults. If individuals cannot be motivated individually to increase their physical

activity then the emphasis to do this moves away from the healthcare professional and towards central and local government who are in a position to make legislative and other changes than will increase the pressure on the population to increase its activity. Such changes are already being implemented including the need for schools to provide at least two hours per week of high quality physical education and school sport for school children (229).

Conclusion

I developed a personalised 10-year CVD risk estimate intervention and a brief lifestyle advice intervention aimed at motivating physical activity in adults at increased risk of CVD. The interventions were developed with input from the target group and were based on sound psychological theory and currently available evidence. However, neither intervention was sufficient to increase physical activity in adults at increased risk of CVD although both were associated with some small health improvements. On the basis of the findings from this and other studies, neither intervention should be recommended as a method of increasing physical activity in adults at increased risk of CVD, and novel approaches should now be sought.

References

1. Office of National Statistics. Mortality statistics deaths registered in 2007 (Accessed 19 May 2009, available at http://www.statistics.gov.uk/downloads/theme_health/DR2007/DR_07_2007.pdf).
2. Prospective Studies Collaboration Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. The Lancet. 2002;360(9349):1903-13.
3. Prospective Studies Collaboration Blood cholesterol and vascular mortality by age, sex, and blood pressure: a meta-analysis of individual data from 61 prospective studies with 55 000 vascular deaths. The Lancet. 2007;370(9602):1829-39.
4. Cigarette Smoking, Cardiovascular Disease, and Stroke A Statement for Healthcare Professionals From the American Heart Association Circulation. 1997;96:3243-7.
5. Prospective Studies Collaboration Body-mass index and cause-specific mortality in 900 000 adults: collaborative analyses of 57 prospective studies. The Lancet. 2009;373(9669):1083-96.
6. Stamler J, Vaccaro O, Neaton J, Wentworth D. Diabetes, other risk factors, and 12-yr cardiovascular mortality for men screened in the multiple risk factor intervention trial. Diabetes Care. 1993;16:434-44.
7. Powell K, Thompson P, Caspersen C, Kendrick J. Physical Activity and the Incidence of Coronary Heart Disease. Annual Review of Public Health. 1987;8:253-87.
8. Castelli W. Epidemiology of coronary heart disease: the Framingham study. American Journal of Medicine. 1984;76:4-12.

9. Cholesterol Treatment Trialists' (CTT) Collaborators Efficacy and safety of cholesterol-lowering treatment: prospective meta-analysis of data from 90 056 participants in 14 randomised trials of statins. The Lancet. 2005;366(9493):1267-78.

10. Heart Protection Study Collaborative Group MRC/BHF Heart Protection Study of cholesterol lowering with simvastatin in 20 536 high-risk individuals: a randomised placebocontrolled trial. The Lancet. 2002;360(9326):7-22.

11. Cannon C, Braunwald E, McCabe C, Rader D, Rouleau J, Belder R, et al. Intensive versus Moderate Lipid Lowering with Statins after Acute Coronary Syndromes. N Engl J Med. 2004;350:1495-504.

12. Sever P, Dahlof B, Poulter N, Wedel H, Beevers G, Caulfield M, et al. Potential synergy between lipid-lowering and blood-pressure-lowering in the Anglo-Scandinavian Cardiac Outcomes Trial. European Heart Journal. 2006;27(24):2982-8.

13. Randomised trial of cholesterol lowering in 4444 patients with coronary heart disease: the Scandinavian Simvastatin Survival Study (4S). Lancet. 1994;344(8934):1383-9.

14. Hansson L, Zanchetti A, Carruthers S, Dahlöf B, Elmfeldt D, Julius S, et al. Effects of intensive blood-pressure lowering and low-dose aspirin in patients with hypertension: principal results of the Hypertension Optimal Treatment (HOT) randomised trial. Lancet. 1998;351(9118):1755-62.

15. Holman R, Paul S, Bethel M, Matthews D, Neil H. 10-year follow-up of intensive glucose control in type 2 diabetes. New England Journal of Medicine. 2008;359(15):1577-89.

16. Ray K, Seshasai S, Wijesuriya S, Sivakumaran R, Nethercott S, Preiss D, et al. Effect of intensive control of glucose on cardiovascular outcomes and death in patients with diabetes mellitus: a meta-analysis of randomised controlled trials. The Lancet. 2009;373(9677):1765-72.

17. Colhoun HM, Betteridge DJ, Durrington PN, Hitman GA, Neil HA, Livingstone SJ, et al. Primary prevention of cardiovascular disease with atorvastatin in type 2 diabetes in the Collaborative Atorvastatin Diabetes Study (CARDS): multicentre randomised placebo-controlled trial. The Lancet. 2004 Aug 21;364(9435):685-96.

18. Heart Protection Study Collaborative Group MRC/BHF Heart Protection Study of cholesterol-lowering with simvastatin in 5963 people with diabetes: a randomised placebo-controlled trial. The Lancet. 2003;361(9374):2005-16.

19. United Kingdom Prospective Diabetes Study Group Tight blood pressure control and risk of macrovascular and microvascular complications in type 2 diabetes: UKPDS 38. BMJ. 1998;317(7160):703-13.

20. Batty G, Shipley M, Marmot M, Smith G. Physical activity and cause-specific mortality in men with Type 2 diabetes/impaired glucose tolerance: evidence from the Whitehall study. Diabetic Medicine. 2002;19:580-8.

21. Gill J, Malkova D. Physical activity, fitness and cardiovascular disease risk in adults: interactions with insulin resistance and obesity. Clinical Science. 2006;110(409-425).

22. Boulé N, Haddad E, Kenny G, Wells G, Sigal R. Effects of Exercise on Glycemic Control and Body Mass in Type 2 Diabetes Mellitus. A Meta-analysis of Controlled Clinical Trials JAMA. 2001;286:1218-27.

23. Ratner R, Goldberg R, Haffner S, Marcovina S, Orchard T, Fowler S, et al. Diabetes Prevention Program Research Group. Impact of intensive lifestyle and metformin therapy on cardiovascular disease risk factors in the diabetes prevention program Diabetes Care. 2005;28:888-94.

24. Eriksson J, Lindstrom J, Valle T, Aunola S, Hamalainen H, Ilanne-Parikka P, et al. Prevention of Type II diabetes in subjects with impaired glucose tolerance: the Diabetes Prevention Study (DPS) in Finland. Study design and 1-year interim report

on the feasibility of the lifestyle intervention programme Diabetologia. 1999;42:793-801.

25. Li G, Zhang P, Wang J, Gregg E, Yang W, Gong Q, et al. The long-term effect of lifestyle interventions to prevent diabetes in the China Da Qing Diabetes Prevention Study: a 20-year follow-up study. The Lancet. 2008;371(9626):1783-9.

26. Davies M, Khunti K, Chauhan U, Stribling B, Goyder E, Farooqi A, et al. UK National Screening Committee: The handbook for vascular risk assessment, risk reduction and risk management2008.

27. JBS 2: Joint British Societies' guidelines on prevention of cardiovascular disease in clinical practice. Heart. 2005;91:1-52.

28. D'Agostino R, Vasan R, Pencina M, Wolf P, Cobain M, Massaro J, et al. General Cardiovascular Risk Profile for Use in Primary Care: The Framingham Heart Study. Circulation. 2008;117:743-53.

29. Hippisley-Cox J, Coupland C, Vinogradova Y, Robson J, May M, Brindle P. Derivation and validation of QRISK, a new cardiovascular disease risk score for the United Kingdom: prospective open cohort study. BMJ. 2007;335(7611):136.

30. Conroy R, Pyorala K, Fitzgerald A, Sans S, Menotti A, DeBacker G, et al. Estimation of ten-year risk of fatal cardiovascular disease in Europe: the SCORE project. European Heart Journal. 2003;24(11):987-1003.

31. Viljoen A. Cardiovascular risk estimation - making sense of the numbers. International Journal of Clinical Practice. 2008;62(9):1300-3.

32. Anderson K, Odell P, Wilson P, Kannel W. Cardiovascular disease risk profiles. American Heart Journal. 1991;121:293-8.

33. National Institute for Health and Clinical Excellence: Statins for the prevention of cardiovascular disease 2006.

34. British National Formulary 57: Pharmaceutical Press; 2009.

35. Hippisley-Cox J, Coupland C, Vinogradova Y, Robson J, Minhas R, Sheikh A, et al. Predicting cardiovascular risk in England and Wales: prospective derivation and validation of QRISK2. BMJ. 2008;336(7695):1475-82.

36. Coleman R, Stevens R, Retnakaran R, Holman R. Framingham, SCORE, and DECODE Risk Equations Do Not Provide Reliable Cardiovascular Risk Estimates in Type 2 Diabetes. Diabetes Care. 2007;30:1292-3.

37. Dalton M, Cameron A, Zimmet P, Shaw J, Jolley D, Dustan D, et al. Waist circumference, waist-hip ratio and body mass index and their correlation with cardiovascular disease risk factors in Australian adults. Journal of Internal Medicine. 2003;254(6):555-63.

38. Woodward M, Brindle P, Tunstall-Pedoe H. Adding social deprivation and family history to cardiovascular risk assessment: the ASSIGN score from the Scottish Heart Health Extended Cohort (SHHEC). Heart. 2007;93(2):172-6.

39. Ridker P, Rifai N, Rose L, Buring J, Cook N. Comparison of C-reactive protein and low-density lipoprotein cholesterol levels in the prediction of first cardiovascular events. N Engl J Med. 2002;347:1557-65.

40. Newman A, Naydeck B, Ives D, Boudreau R, Sutton-Tyrrell K, O'Leary D, et al. Coronary Artery Calcium, Carotid Artery Wall Thickness, and Cardiovascular Disease Outcomes in Adults 70 to 99 Years Old. The American Journal of Cardiology. 2008;101(2):186-92.

41. The DECODE Study Group and on behalf of the European Diabetes Epidemiology Group Prediction of the risk of cardiovascular mortality using a score that includes glucose as a risk factor. The DECODE Study. Diabetologia. 2004;47(12):2118-28.

42. Cederholm J, Eeg-Olofsson K, Eliasson B, Zethelius B, Nilsson P, Gudbjornsdottir S. Risk Prediction of Cardiovascular Disease in Type 2 Diabetes: A risk equation from the Swedish National Diabetes Register. Diabetes Care. 2008;31(10):2038-43.

43. Hubert H, Feinleib M, McNamara P, Castelli W. Obesity as an independent risk factor for cardiovascular disease: a 26- year follow-up of participants in the Framingham Heart Study. Circulation. 1983;67:968-77.

44. Coleman R, Holman R. Are measures of adiposity associated independently with incident cardiovascular disease in individuals with newly diagnosed type 2 diabetes? Diabetologia. 2007;50 (Suppl. 1):S502.

45. Baker S, Priest P, Jackson R. Using thresholds based on risk of cardiovascular disease to target treatment for hypertension: modelling events averted and number treated. British Medical Journal. 2000;320:680-5.

46. D'Agostino R, Grundy S, Sullivan L, Wilson P. Validation of the Framingham Coronary Heart Disease Prediction Scores Results of a Multiple Ethnic Groups Investigation. JAMA. 2001;286:180-7.

47. Stevens R, Coleman R, Holman R. Framingham risk equations underestimate coronary heart disease risk in diabetes Diabetic Medicine. 2005;22:228.

48. Guzder R, Gatling W, Mullee M, Mehta R, Byrne C. Prognostic value of the Framingham cardiovascular risk equation and the UKPDS risk engine for coronary heart disease in newly diagnosed Type 2 diabetes: results from a United Kingdom study. Diabetic Medicine. 2005;22(5):554-62.

49. Price H, Coleman R, Stevens R, Holman R. Impact of using a non-diabetes-specific risk calculator on eligibility for statin therapy in type 2 diabetes. Diabetologia. 2009;52(3):394-7.

50. Ulmer H, Kollerits B, Kelleher C, Diem G, Concin H. Predictive accuracy of the SCORE risk function for cardiovascular disease in clinical practice: a prospective evaluation of 44 649 Austrian men and women. European Journal of Cardiovascular Prevention & Rehabilitation. 2005;12(5):433-41.

51. Coleman R, Stevens R, Holman R. Estimating cardiovascular disease risk for individuals with Type 2 diabetes: the new UKPDS Risk Engine. Diabetic Medicine (Abstract). 2007;24 [Suppl 1]:56.

52. Royston P. Multiple imputation of missing values: update of ICE. Stata Journal. 2005;5:527-36.

53. Hippisley-Cox J, Coupland C, Vinogradova Y, Robson J, Brindle P. Performance of the QRISK cardiovascular risk prediction algorithm in an independent UK sample of patients from general practice: a validation study. Heart. 2008;94(1):34-9.

54. Simmons R, Price H, Holman R, Khaw K, Wareham N, Griffin S. Performance of the UKPDS Risk Engine and the Framingham risk equations in estimating cardiovascular disease in the EPIC-Norfolk cohort. Diabetes Care. 2009;32(4):708-12.

55. Edwards A, Elwyn G, Hood K, Robling M, Atwell C, Holmes-Rovner M, et al. The development of COMRADE--a patient-based outcome measure to evaluate the effectiveness of risk communication and treatment decision making in consultations. Patient Education & Counseling. 2003;50(3):311-22.

56. Rothman A, Kiviniemi M. Treating people with information: an analysis and review of approaches to communicating health risk information. Journal of the National Cancer Institute Monographs. 1999;25:44-51.

57. Edwards A, Elwyn G. How should effectiveness of risk communication to aid patients' decisions be judged? A review of the literature. Medical Decision Making. 1999;19(4):428-34.

58. Edwards A, Elwyn G, Mulley A. Explaining risks: turning numerical data into meaningful pictures. British Medical Journal. 2002;324:827-30.

59. Atkins C. Translating statistics for use in the clinic. Journal of General Internal Medicine. 1997;12(10):626-8.

60. Hollnagel H. Explaining risk factors to patients during a general practice consultation. Conveying group-based epidemiological knowledge to individual patients. Scandinavian Journal of Primary Health Care. 1999;17(1):3-5.

61. Veenstra M, Hofoss D. Patient experiences with information in a hospital setting: a multilevel approach. Medical Care. 2003;41(4):490-9.

62. Edwards A. A systematic review of risk communication-improving effectice clinical practice and research in primary care. Department of Health. 2007.

63. Slovic P. Informing and Educating the Public About Risk. Risk Analysis. 1986;6(4):403-15.

64. Calman KC. Communication of risk choice consent and trust. The Lancet. 2002;360:166-8.

65. Thompson P, Clarkson P, Karas R. Statin-Associated Myopathy. JAMA. 2003;289:1681-90.

66. Graham D, Staffa J, Shatin D, Andrade S, Schech S, Grenade L, et al. Incidence of Hospitalized Rhabdomyolysis in Patients Treated With Lipid-Lowering Drugs. JAMA. 2004;292:2585-90.

67. Austin M, King M, Vranizan K, Krauss R. Atherogenic lipoprotein phenotype. A proposed genetic marker for coronary heart disease risk. Circulation. 1990;82:495-506.

68. Stevens R, Kothari V, Adler A, Stratton I. United Kingdom Prospective Diabetes Study (UKPDS) Group: The UKPDS risk engine: a model for the risk of coronary heart disease in Type II diabetes (UKPDS 56). Clinical Science. 2001;101:671-9.

69. Price H, Dudley C, Barrow B, Kennedy I, Griffin S, Holman R. Use of focus groups to develop methods to communicate cardiovascular disease risk and potential for risk reduction to people with type 2 diabetes Family Practice. 2009;(in press).

70. Peto R, Darby S, Deo H, Silcocks P, Whitley E, Doll R. Smoking, smoking cessation, and lung cancer in the UK since 1950: combination of national statistics with two case-control studies. British Medical Journal. 2000;321:323-9.

71. Myocardial infarction in England 1996-2004. South East England Public Health Observatory. 2006.

72. Haynes R, Sackett D, Taylor D, Gibson E, Johnson A. Increased absenteeism from work after detection and labeling of hypertensive patients. New England Journal of Medicine. 1978;299(14):741-4.

73. Shaw C, Abrams K, Marteau T. Psychological impact of predicting individuals' risks of illness: a systematic review. Social Science & Medicine. 1999;49:1471-598.

74. Axworthy D, Brock D, Bobrow M, Marteau T. Psychological impact of population-based carrier testing for cystic fibrosis: 3-year follow-up. UK Cystic Fibrosis Follow-Up Study Group. Lancet. 1996;347(9013):1443-6.

75. Asimakopoulou K, Fox C, Spimpolo J, Marsh S, Skinner T. The impact of different time frames of risk communication on Type 2 diabetes patients' understanding and memory for risk of coronary heart disease and stroke. Diabetic Medicine. 2008;25(7):811-7.

76. Curry S, Taplin S, Anderman C, Barlow W, McBride C. A randomized trial of the impact of risk assessment and feedback on participation in mammography screening. Preventive Medicine. 1993;22(3):350-60.

77. Goldman R, Parker D, Eaton C, Borkan J, Gramling R, Cover R, et al. Patients' perceptions of cholesterol, cardiovascular disease risk, and risk communication strategies. Annals of Family Medicine. 2006;4:205-12.

78. Kjellgren K, Ahlner J, Dahlof B, Gill H, Hedner T, Saljo R. Perceived symptoms amongst hypertensive patients in routine clinical practice - a population-based study. Journal of Internal Medicine. 1998;244(4):325-32.

79. Durack-Bown I, Giral P, d'Ivernois J, Bazin C, Chadarevian R, Benkritly A, et al. Patients' and physicians' perceptions and experience of hypercholesterolaemia: a qualitative study. British Journal of General Practice. 2003;53:851-7.

80. Carroll C, Naylor E, Marsden P, Dornan T. How do people with Type 2 diabetes perceive and respond to cardiovascular risk? Diabetic Medicine. 2003;20(5):355-60.

81. Hall S, Weinman J, Marteau T. The motivating impact of informing women smokers of a link between smoking and cervical cancer: the role of coherence. Health Psychology. 2004;23(4):419-24.

82. Quillin J, Fries E, McClish D, ShawdeParedes E, Bodurtha J. Gail model risk assessment and risk perceptions. Journal of Behavioral Medicine. 2004;27(2):205-14.

83. Bhargava A, O'Sullivan E, O'Callaghan M, Buckley U, Thabit H, Walsh C, et al. Awareness of risk for cardiovascular disease in Irish patients with diabetes mellitus. Diabetic Medicine. 2007;24(Suppl 1):95.

84. Misselbrook D, Armstrong D. Thinking about risk. Can doctors and patients talk the same language? Family Practice. 2002;19:1-2.

85. Ohnishi M, Fukui T, Matsui K, Hira K, Shinozuka M, Ezaki H, et al. Interpretation of and preference for probability expressions among Japanese patients and physicians. . Family Practice 2002;19:7-11.

86. Nakao M, Axelrod S. Numbers are better than words. Verbal specifications of frequency have no place in medicine. . American Journal of Medicine 1983;74:1061-5.

87. Paling J. Strategies to help patients understand risks. . BMJ. 2003;327:745-8.

88. Misselbrook D, Armstrong D. Patients' responses to risk information about the benefits of treating hypertension. . British Journal of General Practice. 2001;51:276-9.

89. Ancker J, Senathirajah Y, Kukafka R, Starren J. Design features of graphs in health risk communication: a systematic review. Journal of the American Medical Informatics Association. 2006;13(6):608-18.

90. Morris J, Heady J, Raffle P, Roberts C, Parks J. Coronary heart-disease and physical activity of work. Lancet. 1953;265(6795):1053-7.

91. Marwick T, Hordern M, Miller T, Chyun D, Bertoni A, Blumenthal R, et al. Exercise Training for Type 2 Diabetes Mellitus. Impact on Cardiovascular Risk. A Scientific Statement From the American Heart Association Circulation. 2009:doi: 10.1161/CIRCULATIONAHA.109.192521.

92. Barengo N, Hu G, Lakka T, Pekkarinen H, Nissinen A, Tuomilehto J. Low physical activity as a predictor for total and cardiovascular disease mortality in middle-aged men and women in Finland. Eur Heart J. 2004;25:2204-11.

93. Hakim A, Petrovitch H, Burchfiel C, Ross G, Rodriguez B, White L, et al. Effects of walking on mortality among non-smoking retired men. N Engl J Med. 1998;338:94-9.

94. Hu F, Willett W, Li T, Stampfer M, Colditz G, Manson J. Adiposity as compared with physical activity in predicting mortality among women. N Engl J Med. 2004;351:2694-703.

95. Manson J, Greenland P, LaCroix A, Stefanick M, Mouton C, Oberman A, et al. Walking compared with vigorous exercise for the prevention of cardiovascular events in women. N Engl J Med. 2002;347:716-25.

96. Healy G, Wijndaele K, Dunstan D, Shaw J, Salmon J, Zimmet P, et al. Objectively Measured Sedentary Time, Physical Activity, and Metabolic Risk: The Australian Diabetes, Obesity and Lifestyle Study (AusDiab). Diabetes Care. 2008;31(2):369-71.

97. Ekelund U, Franks P, Sharp S, Brage S, Wareham N. Increase in Physical Activity Energy Expenditure Is Associated With Reduced Metabolic Risk Independent of Change in Fatness and Fitness. Diabetes Care. 2007;30(8):2101-6.

98. Fung T, Hu F, Yu J, Chu N, Spiegelman D, Tofler G, et al. Leisure-time physical activity, television watching, and plasma biomarkers of obesity and cardiovascular disease risk. Am J Epidemiol 2000;152:1171-8.

99. Healy G, Dunstan D, Salmon J, Cerin E, Shaw J, Zimmet P, et al. Breaks in Sedentary Time: Beneficial associations with metabolic risk. Diabetes Care. 2008;31(4):661-6.

100. Laaksonen D, Lakka H, Salonen J, Niskanen L, Rauramaa R, Lakka T. Low levels of leisure-time physical activity and cardiorespiratory fitness predict development of the metabolic syndrome. Diabetes Care. 2002;25:1612-8.

101. Franks P, Ekelund U, Brage S, Wong M, Wareham N. Does the association of habitual physical activity with the metabolic syndrome differ by level of fitness? Diabetes Care. 2004;27:1187-93.

102. Byberg L, Melhus H, Gedeborg R, Sundström J, Ahlbom A, Zethelius B, et al. Total mortality after changes in leisure time physical activity in 50 year old men: 35 year follow-up of population based cohort British Medical Journal. 2009;338:b688.

103. Couillard C, Despres J, Lamarche B, Bergeron J, Gagnon J, Leon A, et al. Effects of endurance exercise training on plasma HDL cholesterol levels depend on levels of triglycerides: evidence from men of the Health, Risk Factors, Exercise Training and Genetics (HERITAGE) Family Study. Arteriosclerosis, Thrombosis & Vascular Biology. 2001;21(7):1226-32.

104. Leon A, Connett J. Physical Activity and 10.5 Year Mortality in the Multiple Risk Factor Intervention Trial (MRFIT). International Journal of Epidemiology. 1991;20(3):690-7.

105. Lee I, Rexrode K, Cook N, Manson J, Buring J. Physical activity and coronary heart disease in women: is "no pain, no gain" passe? . JAMA. 2001;285:1447-54.

106. Durstine J, Miller W, Farrell S, Sherman W, Ivy J. Increases in HDL-cholesterol and the HDL/LDL cholesterol ratio during prolonged endurance exercise. Metabolism: Clinical & Experimental. 1983;32(10):993-7.

107. Huttunen J, Lansimies E, Voutilainen E, Ehnholm C, Hietanen E, Penttila I, et al. Effect of moderate physical exercise on serum lipoproteins. A controlled clinical trial with special reference to serum high-density lipoproteins. Circulation. 1979;60(6):1220-9.

108. Ballantyne F, Clark R, Simpson H, Ballantyne D. The effect of moderate physical exercise on the plasma lipoprotein subfractions of male survivors of myocardial infarction. Circulation. 1982;65(5):913-8.

109. Gordon D, Witztum J, Hunninghake D, Gates S, Glueck C. Habitual physical activity and high-density lipoprotein cholesterol in men with primary hypercholesterolemia.

The Lipid Research Clinics Coronary Primary Prevention Trial. Circulation. 1983;67(3):512-20.

110. Brownell K, Bachorik P, Ayerle R. Changes in plasma lipid and lipoprotein levels in men and women after a program of moderate exercise. Circulation. 1982;65(3):477-84.

111. Rainwater D, Mitchell B, Comuzzie A, VandeBerg J, Stern M, MacCluer J. Association among 5-year changes in weight, physical activity, and cardiovascular disease risk factors in Mexican Americans. Am J Epidemiol. 2000;152:974-82.

112. Balkau B, Mhamdi L, Oppert J-M, Nolan J, Golay A, Porcellati F, et al. Physical Activity and Insulin Sensitivity: The RISC Study. Diabetes 2008;27(10):2613-8.

113. Yates T, Khunti K, Bull F, Gorely T, Davies M. The role of physical activity in the management of impaired glucose tolerance: a systematic review. Diabetologia. 2007;50(6):1116-26.

114. Yates T, Khunti K, Bull F, Gorely T, Davies M. Increased physical activity is a cornerstone in the prevention of type 2 diabetes in high-risk individuals. Reply to Laaksonen DE, Lindström J, Tuomilehto J, Uusitupa M. Diabetologia. 2007;50(12):2609-10.

115. Laaksonen D, Lindström J, Tuomilehto J, Uusitupa M. Increased physical activity is a cornerstone in the prevention of type 2 diabetes in high-risk individuals. Diabetologia. 2007;50(12):2607-8.

116. Wilcox S, Parra-Medina D, Thompson-Robinson M, Will J. Nutrition and physical activity interventions to reduce cardiovascular disease risk in health care settings: a quantitative review with a focus on women. Nutrition Reviews. 2001;59(7):197-214.

117. Stensal D. Primary prevention of CVD: physical activity. BMJ Clinical Evidence. 2006;12:218.

118. Bull F, Jamrozik K. Advice on exercise from a family physician can help sedentary patients to become active. American Journal of Preventive Medicine. 1998;15(2):85-94.

119. Lewis B, Lynch W. The effect of physician advice on exercise behavior. Preventive Medicine. 1993;22(1):110-21.

120. Ashenden R, Silagy C, Weller D. A systematic review of the effectiveness of promoting lifestyle change in general practice. Family Practice. 1997;14:160-76.

121. Kreuter M, Chheda S, Bull F. How does physician advice influence patient behavior? Evidence for a priming effect. Archives of Family Medicine. 2000;9(5):426-33.

122. Calfas K, Long B, Sallis J, Wooten W, Pratt M, Patrick K. A controlled trial of physician counseling to promote the adoption of physical activity. Preventive Medicine. 1996;25(3):225-33.

123. Boekholdt S, Meuwese M, Day N, Luben R, Welch A, Wareham N, et al. Plasma concentrations of ascorbic acid and C-reactive protein, and risk of future coronary artery disease, in apparently healthy men and women: the EPIC-Norfolk prospective population study. British journal of nutrition. 2006;96(3):516-22.

124. Myint P, Luben R, Welch A, Bingham S, Wareham N, Khaw K. Plasma vitamin C concentrations predict risk of incident stroke over 10 y in 20 649 participants of the European Prospective Investigation into Cancer Norfolk prospective population study. American journal of clinical nutrition. 2008;87(1):64-9.

125. Liu S, Manson J, Lee I, Cole S, Hennekens C, Willett W, et al. Fruit and vegetable intake and risk of cardiovascular disease: the Women's Health Study. American Journal of Clinical Nutrition. 2000;72(4):922-8.

126. Gordon T, Kannel W, McGee D, Dawber T. Death and coronary attacks in men after giving up cigarette smoking: a report from the Framingham Study. Lancet. 1974;2:1345-8.

127. Foerster M, Marques-Vidal P, Gmel G, Daeppen J, Cornuz J, Hayoz D, et al. Alcohol drinking and cardiovascular risk in a population with high mean alcohol consumption. American Journal of Cardiology. 2009;103(3):361-8.

128. Department of Health QOF Guidance. 2009.

129. Chalmers I, Enkin M, Keirse M. Effective care in pregnancy and childbirth. Oxford University Press. 1985.

130. Armit C, Brown W, Marshall A, Ritchie C, Trost S, Green A, et al. Randomized trial of three strategies to promote physical activity in general practice. Preventive Medicine. 2009;48(2):156-63.

131. Aveyard P, Griffin C, Lawrence T, Cheng K. A controlled trial of an expert system and self-help manual intervention based on the stages of change versus standard self-help materials in smoking cessation. Addiction. 2003;98(3):345-54.

132. Goldstein M, Pinto B, Marcus B, Lynn H, Jette A, Rakowski W, et al. Physician-based physical activity counseling for middle-aged and older adults: a randomized trial. Annals of Behavioral Medicine. 1999;21(1):40-7.

133. Grandes G, Sanchez A, Sanchez-Pinilla R, Torcal J, Montoya I, Lizarraga K, et al. Effectiveness of physical activity advice and prescription by physicians in routine primary care: a cluster randomized trial. Archives of Internal Medicine. 2009;169(7):694-701.

134. Harland J, White M, Drinkwater C, Chinn D, Farr L, Howel D. The Newcastle exercise project: a randomised controlled trial of methods to promote physical activity in primary care. BMJ. 1999;319(7213):828-32.

135. Jimmy G, Martin B. Implementation and effectiveness of a primary care based physical activity counselling scheme. Patient Education & Counseling. 2005;56(3):323-31.

136. Lancaster T, Dobbie W, Vos K, Yudkin P, Murphy M, Fowler G. Randomized trial of nurse-assisted strategies for smoking cessation in primary care. British Journal of General Practice. 1999;49(440):191-4.

137. Little P, Dorward M, Gralton S, Hammerton L, Pillinger J, White P, et al. A randomised controlled trial of three pragmatic approaches to initiate increased physical activity in sedentary patients with risk factors for cardiovascular disease. British Journal of General Practice. 2004;54(500):189-95.

138. Marshall A, Booth M, Bauman A. Promoting physical activity in Australian general practices: a randomised trial of health promotion advice versus hypertension management. Patient Education & Counseling. 2005;56(3):283-90.

139. Petrella R, Koval J, Cunningham D, Paterson D. Can primary care doctors prescribe exercise to improve fitness? The Step Test Exercise Prescription (STEP) project. American Journal of Preventive Medicine. 2003;24(4):316-22.

140. Pieterse M, Seydel E, DeVries H, Mudde A, Kok G. Effectiveness of a minimal contact smoking cessation program for Dutch general practitioners: a randomized controlled trial. Preventive Medicine. 2001;32(2):182-90.

141. Sacerdote C, Fiorini L, Rosato R, Audenino M, Valpreda M, Vineis P. Randomized controlled trial: effect of nutritional counselling in general practice. International Journal of Epidemiology. 2006;35(2):409-15.

142. Steptoe A, Doherty S, Rink E, Kerry S, Kendrick T, Hilton S. Behavioural counselling in general practice for the promotion of healthy behaviour among adults

at increased risk of coronary heart disease: randomised trial. BMJ. 1999;319(7215):943-7.

143. Swinburn B, Walter L, Arroll B, Tilyard M, Russell D. The green prescription study: a randomized controlled trial of written exercise advice provided by general practitioners. American Journal of Public Health. 1998;88(2):288-91.

144. vanSluijs E, vanPoppel M, Twisk J, Chin A, Paw M, Calfas K, et al. Effect of a tailored physical activity intervention delivered in general practice settings: results of a randomized controlled trial. American Journal of Public Health. 2005;95(10):1285-31.

145. Hillsdon M, Foster C, Cavill N, Crombie H, Naidoo B. Health Development Agency Effectiveness of public health interventions for increasing physical activity among adults: a review of reviews2005.

146. SIPS Brief Advice Training (Accessed 19 May 2009, available at http://www.sips.iop.kcl.ac.uk/ba.php).

147. Koelewijn-van-Loon M, van-Steenkiste B, Ronda G, Wensing M, Stoffers H, Elwyn G, et al. Improving patient adherence to lifestyle advice (IMPALA): a cluster-randomised controlled trial on the implementation of a nurse-led intervention for cardiovascular risk management in primary care. BMC Health Services Research. 2008;8:9.

148. Jarvis MJ PP, Erens B et al. Measuring nicotine intake in population surveys: Comparability of saliva cotinine and plasma cotinine estimates Nicotine & Tobacco Research 2003;5:349-55.

149. Khaw K, Bingham S, Welch A, Luben R, Wareham N, Oakes S, et al. Relation between plasma ascorbic acid and mortality in men and women in EPIC-Norfolk

prospective study: a prospective population study. European Prospective Investigation into Cancer and Nutrition. Lancet. 2001;357(9257):657-63.

150. Duaso M, Cheung P. Health promotion and lifestyle advice in a general practice: what do patients think? Journal of Advanced Nursing. 2002;39(5):472-9.

151. Humphreys L, Costarelli V. Implementation of dietary and general lifestyle advice among women with polycystic ovarian syndrome. Journal of the Royal Society of Health. 2008;128(4):190-5.

152. Little P, Slocock L, Griffin S, Pillinger J. Who is targeted for lifestyle advice? A cross-sectional survey in two general practices. British Journal of General Practice. 1999;49(447):806-10.

153. Lainscak M, Cleland J, Lenzen M, Nabb S, Keber I, Follath F, et al. Recall of lifestyle advice in patients recently hospitalised with heart failure: a EuroHeart Failure Survey analysis. European Journal of Heart Failure. 2007;9(11):1095-103.

154. Khaw K, Wareham N, Luben R, Bingham S, Oakes S, Welch A, et al. Glycated haemoglobin, diabetes, and mortality in men in Norfolk cohort of European Prospective Investigation of Cancer and Nutrition (EPIC-Norfolk). British Medical Journal. 2001;322(7277):15-8.

155. Simmons R, Price H, Holman R, Khaw K, Wareham N, Griffin S. Performance of the UKPDS Risk Engine and the Framingham risk equations in estimating cardiovascular disease in the EPIC-Norfolk cohort. Diabetes Care. 2009;32(4):708-12.

156. Day N, Oakes S, Luben R, Khaw K, Bingham S, Welch A, et al. EPIC-Norfolk: study design and characteristics of the cohort. British Journal of Cancer. 1999;80 (Suppl. 1):95-103.

157. Zweig M, Campbell G. Receiver-operating characteristic (ROC) plots: a fundamental evaluation tool in clinical medicine. Clinical Chemistry. 1993;39(8):561-77.

158. Schwartz G. Estimating the dimension of a model. Annals of Statistics. 1978;6(2):461-4.

159. Pencina M, D'AgostinoSr R, D'AgostinoJr R, Ramachandra R. Comments on Integrated discrimination and net reclassification improvements - Practical advice. Statistics in Medicine. 2007;27(2):207-12.

160. Chamnan P, Simmons R, Sharp S, Griffin S, Wareham N. Cardiovascular risk assessment scores for people with diabetes: a systematic review. Diabetologia. 2009;52(10):2001-14.

161. Brindle P, Beswick A, Fahey T, Ebrahim S. Accuracy and impact of risk assessment in the primary prevention of cardiovascular disease: a systematic review. Heart. 2006;92:1752-9.

162. McEwan P, Williams J, Griffiths J, Bagust A, Peters J, Hopkinson P, et al. Evaluating the performance of the Framingham risk equations in a population with diabetes. Diabetic Medicine. 2004;21:318-23.

163. Yeo W, Yeo K. Predicting CHD risk in patients with diabetes mellitus. Diabetic Medicine. 2001;18:341-4.

164. Boekholdt S, Peters R, Day N, Luben R, Bingham S, Wareham N, et al. Macrophage migration inhibitory factor and the risk of myocardial infarction or death due to coronary artery disease in adults without prior myocardial infarction or stroke: the EPIC-Norfolk Prospective Population study. American Journal of Medicine. 2004;117:390-7.

165. McNemar Q. Note on the sampling error of the difference between correlated proportions or percentages. Psychometrika 12 (2): 153-157. 1947;12(2):153-7.

166. Asimakopoulou K, Skinner T, Spimpolo J, Marsh S, Fox C. Unrealistic pessimism about risk of coronary heart disease and stroke in patients with type 2 diabetes. Patient Education & Counseling. 2008;71(1):95-101.

167. Farmer A, Wade A, Goyder E, Yudkin P, French D, Craven A, et al. Impact of self monitoring of blood glucose in the management of patients with non-insulin treated diabetes: open parallel group randomised trial. BMJ. 2007;335(7611):132.

168. Gregg E, Qiuping G, Cheng Y, Venkat-Narayan K, Cowie C. Mortality Trends in Men and Women with Diabetes, 1971 to 2000. Annals of Internal Medicine. 2007;147(3):149-55.

169. Maggin M, Raschetti R, Traversa G, Bianchi C, Caffari B, DaCas R, et al. The cerivastatin withdrawal crisis: a “post-mortem” analysis. Health Policy. 2004;69(2):151-7.

170. Lloyd-Jones DM, Larson MG, Beiser A, Levy D. Lifetime risk of developing coronary heart disease. Lancet. 1999;353(9147):89-92.

171. UK Prospective Diabetes Study (UKPDS). VIII. Study design, progress and performance. Diabetologia. 1991;34(12):877-90.

172. Grundy S, Pasternak R, Greenland P, Smith S, Fuster V. AHA/ACC Scientific Statement. Assessment of Cardiovascular Risk by Use of Multiple-Risk-Factor Assessment Equations. A Statement for Healthcare Professionals From the American Heart Association and the American College of Cardiology Circulation. 1999;100:1481-92.

173. Hiller R, Sperduto R, Podgor M, Ferris F, Wilson P. Diabetic retinopathy and cardiovascular disease in type II diabetics. The Framingham Heart Study and the Framingham Eye Study. American Journal of Epidemiology. 1988;128(2):402-9.

174. Rabiee F. Focus-group interview and data analysis. Proceedings of the Nutrition Society. 2004;63:655-60.

175. Davison C, Frankel S, Smith G. The limits of lifestyle: re-assessing 'fatalism' in the popular culture of illness prevention. Social Science & Medicine. 1992;34(6):675-85.

176. Merz C, Buse J, Tuncer D, Twillman G. Physician attitudes and practices and patient awareness of the cardiovascular complications of diabetes. Journal of the American College of Cardiology. 2002;40(10):1877-81.

177. Price H, Dudley C, Barrow B, Kennedy I, Griffin S, Holman R. Use of focus groups to develop methods to communicate cardiovascular disease risk and potential for risk reduction to people with type 2 diabetes Family Practice. 2009;26:351-8.

178. http://hp2010.nhlbihin.net/atpiii/calculator.asp?usertype=prof (Accessed 02/01/2008).

179. http://www.healthatoz.com/healthatoz/Atoz/tl/misc/heartattack.jsp Accessed 02/01/2008).

180. http://healthlink.mcw.edu/article/1031002203.html (Accessed 02/01/2008).

181. Jackson R. Updated New Zealand cardiovascular disease risk-benefit prediction guide. British Medical Journal. 2000;320:709-10.

182. http://www.bhsoc.org/Cardiovascular_Risk_Prediction_Chart.stm (Accessed 02/01/2008).

183. http://www.yourdiseaserisk.wustl.edu/ (Accessed 02/01/2008).

184. Leventhal H, Leventhal E, Contrada R. Self-regulation, health and behaviour: A perceptual-cognitive approach. Psychology & Health. 1998;13:717-33.

185. Cutler S, Hendricks J, Guyer A. Age Differences in Home Computer Availability and Use. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences. 2003;58:S271-S80.

186. Basak C, Boot W, Voss M, Kramer A. Can training in a real-time strategy video game attenuate cognitive decline in older adults? Psychology and Aging. 2008;23(4):765-77.

187. Thomson R, Edwards A, Grey J. Risk communication in the clinical consultation. Clinical Medicine. 2005;5(5):465-70.

188. O'Connor A, Stacey D, Entwistle V, Llewellyn-Thomas H, Rovner D, Holmes-Rovner M, et al. Decision aids for people facing health treatment or screening decisions Cochrane Database of Systematic Reviews. 2001;CD001431. DOI: 10.1002/14651858.CD001431(3).

189. Elwyn G, O'Connor A, Stacey D, Volk R, Edwards A, Coulter A, et al. Developing a quality criteria framework for patient decision aids: online international Delphi consensus process. British Medical Journal. 2006 Aug 26;333(7565):417.

190. Maes S, Karoly P. Self-Regulation Assessment and Intervention in Physical Health and Illness: A Review. Applied Psychology. 2005;54:267-99.

191. Summary of Intelligence on Physical Activity. Department of Health; 2004.

192. Nutrient and Food Based Guidelines for UK Institutions. Food Standards Agency 2006.

193. Foster R, Marriott, HE. Alcohol consumption in the new millennium - weighing up the risks and benefits for our health Nutrition Bulletin. 2006;31:286-331.

194. http://www.communities.gov.uk/archived/general-content/communities/indicesofdeprivation/216309/ (Accessed 26/01/2009).

195. Freedson P, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. Medicine & Science in Sports & Exercise. 1998;30:777-81.

196. Ekelund U, Griffin S, Wareham N. Physical activity and metabolic risk in individuals with a family history of type 2 diabetes. Diabetes Care. 2007;30:337-42.

197. Yates F. Contingency table involving small numbers and the χ2 test. Supplement to the Journal of the Royal Statistical Society 1934;1(2):217-35.

198. http://encarta.msn.com/map_701515466/oxfordshire.html (Accessed 18 June 2009).

199. World Health Organisation Definition, Diagnosis and Classification of Diabetes Mellitus and its Complications. 1999.

200. Mooy J, Grootenhuis P, deVries H, Kostense P, Popp-Snijders C, Bouter L, et al. Intra-individual variation of glucose, specific insulin and proinsulin concentrations measured by two oral glucose tolerance tests in a general Caucasian population: the Hoorn Study. Diabetologia. 1996;39(3):298-305.

201. Bender R, Lange S. Adjusting for multiple testing—when and how? Journal of Clinical Epidemiology. 2001;54(4):343-9.

202. Baigent C, Keech A, Kearney P, Blackwell L, Buck G, Pollicino C, et al. Efficacy and safety of cholesterol-lowering treatment: prospective meta-analysis of data from 90,056 participants in 14 randomised trials of statins. Lancet. 2005;366(9493):1267-78.

203. Law M, Wald N, Rudnicka A. Quantifying effect of statins on low density lipoprotein cholesterol, ischaemic heart disease, and stroke: systematic review and meta-analysis. BMJ. 2003;326(7404):1423.

204. Wald N, Law M. A strategy to reduce cardiovascular disease by more than 80%. BMJ. 2003;326(7404):1419.

205. Jackson R, Marshall R, Kerr A, Riddell T, Wells S. QRISK or Framingham for predicting cardiovascular risk? BMJ. 2009;339:b2673.

206. Collins G, Altman D. An independent external validation and evaluation of QRISK cardiovascular risk prediction: a prospective open cohort study. BMJ. 2009;339:b2584.

207. Vickers A, Altman D. Analysing controlled trials with baseline and follow up measurements. British Medical Journal. 2001;323:1123-4.

208. Bland J. Cluster randomised trials in the medical literature: two bibliometric surveys. BMC Medical Research Methodology. 2004;4:21.

209. Page L, Henderson M. Appraising the evidence: what is measurement bias? Evid Based Mental Health. 2008;11:36-7.

210. John J, Ziebland S, Yudkin P, Roe L, Neil H. Effects of fruit and vegetable consumption on plasma antioxidant concentrations and blood pressure: a randomised controlled trial. Lancet. 2002;359(9322):1969-74.

211. Wiesemann A, Ludt S, Szecsenyi J, Scheuermann W, Scheidt R. Cardiovascular risk factors and motivation for a healthy life-style in a German community--results of the GP-based Oestringen study. Patient Education & Counseling. 2004;55(1):40-7.

212. Marteau T, Kinmonth A, Thompson S, Pyke S. The psychological impact of cardiovascular screening and intervention in primary care: a problem of false reassurance? British Family Heart Study Group. British Journal of General Practice. 1996;46(411):577-82.

213. Gabhainn S, CCkelleher, Naughton A, Carter F, Flanagan M, McGrath M. Socio-demographic variations in perspectives on cardiovascular disease and associated risk factors. Health Education Research. 1999;14(5):619-28.

214. Kinmonth A, Wareham N, Hardeman W, Sutton S, Prevost A, Fanshawe T, et al. Efficacy of a theory-based behavioural intervention to increase physical activity in an

at-risk group in primary care (ProActive UK): a randomised trial. Lancet. 2008;371(9606):41-8.

215. Riebe D, Blissmer B, Greene G, Caldwell M, Ruggiero L, Stillwell K, et al. Long-term maintenance of exercise and healthy eating behaviors in overweight adults. Preventive Medicine. 2005;40(6):769-78.

216. Kirk A, Higgins L, Hughes A, Fisher B, Mutrie N, Hillis S, et al. A randomized, controlled trial to study the effect of exercise consultation on the promotion of physical activity in people with Type 2 diabetes: a pilot study. Diabetic Medicine. 2001;18(11):877-82.

217. Yates T, Davies M, Gorely T, Bull F, Khunti K. Effectiveness of a pragmatic education program designed to promote walking activity in individuals with impaired glucose tolerance: a randomized controlled trial. Diabetes Care. 2009;32(8):1404-10.

218. Cotinine Testing: Frequently Asked Questions http://www.fbr.org/publications/pamphlets/cotininefaq.html (Accessed 19 December 2009).

219. Health Development Agency Public Health Evidence and Practice A Summary of the HDA Delivery Plan for 2004-05. 2004.

220. Frijling B, Lobo C, Keus I, Jenks K, Akkermans R, Hulscher M, et al. Perceptions of cardiovascular risk among patients with hypertension or diabetes. Patient Education & Counseling. 2004;52(1):47-53.

221. Schuitemaker G, Dinant G, vanderPol G, vanWersch J. Relationship between smoking habits and low-density lipoprotein-cholesterol, high-density lipoprotein-cholesterol, and triglycerides in a hypercholesterolemic adult cohort, in relation to gender and age. Clinical & Experimental Medicine. 2002;2(2):83-8.

222. Tan X, Jiao G, Ren Y, Gao X, Ding Y, Wang X, et al. Relationship between smoking and dyslipidemia in western Chinese elderly males. Journal of Clinical Laboratory Analysis. 2008;22(3):159-63.

223. Center for Disease Control Annual Smoking-Attributable Mortality, Years of Potential Life Lost, and Economic Costs, United States, 1995-1999. Morbidity and Mortality Weekly Review. 2002;51(14):300-3.

224. Black D. A general assessment of the safety of HMG CoA reductase inhibitors. Current Atherosclerosis Reports. 2002;4(1):34-41.

225. Parris E, Lawrence D, Mohn L, Long L. Adherence to Statin Therapy and LDL Cholesterol Goal Attainment by Patients With Diabetes and Dyslipidemia. Diabetes Care. 2005;28:595-9.

226. Osterberg L, Blaschke T. Adherence to medication. New England Journal of Medicine. 2005;353(5):487-97.

227. Szczepura A, Price C, Gumber A. Breast and bowel cancer screening uptake patterns over 15 years for UK south Asian ethnic minority populations, corrected for differences in socio-demographic characteristics. BMC Public Health. 2008;8:346.

228. Banks E, Beral V, Cameron R, Hogg A, Langley N, Barnes I, et al. Comparison of Various Characteristics of Women Who Do and Do Not Attend for Breast Cancer Screening. Breast Cancer Res. 2002;4:R1.

229. British Heart Foundation Health Schools Healthier Living and Learning Physical Activity Booklet A2007.

Appendices

Appendix 1: The Understanding Risk Focus Groups Question Map

Appendix 2: Brief lifestyle advice intervention

Appendix 3: Understanding Risk study electronic case report forms

Appendix 1

The Understanding Risk Focus Groups Question Map

Introduction

What the research is about?

The Understanding Risk Pilot Study is a randomised study to investigate the effect of personalised heart disease risk information on physical activity levels in adults at high risk of developing heart disease.

What will be done with the research?

The information collected will be used to design the risk information and develop the lifestyle advice that is given to participants in the Understanding Risk trial. For example, is the advice useful, informative, helpful or are things missing, need expanding or unclear.

Purpose of focus group

Group interview

Confidentiality

All information collected will be confidential and the anonymity of participants preserved in any publications of the research findings

Opinions

No right or wrong answers

Questions

Some questions may seem obvious but this is to ensure that we are absolutely clear about what is being said

Opening Circle

Name

Relevant information

Initial view on subject matter

Key Questions

In general, how concerned are people about having a heart attack (is having a heart attack something people worry about)?

Do people see themselves as more or less likely to have a heart attack than their peers and why?

What can be done to reduce the risk of having a heart attack?

At what level of risk would people consider trying to do something to try and reduce their risk?

How will doing more exercise reduce the risk of having a heart attack?

Where do people get their knowledge about risk factors for heart attacks from?

Risk communication examples

Ask if everyone has had the opportunity to read the risk information

Ask if there were any terms that were not understood by participants

Thoughts on each example of risk representation and draft brief lifestyle advice intervention

Is it comprehensible?

Is it acceptable?

Ending Questions

Does anyone have any final comments that they would like to make or feel we haven't covered.

Closing circle

How have you found the experience today? What could we do to improve for subsequent focus groups?

Appendix 2

Appendix 3