Since the beginning of written history — and likely before this as tomb drawings attest — civilisations have linked physical activity and diet with health and wellbeing. Ancient Greeks believed that maintaining good health relied on the balance of black bile, yellow bile, phlegm and blood — the body's four 'humours' — and that diet modifications could restore this balance if it was out of synch. It was also an Ancient Greek, Hippocrates in fact, who advised that, "All parts of the body... if unused they become liable to disease, defective in growth and age quickly.”

Whilst it may once have been dismissed as mumbo jumbo and at best, educated guesswork, science has steadily proved the Ancient Greeks right. Physical inactivity is the fourth leading cause of global mortality\(^1\), being linked to cancers, heart disease and diabetes. The World Health Organization estimates that around 3.2 million people die each year because of physical inactivity\(^2\). And Public Health England (PHE) cautioned in 2014 that half of women and one third of men were damaging their health through insufficient physical activity\(^3\).

An unhealthy diet is also a major risk factor for many chronic diseases. The UK faces a double disease burden caused by dietary excess and imbalance and by nutritional deficiencies. The proportion of people who are obese or overweight has risen significantly in recent years. In England, this increased from 53.1 per cent in 1993 to 62.15 per cent in 2013-14\(^4\). Being overweight or obese increases a person's risk of high blood pressure, type 2 diabetes, stroke and coronary heart disease\(^5\). Vitamin and mineral deficiencies, including iron, folate and vitamin D, are also common and contribute to diseases such as osteoporosis, which affects more than three million people in the UK\(^6\). And after smoking, diet is the major modifiable risk factor for cancer\(^7\), with 30-35 per cent of cancers being attributed to poor diet\(^8\). An estimated 70,000 premature deaths in the UK could be avoided each year if UK diets matched nutritional guidelines\(^9\).

The financial costs are enormous. In the UK, poor diet-related ill health costs the NHS an estimated £5.8 billion each year and physical inactivity around £900 million\(^10\).

The MRC has been at the forefront of research linking physical activity and diet to health and wellbeing. This research has been behind many public health policy decisions and interventions aimed at addressing nutrient-deficient diets and inactivity. These range from the Department of Health recommendation that all pregnant women should take folic acid supplements to healthy living schemes such as Football Fans in Training.
Physical activity and diet

1918: Sir Edward Mellanby demonstrates that a dietary deficiency is the cause of rickets and that this could be resolved with the treatment of cod liver oil. This study is funded by the MRC.

1929: Professor Sir Frederick Gowland Hopkins, a founding MRC member, wins the 1929 Nobel Prize in Physiology or Medicine for the discovery of vitamins. He had shown that rats failed to grow if fed a diet of pure proteins, carbohydrates, fats, minerals and water and concluded that foods must contain unidentified substances needed for survival. Before his work, most researchers believed that diet-linked illnesses, such as the scurvy that sailors suffered from during long trips, were caused by a toxic substance in certain foods.

1934: In an MRC-funded study, Dr Elsie Widdowson and Professor Robert McCance demonstrate that the amount of iron in the body is regulated by absorption rather than excretion.

1939: By walking miles in the Lake District on proposed Second World War diet rations, Dr Widdowson and Professor McCance demonstrate that they provide sufficient nutrition for healthy functioning. They also conclude that in a rationed diet with limited dairy, calcium fortification of bread would be beneficial. This led to the statutory fortification of bread with calcium, which still continues today.

1953: MRC scientist Professor Jeremy Morris demonstrates for the first time the link between physical activity and coronary heart disease. See case study ‘Physical activity and heart disease’.

1965: An MRC study shows that in patients with coronary heart disease, a low fat diet results in a 10 per cent reduction in cholesterol but has no effect on the rate of death or reinfarction – a successive heart attack within 28 days of the first. The researchers therefore conclude that a low fat diet is not necessary in the treatment of heart attacks.

1968: Professor Jeremy Morris demonstrates that vigorous aerobic exercise including running, swimming, cycling and brisk walking results in fewer heart attacks when compared to comparatively sedentary leisure activities such as gardening or DIY.

1977: A large population study coordinated by the MRC Dunn Nutrition Unit links low fibre intake to increased colon cancer rates.

1979: Babies of a low birth-weight, and typically suffering from poor nutrition, are more likely to develop coronary heart disease as adults, according to Professor David Barker and colleagues at the MRC Environmental Epidemiology Unit. Adults of low birth-weight are also more prone to strokes, higher blood pressure, altered stress responses and chronic bronchitis.

1940: Dr Widdowson and Professor McCance publish The Composition of Foods, regarded as the foremost nutrition publication and the basis of most nutritional databases around the world. 2014 saw the publication of its eighth edition.

1989: Researchers at the MRC Environmental Epidemiology Unit follow up a large cohort of elderly people to assess the link between calcium intake, physical activity and risk of hip fracture. They find that whilst reduced calcium intake did not seem to be a risk factor for hip fracture, the risk did increase with decreasing outdoor activity and in those with the weakest grip. The researchers conclude that physical activity and muscle strength may protect against hip fracture by preserving bone mass or reducing the risk and severity of falls.

1985: An MRC trial shows that oily fish consumption reduces death from heart disease by 29 per cent in patients who had already experienced a myocardial infarction – or heart attack. This added to the evidence compiled by the Committee on Medical Aspects of Food Policy (COMA) who advised people to ‘eat at least two portions of fish, of which one should be oily, weekly’. The study also showed that a reduction in fat consumption was not associated with any difference in death rate.

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Physical activity and diet

1991: An MRC-funded trial shows that folic acid supplements taken at the time of conception can prevent neural tube defects such as anencephaly and spina bifida. The study is halted so that all participants can receive folic acid supplements. This leads to the Government recommendation that both women wishing to conceive and pregnant women take a 400µg folic acid supplement. The UK Scientific Advisory Committee on Nutrition also recommends that folic acid is added to flour or bread. See case study 'Food fortification and supplements'.

2002: The UK’s first national dietary survey programme begins, with on-going collaboration with the MRC. It provides the Government with sound scientific evidence on which to base nutrition and public health strategies.

2003: A high-fibre diet reduces colorectal cancer risk, according to the part-MRC funded EPIC study involving researchers from the MRC Dunn Human Nutrition Unit.

2005: The MRC Collaborative Centre for Human Nutrition Research (HNR) produces a review summarising the evidence behind the public health target to reduce salt intakes to 6g per day.

2006: The EPIC study demonstrates a 20-25 per cent reduced risk of developing colon cancer among the physically active population.

2007: Findings from the MRC-funded Southampton Women’s Survey show that mothers with the least healthy diets were less likely to follow guidance on optimum infant feeding.

2009: A study discovers that B vitamins in the body decrease significantly with age, corresponding with higher levels of homocysteine, a chemical in the blood linked to heart disease. B vitamins are thought to play a role in combating heart disease by mopping up homocysteine.

2010: Minute weight changes have a bigger impact on insulin sensitivity than changes in the macronutrient composition of the diet, according to research conducted by Professor Susan Jebb and colleagues at MRC HNR.
2011:
MRC-funded scientists discover that a mother’s nutrition during pregnancy can strongly influence her child’s risk of obesity and, as an adult, their risk of heart disease, stroke and diabetes. This is caused by epigenetic change, which alters the function of her child’s DNA.

The MRC/CSO SPHSU launches the first ‘Football Fans in Training’ (FFIT) programme. This is a free 12-week physical activity and healthy eating programme for overweight and obese men delivered by community coaches at professional football clubs. 412 men who were on FFIT in autumn 2010 lost a total of 2,300 kg in weight. This leads to a European-wide programme to increase physical activity after a further £5 million funding is awarded.

2012:
Researchers at the MRC Lifecourse Epidemiology Unit (LEU) show that adequate calcium intake may be required to maximise the benefits of physical activity on bone development. Improving levels of physical activity and calcium intake in childhood may help to improve bone mass accrual.

Researchers at the MRC/CSO SPHSU examine the relationship between ethnic concentration and access to fast food outlets, supermarkets and physical activity facilities and show that increasing ethnic minority concentration is associated with increasing rates of fast food outlets. The study highlights that neighbourhood strategies to reduce barriers to maintaining health lifestyles should incorporate targeted strategies to reduce the density of fast food outlets in ethnically-dense areas.

2013:
In the largest twin study of its kind to date, MRC-funded researchers show that daily physical activity and sedentary behaviour are moderately heritable (43 per cent). These findings have important consequences for public health initiatives because adherence to a physical activity intervention is likely to be more challenging for individuals who lack a biological drive to be active.

Iodine deficiency in pregnancy has an adverse effect on children’s mental development, according to the MRC-funded Avon Longitudinal Study of Parents and Children (ALSPAC).

Research led by the MRC Epidemiology Unit demonstrates that consuming at least one sugar-sweetened beverage each day is associated with increased risk of developing type 2 diabetes. This research is part of the world’s largest study of new-onset diabetes across eight European countries.

Researchers at MRC HNR demonstrate a link between the high consumption of sugary drinks by teenagers and risk factors for heart disease in later life. These include lower ‘good’ cholesterol levels and higher levels of the ‘bad’ triglyceride form of fat in their blood.

Iodine deficiency in pregnancy has an adverse effect on children’s mental development, according to the MRC-funded Avon Longitudinal Study of Parents and Children (ALSPAC).

MRC-funded researchers at the University of Leeds develop My Meal Mate, a smartphone app that enables users to monitor their food intake and exercise. A study found that those using the app lost more weight than those monitoring food intake and exercise via an online diary and a paper-based version. This is the first weight loss app to be supported by published peer-reviewed evidence.

MRC-funded researchers demonstrate that supplementing Gambian children and pregnant women with calcium causes unintended, potentially adverse, long-term effects on growth and skeletal mineralisation without the anticipated benefits. This cautions against applying dietary recommendations based on Western populations to countries such as The Gambia without supporting evidence. See case study ‘Calcium and health in The Gambia’.
Physical activity and diet

2011-2014: MRC Epidemiology Unit research highlights the first large-scale evidence in Europe linking dietary factors to risk of type 2 diabetes. Key findings include associating increased type 2 diabetes risk with regular high red and processed meat intake and reduced risk with fruit and vegetable intake. The research also shows that certain food subtypes (e.g., oily fish, fermented dairy products) have inverse associations with the disease, which may be missed if only the total intake of those food groups is considered.

2014: Adherence to public health guidelines recommending 30 minutes physical activity per day is associated with reduced death rate during more than 20 years of follow-up in the Allied-Dunbar National Fitness Survey. Research undertaken by the EPIC-InterAct consortium led by the MRC Epidemiology Unit and involving researchers from MRC Human Nutrition Research demonstrates that not all saturated fatty acids are the same. It highlights the importance of recognizing differences between the health effects of different types and the need for more nuanced public health messages about overall intake.

2015: Researchers at the MRC Epidemiology Unit show that lack of physical exercise may be responsible for twice as many deaths as obesity.

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Until the Second World War, it was unknown that a lack of physical activity could contribute to coronary heart disease (CHD). It was only afterwards, when the rates of heart disease started to rise, that this link was made by Professor Jeremy Morris in 1953. He found that the rate of CHD was higher in sedentary double-decker bus drivers than in the presumably more active bus conductors. He found similar results when comparing postal workers who sat behind desks to roaming postmen.

Professor Morris considered that the protection against CHD granted to more active workers was a result of their larger amounts of energy expended, rather than a difference in nervous strain, as previously believed.

Further studies showed that ischaemic myocardial fibrosis — blockage of the heart’s arteries — was four to five times more common in those categorised as ‘light’ workers than in those classified as ‘heavy’ workers at 45–59 years of age, and two to three times more common at 60–69 years. Clinical records showed that hypertension and hypertensive heart disease were more commonly found in the ‘light’ workers and appeared 10 to 15 years earlier in them than in the ‘heavy’ workers.

Professor Morris believed that because occupations were becoming increasingly sedentary, any future role of physical activity in the protection against heart disease would have to be related to leisure time activity. He therefore set up various studies to investigate this link. The first of these was the pioneering Whitehall study, which looked at the leisure activities of almost 17,000 civil servants. This research demonstrated that vigorous aerobic exercise including running, swimming, cycling or brisk walking resulted in a lower incidence of heart attacks when compared to comparatively sedentary leisure activities such as gardening or DIY.

Professor Jeremy Morris was an epidemiologist looking at patterns of disease in a population and why some people suffered ill health and not others. This methodology had so far only been used for infectious diseases and so his use of it in this field was ground-breaking. Professor Morris published a number of papers that set out the potential for epidemiological research, pioneering its use in a range of areas of medicine and public health.
It is important for pregnant and breast-feeding women to obtain sufficient calcium to assist the growth of their baby’s developing skeleton. Studies have also shown that supplementing calcium-deficient pregnant women with calcium may reduce their risk of high blood pressure and pre-eclampsia.

The MRC has funded several studies to determine whether calcium supplementation in Gambian women — whose calcium intake is low and whose infants experience poor growth and bone mineral growth is poor compared to those in Western populations — would be beneficial.

In 2006 researchers from MRC Human Nutrition Research (HNR) and the MRC International Nutrition Group showed in fact that supplementing pregnant Gambian women, accustomed to a low-calcium diet, with calcium had no significant benefit for breast-milk calcium concentrations, or infant birth weight, growth or bone mineral status in the first year of life. This supports research showing that metabolic adaptations occur during human pregnancy and lactation to provide sufficient calcium for foetal growth and breast-milk production.

These results were followed by a publication in 2013, which showed that calcium supplementation had no significant effect on a mother’s blood pressure.

These research groups also investigated whether there was an association between maternal calcium supplementation and offspring blood pressure at age five-10 years old. The researchers found no association between maternal calcium supplementation and offspring blood pressure.

A separate study undertaken by these MRC researchers has however demonstrated that calcium supplementation in Gambian children aged 8-12 years old may increase bone mineralisation and, ultimately, peak bone mass.

However, recent results from long-term follow-up of these studies have indicated that calcium supplementation of Gambian children and pregnant women causes unintended, potentially adverse, long-term effects on growth and skeletal mineralisation, without the anticipated benefits. This cautions against applying dietary recommendations based on Western populations to countries such as The Gambia without supporting evidence.

These findings have implications for nutrition policy in The Gambia and other populations with low calcium intake.
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Image: Bone structure. Copyright: zimowa, Shutterstock
In recent years, there has been increasing interest in micronutrient malnutrition. This is largely due to an increased understanding of its contribution to the global burden of disease. The 2000 World Health Report identified iodine, iron, vitamin A and zinc deficiencies as being among the world’s most serious nutrition-related health risk factors. Micronutrient deficiency is responsible for a variety of non-specific physiological impairments which can lead to reduced resistance to infections, metabolic disorders and impaired physical and psychomotor development in addition to the more obvious diseases caused by micronutrient deficiency. The best way to prevent micronutrient malnutrition is consumption of a balanced diet sufficient in every nutrient. However, this relies on universal access to adequate food and appropriate dietary habits. Fortifying food with micronutrients can deliver nutrients to large segments of the population without needing drastic changes in food consumption patterns.

The MRC has played an important role in demonstrating the benefits of food fortification leading to Government recommendations and national and international policies.

After a number of studies suggested that folic acid might reduce the risk of neural tube defects (NTDs), the MRC conducted a randomised controlled trial to determine the effectiveness of folic acid supplementation in the prevention of the recurrence of NTDs. The RCT found that women with a previous history of a pregnancy affected by an NTD reduced their recurrence risk by 70 per cent by taking 4000 micrograms (µg) of folic acid daily. The study was halted so that all participants could receive folic acid supplements. Observational studies indicate that a similar level of prevention can be achieved among women who have not already had an affected pregnancy and that this may be achieved with the currently recommended lower dose of folic acid (400 microg/d). Encouraging women to consume a supplement however has limitations, particularly as folic acid should be taken in early pregnancy and according to data from an MRC-funded study, one in six pregnancies in the UK are unplanned. However, a 2009 study from the MRC Epidemiology Resource Centre, using data from the Southampton Women’s Study, showed that women planning a pregnancy only marginally increased their compliance with health behaviours and folic acid supplement. The Scientific Advisory Committee on Nutrition (SACN, Chair: Dr Ann Prentice from MRC Human Nutrition Research) and the Food Standards Agency both recommend the mandatory fortification of bread or flour with folic acid. The Government will finalise its decision on mandatory fortification of flour in 2015.

It was MRC-funded researchers Dr Elsie Widdowson and Professor Robert McCance who, when analysing Second World War diet rations, concluded that in a rationed diet with limited dairy, calcium fortification of bread would be beneficial. This led to the statutory fortification of bread with calcium, which still continues today.
As part of the Government’s Red Tape Challenge on ‘Hospitality, Food and Drink’ to reduce regulatory burdens on business, the Department for Environment, Food and Rural Affairs (DEFRA) was asked in 2013 to review whether mandatory fortification of bread with calcium, iron, niacin and thiamine should continue. The SACN demonstrated that removal of calcium and iron would adversely affect the intake among certain population groups. It was recognised that the current system provided equal health benefits for all consumers and that flour should be preserved as a vehicle for population nutritional intervention. In particular, flour was a particularly important source of calcium, especially for those who do not consume dairy products. The Government has since concluded that the mandatory fortification of bread with calcium, iron, niacin and thiamine should continue.

The MRC has also shaped national and international guidance on vitamin D supplementation. Vitamin D is essential for musculoskeletal health as it promotes calcium absorption from the bowel, enabling bone mineralisation and preventing osteoporosis. Osteoporosis is a major public health problem, affecting around three million people in the UK. 300,000 people receive hospital treatment for fragility fractures each year as a result of the condition, which is estimated to cost the NHS more than £1.73 billion each year. In the early to mid-2000s, it was thought that universal vitamin D supplementation in the elderly would help to prevent these fractures. However, studies led by Professor Cyrus Cooper at the MRC Lifecourse Epidemiology Unit (LEU) at the University of Southampton showed that vitamin D supplementation had no marked impact on fracture incidence. Professor Cooper’s team however demonstrated that the risk of osteoporotic fracture is modified by environmental influences during intrauterine and early postnatal life. One study linked maternal vitamin D insufficiency with poor offspring bone mineral accrual during childhood — likely to lead to an increased risk of fracture in late adulthood. Data from the Southampton Women’s Survey also showed a link between maternal vitamin D concentrations during pregnancy and a reduced bone mass in their offspring’s bone mass at birth. This reinforced government recommendations encouraging vitamin D supplementation during pregnancy to optimise skeletal development in offspring and to reduce the risk of osteoporosis in later life. The SACN is currently reviewing its advice on vitamin D dietary recommendations for the UK, to be published in 2015. MRC-funded research has contributed to the evidence on which these recommendations will be based.

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Image: Fresh bread and wheat. Copyright: Scorpp, Shutterstock