



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

The health benefits of walking

Citation for published version:

Kelly, P, Murphy, M & Mutrie, N 2017, The health benefits of walking. in C Mulley, K Gebel & D Ding (eds), *Walking*. Transport and Sustainability, vol. 9, Emerald Publishing, pp. 61-79. <https://doi.org/10.1108/S2044-994120170000009004>

Digital Object Identifier (DOI):

[10.1108/S2044-994120170000009004](https://doi.org/10.1108/S2044-994120170000009004)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Peer reviewed version

Published In:

Walking

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.



Health Benefits of Walking

The Health Benefits of Walking

Authors

Paul Kelly¹, Marie Murphy² and Nanette Mutrie¹

¹Physical Activity for Health Research Centre (PAHRC), University of Edinburgh, UK

²School of Health Science, University of Ulster, Newtownabbey, UK

Abstract

Purpose

To review and synthesise the available evidence for the health benefits of walking.

Design

Non-systematic evidence review.

Findings

The evidence base for the health benefits of walking is growing. Increasingly we are finding strong evidence for the beneficial effects of walking for both individuals and populations.

Research limitations and implications

More evidence is required on how to better understand the health outcomes associated with walking and how to promote long term increases in walking behaviour. Systematic reviews of specific health benefits remain rare.

Practical implications

Walking should be promoted in all population groups regardless of age or sex.

Originality

Health Benefits of Walking

There are currently few existing integrative syntheses of the physical and mental health outcomes associated with walking.

Introduction

Walking is a prevalent form of physical activity across places, cultures, ages and gender. In this chapter we will discuss the behaviour of walking and the evidence for the health benefits that are associated with this activity. We will consider both positive improvements in health status, as well as avoidance of disease states.

What is walking?

Before we consider the health benefits of walking, we should first try to understand the behaviour. Walking is the most natural form of movement around our environment (Morris & Hardman, 1997) and occurs in multiple diverse contexts. Walking has been the primary mode of locomotion for humans until very recent times when we began to sit and ride - first on horses and then in carriages, then trains and bicycles, and finally cars, trucks, buses, and airplanes – rather than go on foot (Amato, 2004).

In modern times walking is still prominent. We may walk for transport, we may walk around our home or workplace, or our jobs may require us to walk (National Institute for Health and Clinical Excellence, 2012). For others walking can be a recreational activity for relaxation and enjoyment. Beyond this many other activities such as golf, gardening, dog walking, and housework, involve walking to greater or lesser degrees. From a physiological perspective, walking is a dynamic rhythmical activity involving the major muscle groups. For the purpose of this chapter we will consider walking to mean all forms of purposeful or incidental bipedal locomotion.

Walking is of particular interest to population health. It is convenient, accessible to most people, low risk, and low cost. For these reasons and more it was famously described as the “...nearest activity to perfect exercise” (Morris & Hardman, 1997). This review will discuss the state of the accumulated evidence for the health benefits of walking as we write this in 2016.

The history of research related to the health benefits of walking

Historically, walking has been a subject of much attention. The early literature largely

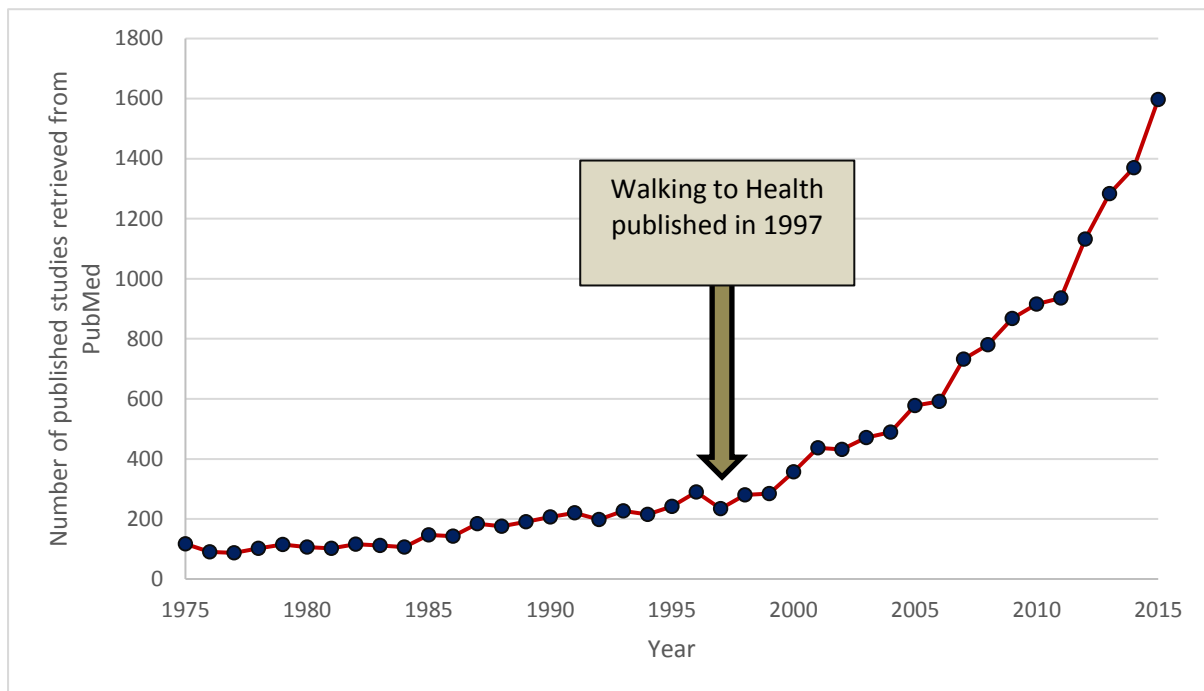
Health Benefits of Walking

explored the history of walking in society and the relationships between walking and creative reflection or culture (Solnit, 2001). However, research into walking as a mode of physical activity has a more recent history. In the 1950s Jeremy Morris first noted the association between workplace walking and the incidence of coronary heart disease, first among bus conductors (compared to bus drivers) and confirmed this among postmen (compared to sedentary telephonists) (Morris, Heady, Raffle, Roberts & Parks, 1953).

From here, the role of walking in improving health was supported by both observational studies, which examined associations between walking and disease endpoints, and intervention studies, which showed changes in range of health or disease risk outcomes. In 1993 Davison and Grant, in an editorial entitled “Is walking sufficient exercise for health?”, advanced a case for the importance of walking by summarizing the available evidence on the effect of walking on blood pressure, lipid and cholesterol levels, body composition, mental health osteoporosis, aerobic power and orthopaedic problems (Davidson & Grant, 1993). In 1997 Morris and Hardman published a seminal review paper “Walking to health” that assembled the evidence surrounding health gains to walkers (Morris & Hardman, 1997). It is considered to be one of the most important and influential papers ever published on walking and its associated health benefits. Since the Morris and Hardman review, there has been an explosion of research interest in the role of walking and health. Figure 1 illustrates the number of peer-reviewed papers found by searching PubMed that have the word walking in the title over the last few decades.

Health Benefits of Walking

Figure 1 - Published studies retrieved from the PubMed US National Library of Medicine with (walk*) in the title 1975-2015 (National Institute of Health, 2016).¹



Early intervention studies examining the effect of walking on health outcomes focused largely on cardiovascular disease (CVD) risk factors. More recently walking intervention research has expanded to include a wider range of health outcomes including alterations in haemostatic, metabolic, musculoskeletal and immune function. These findings will be expanded in the next section.

Another influential contribution to the history of walking research was the first systematic review of walking interventions (Ogilvie et al., 2007). The review concluded that it is feasible to increase walking by 30-60 minutes per week through intervention. It also reported that people can be encouraged to walk more when interventions are tailored to their needs, or are targeted to the most sedentary or most motivated to change. The evidence came from interventions delivered at the level of the individual or households or group based approaches rather than population scales. The review also highlighted gaps in the knowledge about how to intervene to promote

¹ Note: we realise that total publications on most topics will have increased in “real terms”. Our point is not that relative importance compared to other topics e.g. smoking or sports participation has changed. Rather that the absolute number of publications on walking is higher now. From this we infer that there are a greater number of investigations, research questions and designs, insights, replicability attempts and/or findings that can be generalized to wider populations.

Health Benefits of Walking

walking. This included a need for further research on the use of pedometers (step counters), more targeted interventions for older adults, and wider appraisal of the potential health benefits from increased walking.

Writing now in 2016 the number of pedometer based walking interventions has increased and additional systematic reviews show their effectiveness in helping people increase walking and improve health. However, pedometers must be used in a particular way; the National Institute of Clinical Health and Excellence (NICE) in the UK produced guidance on the promotion of walking and cycling and suggested that pedometers could be useful but should be used in programmes in which monitoring and support and goal setting are involved. The guidance also warns against the use of 10,000 steps per day as a target when working with inactive populations because, despite the evidence of the health benefits of this number of steps, it may not be feasible for all adults to achieve (National Institute for Health and Clinical Excellence, 2012).

Physical health benefits of walking

Walking is a dynamic rhythmical activity involving the major muscle groups. The large muscles of the lower body and to a lesser extent muscles of the arms and upper body and postural muscles of the trunk contract to produce the coordinated movement that is walking. It is estimated that over half of the body's muscle mass is engaged while walking. The energy required by this muscle contraction increases the demand for oxygen in muscle cells. This increased demand is the stimulus for many of the acute and chronic physiological changes resulting from walking which benefit health.

The physiological demands of walking vary as a function of the pace, incline and terrain chosen, with faster paces, uphill slopes and softer surfaces increasing both the physiological stimulus and energy expenditure. Walking is a weight-bearing activity, so body mass also alters energy expenditure with heavier individuals expending more energy to walk a given distance than their lighter counterparts. Likewise cardiovascular fitness can determine the relative intensity of walking at a given speed with older individuals, or those with lower fitness, more likely to reach moderate and vigorous intensity while younger, fitter individuals may achieve only low intensity when walking at the same pace.

Health Benefits of Walking

A number of intervention studies have evaluated the effects of walking on a range of physiological and biochemical outcomes thought to impact upon physical health. This section will provide an overview of the main physical and physiological changes that underlie the health benefits associated with walking.

Body composition

Given the additional energy expenditure that occurs with increased levels of physical activity many walking interventions have evaluated the effect on body mass, body mass index, body fat, and the distribution of body fat. The results of our recent meta-analysis combined the data from 25 such randomized controlled trials (RCTs). Walking interventions varied widely in terms of frequency duration and walking pace as well as the overall intervention length. Participants walked between 20–60 mins per session on 2–7 days per week. Interventions lasted on average 18.7 weeks (range: 8–52 weeks). All but 1 study showed that weight loss was associated with the walking intervention, with a mean treatment effect of 1.37kg (Murtagh et al., 2015). We also noted a 0.5 kg.m⁻² reduction in BMI from 23 studies (Murtagh et al., 2015). Perhaps more important than absolute changes in body mass or weight for height is the proportion of body mass which is composed of fat stores and the distribution of this fat in the body. In addition to changes in weight, 11 of the 25 walking interventions examined waist circumference and reported a 1.51cm reduction. Given the impact of overweight and obesity on the risk of many diseases, it seems that walking can make a contribution to weight management and thereby better health.

Cardiovascular fitness

Aerobic capacity or cardiovascular fitness is an independent risk factor for cardiovascular disease (Blair, Chend & Holder, 2001). Walking is sometimes considered to be at an intensity which was unlikely to alter cardiovascular fitness. However, our recent meta-analysis of 18 studies reporting changes in aerobic fitness as a result of a moderate intensity walking intervention showed a significant treatment effect which equated to a 10% increase in fitness (Murtagh et al., 2015). Such a change in cardiovascular fitness is likely to translate into a 15% reduction in mortality risk (Dunn et al., 1999). Many of the studies in the review included inactive participants with modest levels of aerobic fitness, maximizing the potential for improvement. Changes in aerobic capacity are likely to be due to structural adaptations such as an

Health Benefits of Walking

increased capacity of the heart and altered control of vascular resistance to blood flow. Using data from a national physical activity survey, which measured heart rate response to submaximal walking speed, we estimated that 20.1% of the English population, one in four women and one in ten men, could improve their aerobic fitness by walking at just 3 mph (4.8 kmh) (Kelly, Murphy, Oja, Murtagh & Foster, 2011).

Blood pressure

Hypertension or elevated resting blood pressure is an established risk factor for cardiovascular disease. In our recent meta-analysis, when changes in resting blood pressure as a result of a walking intervention from 16 RCTs were pooled we found a significant reduction in systolic (-3.58 mmHg) and diastolic (-1.54 mmHg) blood pressure (Murtagh et al., 2015). Prospective studies have suggested that a 2 mmHg reduction in systolic blood pressure would result in 10% lower stroke mortality and 7% lower mortality from ischaemic heart disease or other vascular disease such as intermittent claudication (Lewington et al., 2002). This highlights the clinical relevance of the changes in resting blood pressure, which can be achieved by walking.

In addition to the reduction in resting blood pressure noted with regular walking in these training studies, a single walking bout has been shown to cause a transient reduction in blood pressure which lasts for at least several hours following a bout of brisk walking. Park, Rink & Wallace (2008) showed a reduction in resting systolic (~5mmHg) and diastolic (~3mmHg) blood pressure when individuals with slightly elevated blood pressure (prehypertension) undertook four 10 minute walks distributed over the course of the day (Park, Rink, & Wallace, 2008). This reduction lasted 10-11 hours after the final walk. This post-exercise reduction in blood pressure resulting from walking may contribute to the lower blood pressure observed in cross-sectional studies. More importantly in individuals who walk daily, this acute or 'last bout effect' of walking on blood pressure is likely to be sustained thereby reducing cardiovascular disease risk.

Vascular Function

The vascular endothelium is a single layer of cells on the inner lining of blood vessels providing an interface between the blood and the body systems. Endothelial dysfunction is one of the factors that lead to the development of atherosclerosis.

Health Benefits of Walking

Exercise training leads to improved endothelial function in individuals with disturbed endothelial function at baseline (Moyna & Thompson, 2004). It should be noted that few studies included in the review by Moyna and Thompson (2004) looked specifically at the effect of walking on endothelial function. One recent study by Kearney, Murphy, Davison, O’Kane and Gallagher (2014). Kearney et al., (2014) did examine the effect of a six-month walking intervention consisting of three 10-minute brisk walks per day 5 days per week for six months on arterial stiffness (a surrogate marker of endothelial function) in overweight individuals (Kearney et al., 2014). This study yielded a 12% reduction in pulse wave velocity (a measure of arterial stiffness shown to be a strong independent predictor of cardiovascular morbidity) in the brachial artery following the intervention illustrating the potential for walking to improve vascular function.

Blood lipids

Although several studies have reported favourable alterations in blood lipids such as decreases in total cholesterol and increases in HDL cholesterol, these findings are not entirely consistent. Our recent meta-analysis pooled data from walking interventions that measured changes in total cholesterol (16 studies) HDL cholesterol (15 studies) and LDL cholesterol (14 studies) and found no significant effect of walking on these outcomes (Murtagh et al., 2015) It is likely that the baseline levels of cholesterol may determine the extent of any walking-induced alterations in blood lipids with elevated lipids ‘normalizing’ rather than reducing. Moreover changes to the composition of lipids (such as particle size and apolipoprotein type) although not detectable by when total lipid levels are measured, may change with exercise making LDL less atherogenic (Holme, Hostmark & Anderssen, 2007).

In addition to any changes in fasting blood lipids resulting from a walking intervention, several studies have considered the acute and chronic effect of walking (single and multiple bouts) on the clearance of lipids from the blood following a meal (Gill & Hardman, 2003). A review by (Petit & Cureton, 2003) concluded that aerobic exercise performed up to 24 hours prior to the ingestion of a meal containing fat decreases postprandial lipemia. Although few studies have looked specifically at walking as the activity mode, (Gill & Hardman, 2003) suggest that energy expenditure during the activity rather than either the intensity or mode of activity was the most important determinant of the extent of lipid lowering. This is reinforced by studies considering

Health Benefits of Walking

the pattern of walking. In our laboratory we found that walking 30 minutes in the morning, or in three 10 minute bouts spread over the course of the day was equally effective in reducing the plasma triglyceride response to the meals eaten during the day (Murphy, Nevill & Hardman, 2000).

Haemostatic, inflammatory and immune function markers

In addition to traditional blood lipid profiles, a variety of novel circulating biomarkers that reflect blood coagulation, fibrinolysis, and inflammation have been identified as risk factors for cardiovascular and other disease (Libby, 2007; Ross, 1999; Vasan, 2006). Alterations in a range of haemostatic factors (such as fibrinogen, von Willebrand factor, tissue plasminogen activator (tPA) antigen, plasminogen activator inhibitor-1 (PAI-1), and factor VI) are associated with the development of cardiovascular disease (Kannel, 2005). Increases in markers of inflammation, such as C-reactive protein (CRP) interleukin (IL-6), and tumor necrosis factor- α (TNF- α) have been examined as predictors of cardiovascular disease (Kasapis & Thompson, 2005). The effect of walking on these biomarkers has been investigated in cross-sectional studies and both acute (as single bout) and walking intervention studies.

In 400 individuals being screened for Type 2 diabetes, Yates et al., (2008) noted that those who reported walking for at least 30min on at least 5 days/week had lower levels of CRP, IL-6 and TNF- α compared to those who reported lower walking activity levels (Yates et al., 2008). In another cross-sectional study of 185 healthy adults, Hamer and Steptoe (2008) noted that regular walking was associated with lower levels of haemostatic and inflammatory markers von Willebrand factor antigen (vWF), fibrinogen, interleukin (IL)-6, and tumor necrosis factor- α (TNF- α) independent of vigorous physical activity in healthy men and women (Hamer and Steptoe, 2008). Such epidemiological observations remain less well-substantiated by walking interventions

Exercise has been shown to have transient effects on immune function measured through changes in white blood cells (leukocytes) neutrophils and natural killer cells (Gleeson, 2007). Although prolonged and intense exercise may suppress immune function and increase the risk of infection it seems likely that more moderate activity volumes and intensities typically used when walking may result in favourable

Health Benefits of Walking

alterations in immune function. In a recent review we found that 30-60 minutes of moderate intensity exercise increased neutrophil activity in previously untrained adults (Brown, Davison, McClean & Murphy, 2015). Cross-sectional studies have demonstrated positive associations between physical activity levels categorized by the number of pedometer-recorded steps per day and immune function in older adults with adults in the third quartile of daily steps (6832 +/- 59 steps per day) (having greater salivary secretory immunoglobulin A (a marker of immune function) than those in the lowest quartile of daily steps (2962 +/- 94) suggesting that 7000 steps per day may be an appropriate target for enhanced immune function this population (Shimizu et al., 2007). Findings from exercise training studies are more equivocal and there are only a handful of studies specifically considering the effects of walking on immune function. Whether any changes in markers of immune function translate into reduced levels of infection is also not entirely clear. However, Nieman, Henson, Austin and Brown (2005) reported that women who walked briskly for 35 to 45 minutes per day on 5 days per week for 12–15 weeks experienced about half the number of days with symptoms of upper respiratory tract infections compared to those assigned to a control group (Nieman et al., 2005).

Glucose Metabolism

Exercise has been shown to improve the sensitivity of tissues to insulin (Goodyear & Kahn, 1998), improving glucose control (Boule, Haddad, Kenny, Wells and Sigal, 2001) and reducing the risk of Type 2 diabetes (American Diabetes Association, 2003). Epidemiological evidence strongly supports the role of walking in the maintaining or achieving good glucose control. In a systematic review, regular walking (typically 2.5 h/week brisk walking) was associated with a 30% lower risk of developing type 2 diabetes (Jeon, Lokken, Hu and van Dam, 2007). In the Finnish Diabetes Prevention Programme, individuals with impaired glucose tolerance who increased the amount of walking they undertook were less likely to progress to diabetes (Laaksonen et al., 2005). The importance of walking pace is highlighted by the fact that those who increased the intensity of their walking during follow-up had a 48% lower risk of diabetes than other participants.

Health Benefits of Walking

In training studies overweight women at risk of type 2 diabetes, who were asked to increase their daily walking to a target of 10,000 steps/day, improved glucose tolerance over an 8 week period (Swartz et al., 2003). In a recent RCT in the UK, individuals with impaired glucose tolerance were given a pedometer and encouraged to increase their daily walking over a 12 month period through the use of a pedometer and personalised step goals. Participants in the walking intervention increased walking by an average of 2000 steps per day (140 mins per week) and decreased the magnitude of their response to an oral glucose tolerance test (Yates et al., 2008). Notably this decrease was observed without the concomitant decrease in body weight often thought to determine the extent of exercise-induced changes in glycaemic function. This highlights the importance of walking, even in the absence of weight loss, for improving glucose metabolism.

Similar to the postprandial blood lipid response described above, at least some of the beneficial effects of walking on glucose control are likely to be due to the acute effects derived from a single bout of walking. A recent study by Deguchi et al., (2015) demonstrated a reduction in postprandial blood glucose levels among patients with type 2 diabetes following 30 minutes of fast paced walking performed in a single bout one hour after lunch. Such acute effects underscore the importance of daily walking for optimum health benefit.

Musculoskeletal

There is limited evidence to suggest that walking alone can increase musculoskeletal health and fitness in healthy individuals. This is probably because walking is low-impact and does not require high force production in comparison to other activities. This means it is unlikely to overload muscle or bone to a level that would stimulate adaptations to increase bone or muscle mass or increase muscular strength or endurance.

However, because walking is weight-bearing exercise, it may help individuals at risk of osteoporosis prevent the decline in bone mineral content common in postmenopausal women and older adults. A review found that walking interventions resulted in significant positive effects at the femoral neck in postmenopausal women

Health Benefits of Walking

but the magnitude of these changes unlikely to have any clinical significance in terms of fracture prevention (Martyn-St James & Carroll, 2008).

In individuals with compromised musculoskeletal health such as those with low back pain, walking may be an effective intervention. A recent review comparing walking with other non-pharmacological interventions concluded that walking is as effective as usual care (varied by study but normally involving advice on PA), specific strength exercises, medical exercise therapy, or supervised exercise classes at improving disability, function, and quality of life in adults with chronic low back pain (Lawford, Walters & Ferrar, 2015).

Mental health benefits of walking

There is a great deal of research evidence linking physical activity to many aspects of mental health (Ekkekakis, 2013). The evidence covers the promotion of good mental health, such as the ‘feel-good’ effect, self-esteem, cognitive functioning, positive mood, and quality of life. There is also a growing evidence base on the prevention and treatment of poor mental health such as depression, stress and anxiety, through regular physical activity.

“Broadly speaking, the less you do, the more likely you are to end up with: low mood, depression, tension and worry. If you keep active, you are: less likely to be depressed, anxious or tense; more likely to feel good about yourself; more likely to concentrate and focus better; more likely to sleep better; more likely to cope with cravings and withdrawal symptoms if you try to give up a habit, such as smoking or alcohol; more likely to be able to keep mobile and independent as you get older; and possibly less likely to have problems with memory and dementia.” (The Royal College of Psychiatrists, 2015).

We could simply accept the evidence from the general physical activity field and assume that walking, given that it is a mode of everyday physical activity, could also provide these benefits. While it would be beneficial to have a summary of the effects of walking on mental health, unlike the evidence for the physiological benefits of walking, there is no clear synthesis of the literature that focuses on walking to date. A series of workshops on the meaning of walking for well-being, run by the Scottish Universities Insight Institute, offer interesting ideas and resources for understanding

Health Benefits of Walking

both the meaning and the measurement issues involved. These resources can be viewed at Scottish Universities Insight Institute, 2016).

Many of the intervention studies that promote walking have walking or step counts as the primary outcome and mental health as a secondary outcome. Some benefits have emerged from these walking studies. For example, in a walking intervention for adults, we found that a graduated approach (incremental goals) with a pedometer led to increased step counts and more positive moods after 12 weeks (Baker et al., 2008). We have also observed that increases in walking are associated with improved perceived quality of life and are cost-effective (Shaw et al., 2011).

Conversely, sometimes mental health benefits do not emerge from studies aimed at increasing walking behavior. For example, in a walking study we conducted among older adults, in which the primary outcome was objectively measured step counts, we included measures of quality of life using the SF 36 scale (Fitzsimmons et al., 2012). We saw an intervention effect for the step counts and for the physical dimensions of the SF 36 scale. In contrast the mental dimension of the scale showed a trend towards an effect from the walking intervention but it was not statistically significant. In this case the sample size was calculated based on the expected effect size for step count ($n=46$ (23 per group)). As a result the study may not have had statistical power for the secondary outcome. Alternatively, the mental dimensions of the SF36 may not be sensitive to the change in mood or quality of life that walking can provide.

Clearly, walking offers great potential for the promotion of good mental health and the prevention of poor mental health. At the moment, however, walking as a particular mode of good mental health promotion is under researched but we are confident that evidence will continue to emerge. This will have greater utility than more general evidence linked all PA to mental health. In addition, the mental health benefits are likely to vary as a function of pace, the nature of the environment and the social context. One issue that remains intriguing is the mechanisms through which physical activity and walking confer mental health benefits. Several plausible mechanisms have been suggested such as the popular, but not yet convincing, idea that physical activity releases endorphins which provide a feel-good effect. This neurobiological mechanism remains challenging to uncover in humans but it is clear that endorphins are only one of a host of potential neurotransmitters that may provide mood

Health Benefits of Walking

improvements (Dishman & O'Connor, 2009). It is also likely that simultaneous psychological mechanisms could be operating. For example, physical activity might help us feel better because we are in control of doing something good for ourselves or we can see progress in our abilities or simply distract us from things that are causing us stress or anxiety (Biddle, Mutrie & Gorely, 2015). Another potential mechanism lies in the field of social psychology because if we are active by walking in and around our communities then we may interact more with people in the environment and this interaction has potential benefits such as decreasing isolation.

In addition, new evidence is emerging that green space and nature offer well-being effects (Hartig, Mitchell, de Vries & Frumkin, 2014). It is tempting to suggest that walking in green spaces will therefore confer even more benefit than walking in urban or indoor environments. There is a suggestion from one review that walking outdoors might offer more mental health benefit than the equivalent physical activity indoors, but the authors note that the evidence base is incomplete and hampered by studies with poor designs (Coon et al., 2011).

Could walking be a treatment for depression and other mental health problems?

Physical activity has been shown to be a viable treatment option for many mental health problems, such as depression, anxiety, and schizophrenia, often alongside more conventional treatments (Biddle et al., 2015). One aspect of mental health that has been the focus of many physical activity studies is clinically defined depression. Several systematic reviews have been conducted over the past 15 years on the topic of 'exercise' as a treatment for depression. The first of these reviews (Lawlor & Hopker, 2001, p. 1) found a large effect size, similar to that found for cognitive therapies for depression, but concluded that "The effectiveness of exercise in reducing symptoms of depression cannot be determined because of lack of good quality research on clinical populations with adequate follow up". Since then the quality of the studies has improved and the most recent review showed a moderate effect size for exercise versus no treatment control conditions (Cooney et al., 2013). The authors compared the exercise effects to those of cognitive behavioural therapy for the seven trials that had these comparisons and found no significant difference. Similarly, four trials compared exercise with antidepressant medication and no significant difference was found. Thus exercise appears to be as effective as other psychological or

Health Benefits of Walking

pharmacological treatments. However many different kinds of exercise were included in these review but only recently have we had a review that has examined the physical activity mode of walking (Robertson, Robertson, Jepson & Maxwell, 2012). This systematic review found eight trials that met their inclusion criteria and showed a large effect size of 0.86 (CI 1.12 to 0.61). The authors concluded that “Walking has a statistically significant, large effect on the symptoms of depression in some populations but the current evidence base from RCTs is limited.” (Robertson et al., 2012, p. 73). Thus, some evidence suggests that walking could be a treatment for depression, but further research is needed.

We conclude that there is good evidence that physical activity may prevent poor mental health and may also improve good mental health even within clinical populations. However, the evidence that walking as a mode of activity may also provide these benefits requires further confirmation.

Avoidance of mortality and morbidity

As discussed above, the health benefits of PA in terms of disease prevention are well known. Specific benefits of long-term higher levels of PA include reduced risk of cardiovascular disease, coronary heart disease and stroke, type II diabetes, hypertension, colon cancer, breast cancer, obesity, depression, and all-cause mortality (World Health Organisation, 2010). Therefore, as discussed in the mental health section the first consideration of walking and the avoidance of disease is the contribution that walking can make to overall accumulation of health enhancing physical activity (Bull et al., 2010). This consideration is particularly relevant given that in the UK walking is one of the most prevalent forms of population level PA (Murphy, Donnelly, Shibli, Foster & Nevill, 2012; Strain et al., 2016). However, for the rest of this chapter we will focus on evidence that comes directly from investigating exposures to walking and resulting disease outcomes.

All-cause mortality and walking

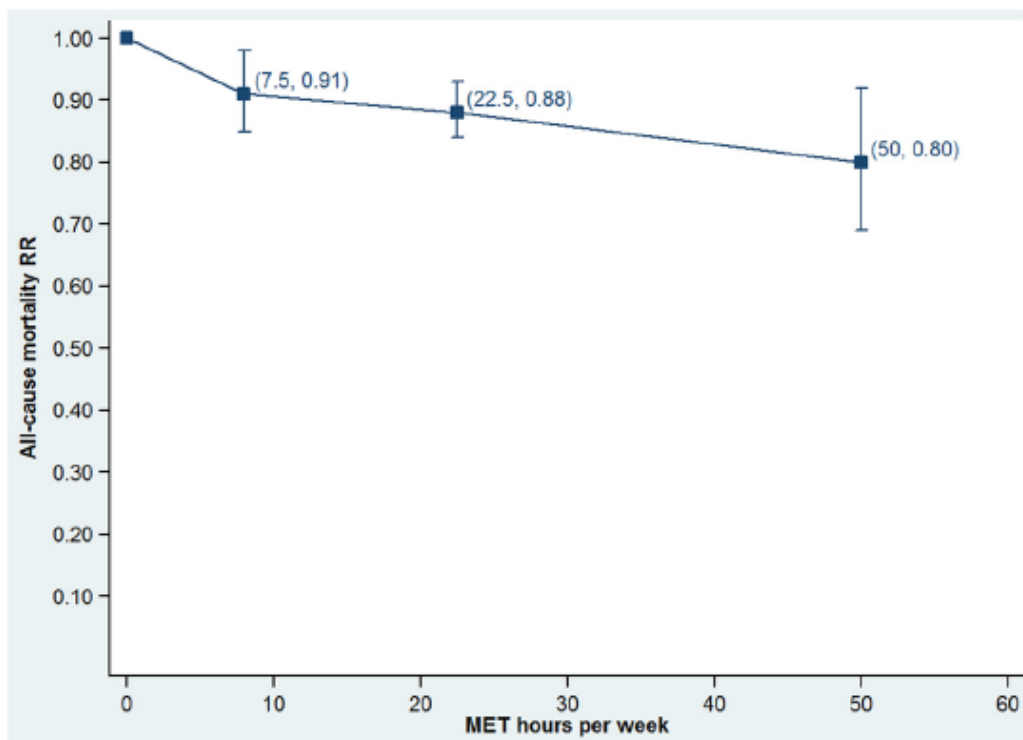
Meta-analyses of prospective cohort studies reporting the effect on all-cause mortality have suggested a reduced risk of between 3% and 32% in groups who report more walking than a referent group (Hamer & Chida, 2008; Samitz, Egger & Zwahlen, 2011; Woodcock, Franco, Orsini & Roberts, 2011). Included studies came from a range of

Health Benefits of Walking

geographical locations and heterogeneous populations. They also used a wide range of exposure stratifications (amount of walking) so comparisons between reported results are challenging. In 2014 we conducted a new meta-analysis and for each study calculated a risk estimate at a standardised exposure of 11.25 MET.hours per week (MET = Metabolic Equivalent of Task) (Ainsworth et al., 2011). This exposure corresponds to 150 minutes per week of MVPA at 4.5 METs. We found that from 14 included studies the pooled estimate for risk reduction was 11% (relative risk = 0.89 (95% CI = 0.83 to 0.96)) (Kelly et al., 2014). This was the independent effect of walking as we only included studies that adjusted risk estimates for other PA.

We also investigated the exposure-response relationship across the entire range of walking exposures and found evidence that the greatest risk reductions (i.e. steepest gradient) occur in the first 7.5-8.0 MET hours per week (approximately 100 minutes per week of walking). In other words the potential population impact is the greatest when increasing walking levels in those who currently do less than 100 minutes of walking per week (see figure 2).

Figure 2 Graded exposure-response relationship of walking with all-cause mortality. Reproduced from Kelly and colleagues (2014).



Health Benefits of Walking

Walking and specific diseases

A full synthesis of disease prevention and treatment through walking has not yet been completed. There is [systematic review] evidence for the beneficial effect of walking on certain diseases with examples including cardiovascular disease (Hamer & Chida, 2008; Physical Activity Guidelines Advisory Committee, 2008), coronary heart disease (Zheng et al., 2009), type II diabetes (Jeon et al., 2007) and depression (Robertson et al., 2012).

Taking type 2 diabetes as an example, regular walking (typically 2.5 h/week brisk walking) was associated with a 30% lower risk of developing the disease (Jeon et al., 2007). In terms of treatment, in the Finnish Diabetes Prevention Programme, individuals with impaired glucose tolerance who increased the amount of walking were less likely to progress to diabetes (Laaksonen et al., 2005).

There are further examples of individual studies showing the preventive effects of walking on diseases such as dementia (Abbott, 2004; Physical Activity Guidelines Advisory Committee, 2008), however in these cases the evidence remains incomplete or equivocal.

What about the risks of walking?

It is possible that walking may be associated with, or even lead to certain health risks or harms. For example, exacerbation of arthritis or other musculo-skeletal conditions, risks or cardiac events, exposure to pollution, or risk of traffic accidents. It was not our purpose to review these risks and they are not discussed in this chapter. Future research may wish to investigate and quantify these potential dis-benefits and harms. A point worth considering here is that in studies of all-cause mortality (Kelly et al., 2014) the benefits appear to outweigh the risks by orders of magnitude. The same is true even when factoring in the additional risks from air pollution (Tainio et al., 2016). Further investigation in high risk populations and environments would be informative.

Future research directions

There are a number of clear research directions in the field of walking and health. In terms of prevention we need better understanding of dose-response and differences between different conditions. We also require better understanding of the determinants

Health Benefits of Walking

of walking among different population subgroups to inform policy and intervention design. This might include investigation across ages, environments, socio-economic status, and overall health risk profile.

When it comes to treating disease we need clearer indications of the required dose in terms of volume, frequency and intensity, and better understanding of the ingredients of effective and efficacious treatments by sex, age, and context.

We have some good understanding of interventions that work in the short to medium term but need more evidence on long term maintenance and how to generalize and scale up successful approaches to population levels in order to see if the same health gains can be generalised to larger and more diverse populations.

There are also methodological challenges in assessing the exposures and outcomes in population and individual level observational and experimental studies. In the field of measurement challenges remain in identifying measures that give appropriately valid and reliable data on walking (Kelly, Fitzsimons & Baker, 2016). Future research is likely to rely more on objective approaches such as mobile phones and wearable devices.

Conclusion

We conclude that the accumulated evidence for walking as a health enhancing physical activity points to further promotion for all. Walking is good for health and people of all ages and sexes should be encouraged to sit less and walk more.

Acknowledgements

We would like to thank Ellie Mutrie and Steve Munro, our dogs, who attended and assisted the writing retreat that that generated this chapter.

Health Benefits of Walking

References

- Dunn, A. L., Marcus, B. H., Kampert, J. B., Garcia, M. E., Kohl, H. W., 3rd, & Blair, S. N. (1999). Comparison of lifestyle and structured interventions to increase physical activity and cardiorespiratory fitness: a randomized trial. *JAMA*, 281(4), 327-334.
- Gill, J. M., & Hardman, A. E. (2003). Exercise and postprandial lipid metabolism: an update on potential mechanisms and interactions with high-carbohydrate diets (review). *The Journal of nutritional biochemistry*, 14(3), 122-132.
- Kannel, W. B. (2005). Overview of hemostatic factors involved in atherosclerotic cardiovascular disease. *Lipids*, 40(12), 1215-1220.
- Kasapis, C., & Thompson, P. D. (2005). The effects of physical activity on serum C-reactive protein and inflammatory markers: a systematic review. *J Am Coll Cardiol*, 45(10), 1563-1569. doi: 10.1016/j.jacc.2004.12.077
- Kelly, P., Kahlmeier, S., Götschi, T., Orsini, N., Richards, J., Roberts, N., . . . Foster, C. (2014). Systematic review and meta-analysis of reduction in all-cause mortality from walking and cycling and shape of dose response relationship. *Int. J. Behav Nutr. Phys. Activ*, 11.
- Murtagh, E. M., Nichols, L., Mohammed, M. A., Holder, R., Nevill, A. M., & Murphy, M. H. (2015). The effect of walking on risk factors for cardiovascular disease: an updated systematic review and meta-analysis of randomised control trials. *Prev Med*, 72, 34-43. doi: 10.1016/j.ypmed.2014.12.041
- Ogilvie, D., Foster, C. E., Rothnie, H., Cavill, N., Hamilton, V., Fitzsimons, C. F., & Mutrie, N. (2007). Interventions to promote walking: systematic review. *BMJ*, 334(7605), 1204. doi: 10.1136/bmj.39198.722720.BE
- Park, S., Rink, L., & Wallace, J. (2008). Accumulation of physical activity: blood pressure reduction between 10-min walking sessions. *J Hum Hypertens*, 22(7), 475-482. doi: 10.1038/jhh.2008.29
- Petit, D., & Cureton, K. (2003). Effects of prior exercise on post-prandial lipemia. *Metabolism*, 52(4), 418-424.
- Shimizu, K., Kimura, F., Akimoto, T., Akama, T., Kuno, S., & Kono, I. (2007). Effect of free-living daily physical activity on salivary secretory IgA in elderly. *Med Sci Sports Exerc*, 39(4), 593-598. doi: 10.1249/mss.0b013e318031306d
- Swartz, A. M., Strath, S. J., Bassett, D. R., Moore, J. B., Redwine, B. A., Groer, M., & Thompson, D. L. (2003). Increasing daily walking improves glucose tolerance in overweight women. *Prev Med*, 37(4), 356-362.