



# Acknowledgements

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# 1 Introduction

Physical activity has a critical role to play in the prevention and treatment of cardiovascular disease across Europe. The human body evolved to be physically active, yet much routine bodily movement has been removed from our daily lives. This has been associated with many aspects of poor health. This report focuses on cardiovascular disease, but there are strong associations between physical inactivity and obesity, diabetes, poor mental health and some cancers.

This report presents a review of the role of physical activity in preventing and treating cardiovascular disease across Europe. It aims to provide a concise summary of recent knowledge, based on the most recent systematic reviews, meta-analyses and also scientific and policy summary statements.

This report is written primarily for policy-makers who have an influence on European or national-level policies influencing physical activity. It may also be of interest to members of the European Heart Network (EHN), whose work encompasses advocacy for policy change, support for cardiovascular patients, and funding research.

Finally, what is meant by the term ‘physical activity’? In this report the authors use the classic definition: any bodily movement produced by skeletal muscles that results in energy expenditure.<sup>1</sup> This means that as well as sport and deliberate exercise, we are interested in the role of daily activities such as walking, cycling, climbing stairs, or active play and recreation.



## 2 Cardiovascular disease in Europe

The fifth edition of European Cardiovascular Disease Statistics, which was published in 2017 by the European Heart Network (EHN),<sup>2</sup> showed that diseases of the heart and circulatory system remain the leading cause of mortality and a major cause of morbidity in Europe.

### Mortality

- Each year cardiovascular disease (CVD) causes 3.9 million deaths in Europe and over 1.8 million deaths in the European Union (EU).
- CVD accounts for 45% of all deaths in Europe and 37% of all deaths in the EU.
- The main forms of CVD are ischaemic heart disease (IHD) and stroke. IHD is the leading single cause of mortality in Europe, responsible for 862 000 deaths (19% of all deaths) among men and 877 000 deaths (20%) among women each year.
- Stroke is the second most common single cause of death in Europe, accounting for 405 000 deaths (9%) in men and 583 000 (13%) deaths in women each year.

Figure 1 Deaths by cause, males, latest available year, Europe (Wilkins 2017)<sup>2</sup>

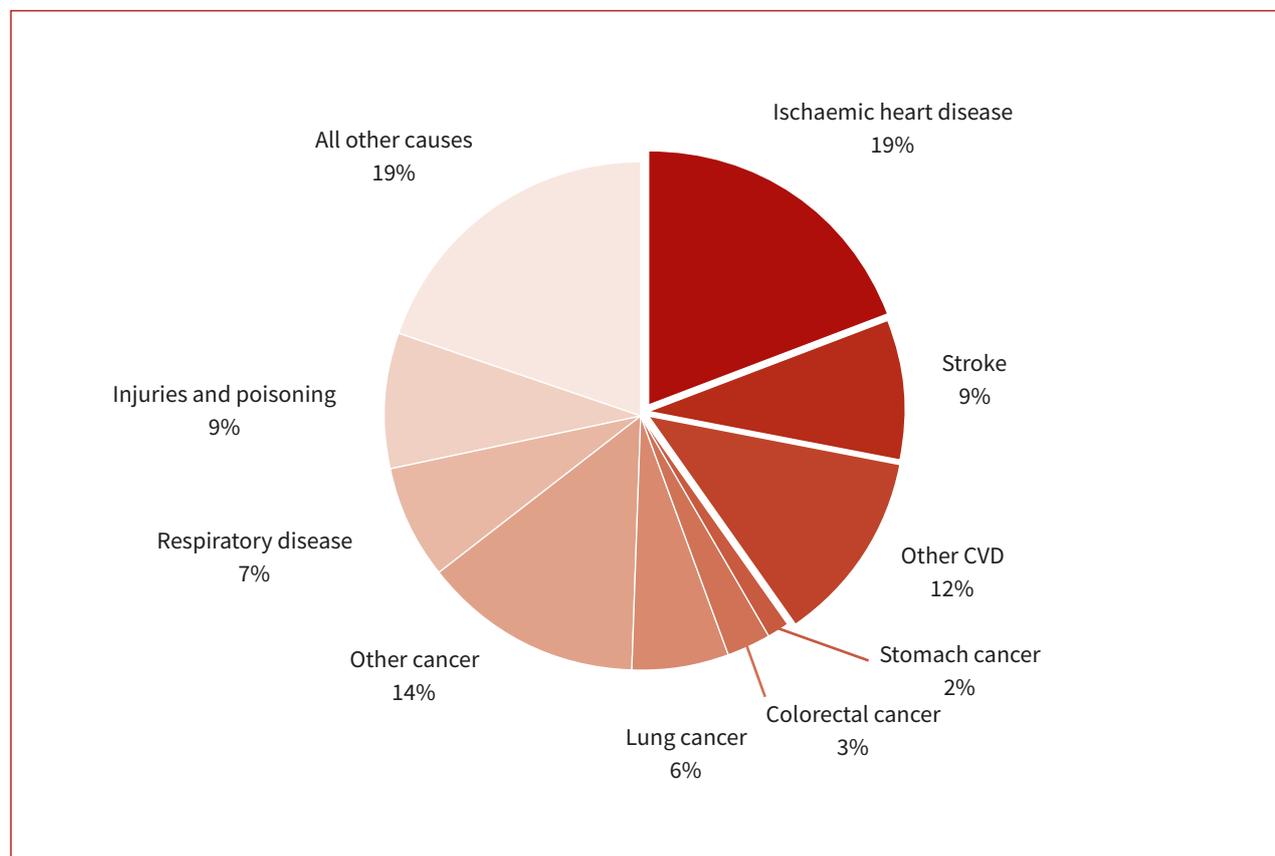
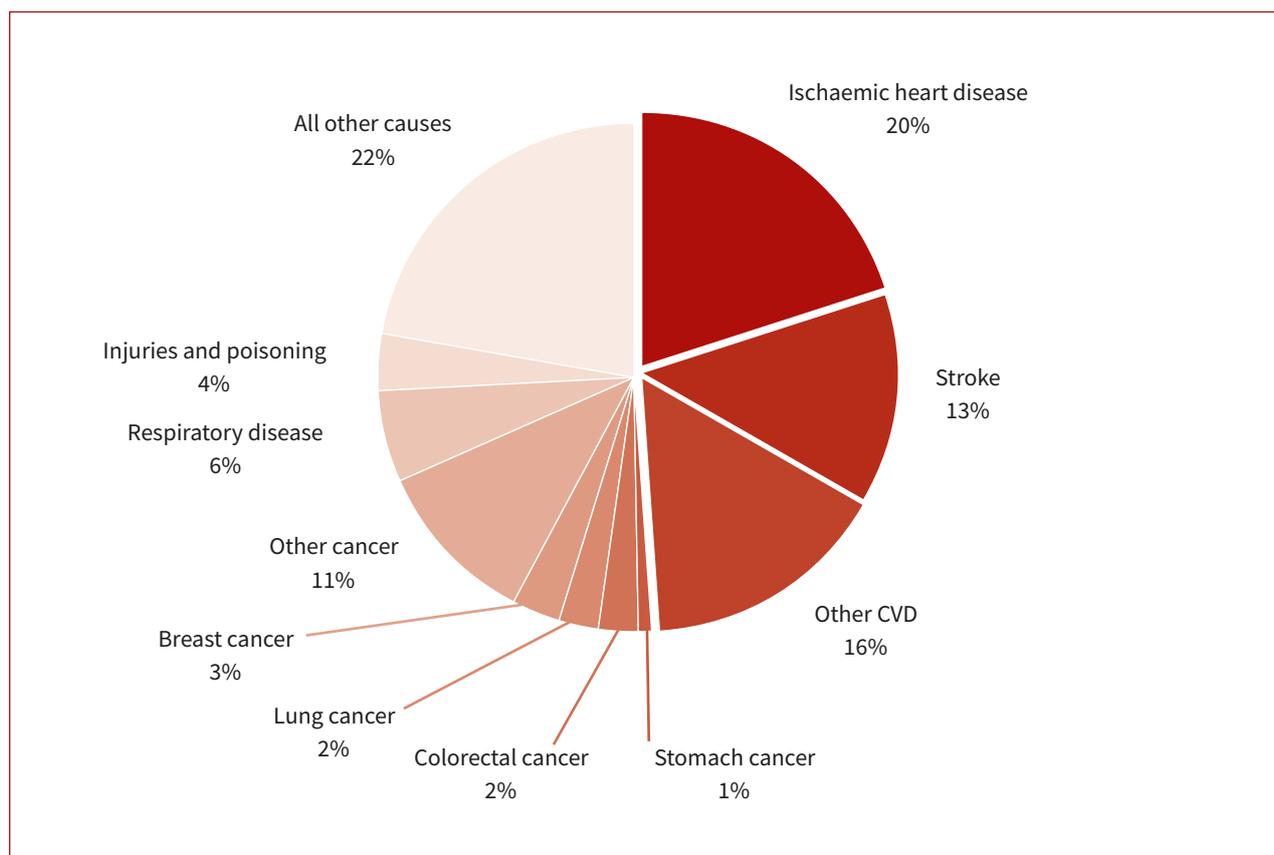


Figure 2 Deaths by cause, females, latest available year, Europe (EHN, 2017)<sup>2</sup>



## Patterns

- CVD is the main cause of death in men in all but 12 countries of Europe and is the main cause of death in women in all but two countries.
- Death rates from both ischaemic heart disease (IHD) and stroke are generally higher in Central and Eastern Europe than in Northern, Southern and Western Europe.
- Within the EU, the proportion of all deaths due to CVD among men ranges from 23% in France to 60% in Bulgaria. Among women, the burden ranges from 25% in Denmark to 70% in Bulgaria.
- Outside the EU, the CVD mortality burden varies from 24% in Israel to 59% in Ukraine among men, and from 25% in Israel to 75% in Ukraine among women.

Figure 3 Age-standardised death rates from IHD, males, latest available year, Europe (EHN 2017)<sup>2</sup>

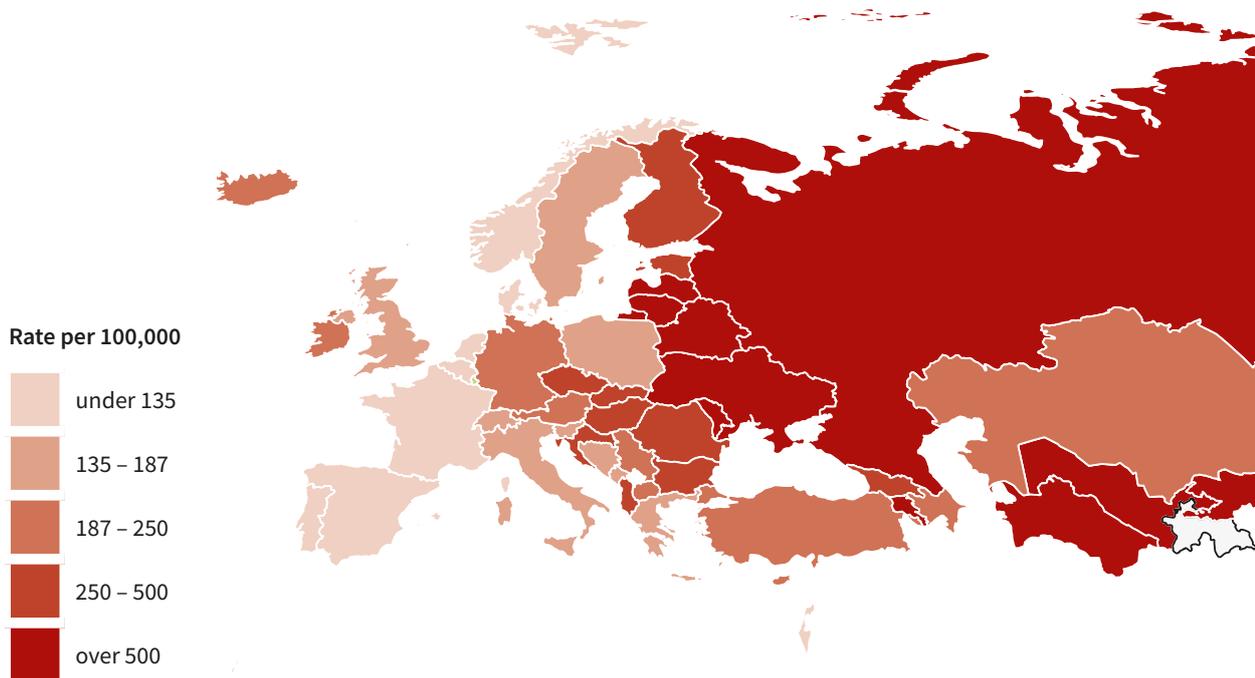
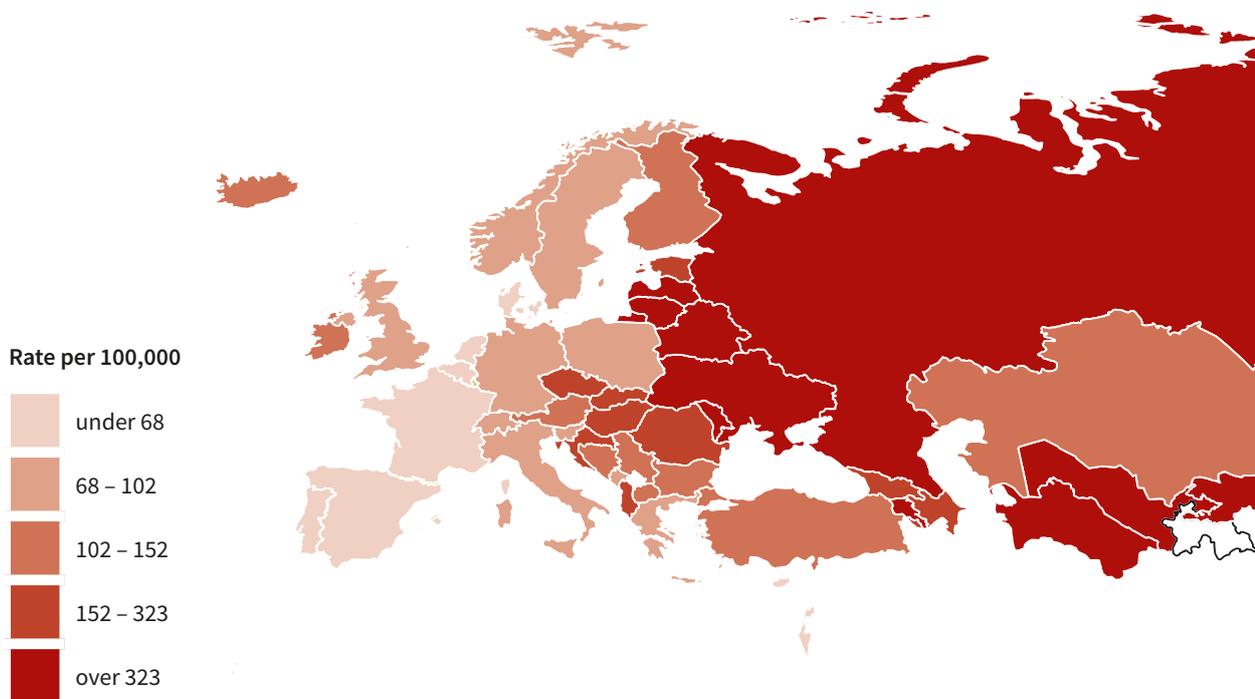


Figure 4 Age-standardised death rates from IHD, females, latest available year, Europe (EHN 2017)<sup>2</sup>



## Trends

- Over the past 25 years, the absolute number of CVD cases has increased in Europe and in the EU, with increases in the number of new CVD cases found in most countries. The absolute increase is due to the ageing of the population.
- In 2015, there were just under 11.3 million new cases of CVD in Europe and 6.1 million new cases of CVD in the EU.
- Age-standardised CVD mortality is now falling in most European countries, including Central and Eastern European countries which saw considerable increases until the beginning of the 21st Century. Age-standardisation adjusts crude mortality rates to remove the influence of different population age structures, and hence allows more meaningful comparisons to be made between countries and over time.
- The reductions in CVD mortality rates that have been achieved over the past 50 years thanks to population-wide interventions/behavioural changes (e.g. reduced hypertension due to a decrease in salt intake) and advances in treatment (e.g. new drugs to control high blood pressure and to lower cholesterol levels in the blood; arterial stents to treat heart attacks), are now slowing down. Suspected causes include the rising prevalence of obesity and diabetes along with the ageing of the population.

## Morbidity

- In 2015, more than 85 million people across Europe were living with CVD; 48% of cases (41.2 million) had occurred in males and 52% (44.1 million) in females.
- The most prevalent cardiovascular conditions were peripheral vascular disease and IHD. Peripheral vascular disease accounted for 15.3 million cases (37% of all CVD) among males and for just over 21 million cases (48% of all CVD) among females, while IHD was responsible for almost 17 million cases (41% of all CVD) in males and just over 13 million cases (30% of all CVD) in females.
- In 2015, CVD was the main cause of disability-adjusted life years lost in Europe, responsible for 64.7 million DALYs, or 23% of the total.



# 3 Physical activity levels in Europe

## Physical activity in adult populations

Physical activity (PA) can take place in various settings, including during transport, leisure activities in the community, at school, at the workplace and at home during daily life. Maintaining sufficient levels of physical activity is, however, becoming more and more difficult, as most daily environments have become more sedentary.<sup>3,4</sup> Some types of physical activity are part of everyday living, such as active transport and activity at work, and these are highly dependent on the environment and political decisions. Other activities such as leisure activities and deliberate 'exercise' are based more on individual decisions, but these may also be influenced by policies and issues such as support from friends or family.

Most studies assess physical activity in adults by self-report, but over the past decade there has been an increase in the use of accelerometers to provide an objective measure of PA. The correlation between self-report and objective measures is weak and the methods give different types of information. World Health Organization (WHO) Regional Office for Europe and the European Commission have been assessing the promotion of PA in the EU member states through 23 indicators. Results are published regularly as 'Physical Activity Factsheets'.<sup>5,6</sup> A direct comparison of physical activity levels between the 28 member states was not performed, because states use several different measurement instruments. Many national surveys have used their own national questionnaire, or International Physical Activity Questionnaire (IPAQ), or Global Physical Activity Questionnaire (GPAQ), or Eurobarometer data,<sup>7</sup> but these are not directly comparable.

The first attempt to compare physical inactivity globally was done by WHO using IPAQ and GPAQ.<sup>8</sup> Both questionnaires have since been used in many surveys, including several large, international surveys such as the World Health Survey,<sup>9</sup> the Eurobarometer surveys,<sup>10</sup> and the WHO STEPwise Approach to Noncommunicable Disease Risk-Factor Surveillance.<sup>11,12</sup> Mainly based on data from these questionnaires, WHO produced comparable estimates of insufficient physical activity in 122 countries in 2008, and updated them for 2010 for 146 countries. Both sets of estimates were published in The Lancet Physical Activity Series<sup>13,14</sup> and used to calculate the effect of insufficient physical activity on non-communicable diseases.<sup>15</sup> However, in The Lancet Physical Activity 2016 Series, Sallis and colleagues noted that consistent data for trends in adult physical activity are still scarce.<sup>14</sup> As a consequence, Guthold et al. updated previously published country, regional, and global estimates of adult prevalence of insufficient physical activity with new data and new methods, and estimated, for the first time, global and regional trends from 2001 to 2016.<sup>16</sup>

Guthold et al validated questionnaires against each other and adjusted for differences in their study of global insufficient physical activity levels – i.e. providing estimates of the

prevalence of populations having activity levels below WHO guidelines.<sup>16</sup> The study by Guthold et al standardised and pooled measurements from 358 population-based studies, which included almost 2 million participants worldwide. They compared the prevalence of insufficient physical activity from different regions of the world, including 20 European countries. The overall prevalence of physical inactivity was 28%, but the prevalence was higher for women (33%) than for men (23%). The prevalence for European countries was somewhat lower (23% for both sexes, 22% for men and 25% for women). This assessment of physical activity includes all domains or types of activity, even if the health benefits of leisure time physical activity and active travel may be greater than for occupational physical activity.<sup>17-19</sup>

Within Europe there is a large difference in the prevalence of physical inactivity between countries (see figures 5–10). Guthold et al reported a prevalence of 12% in Moldova and 40% in Serbia.<sup>16</sup> Also, there is a trend for Nordic countries to be more active than countries in Southern Europe. The fact that physical activity varies greatly across countries, even within regions, suggests that the factors that influence inactivity lie mostly at the national, subnational, or community level, which is where policies are needed to increase physical activity.<sup>4</sup>

A concerning trend is that when considering total activity (i.e. occupational as well as transport and leisure time activity), levels of inactivity increase with economic development.<sup>20</sup> Adults are less active in high-income countries than in low- and middle-income countries, a pattern suggesting that inactivity will rise as middle-income countries develop economically. These societal changes are well underway in many low- and middle-income countries and without mitigation, they will likely lead to further decreases in levels of physical activity. The prevalence of insufficient physical activity in high-income countries was more than double the prevalence in low-income countries in 2016.<sup>16</sup> The prevalence increased over time in high-income countries, from 32% in 2001, to 37% in 2016, whereas it was stable in low-income countries, at 16% in 2001, and 2016.<sup>16</sup>

Between 2001 and 2016, levels of insufficient physical activity have decreased only marginally and insignificantly, with a global prevalence of 28% in 2001. Women were less active than men, with a prevalence difference of 6% between sexes in 2001 (26% for men, and 32% for women), and of more than 8% in 2016 (23% for men, and 32% for women; figures 1 and 2 in Guthold et al.<sup>16</sup>). Data is not available to describe specific European trends.

Figures 5–10 are constructed from data from the WHO Global Health Observatory. The prevalence estimates are adjusted for age and the questionnaire used.<sup>16</sup> Data was kindly provided by the WHO Global Health Observatory. Countries not included in the figures have not provided data to the WHO Global Health Observatory.

Figure 5 Insufficient Physical Activity in EU countries (both sexes) Guthold et al 2018<sup>6</sup>

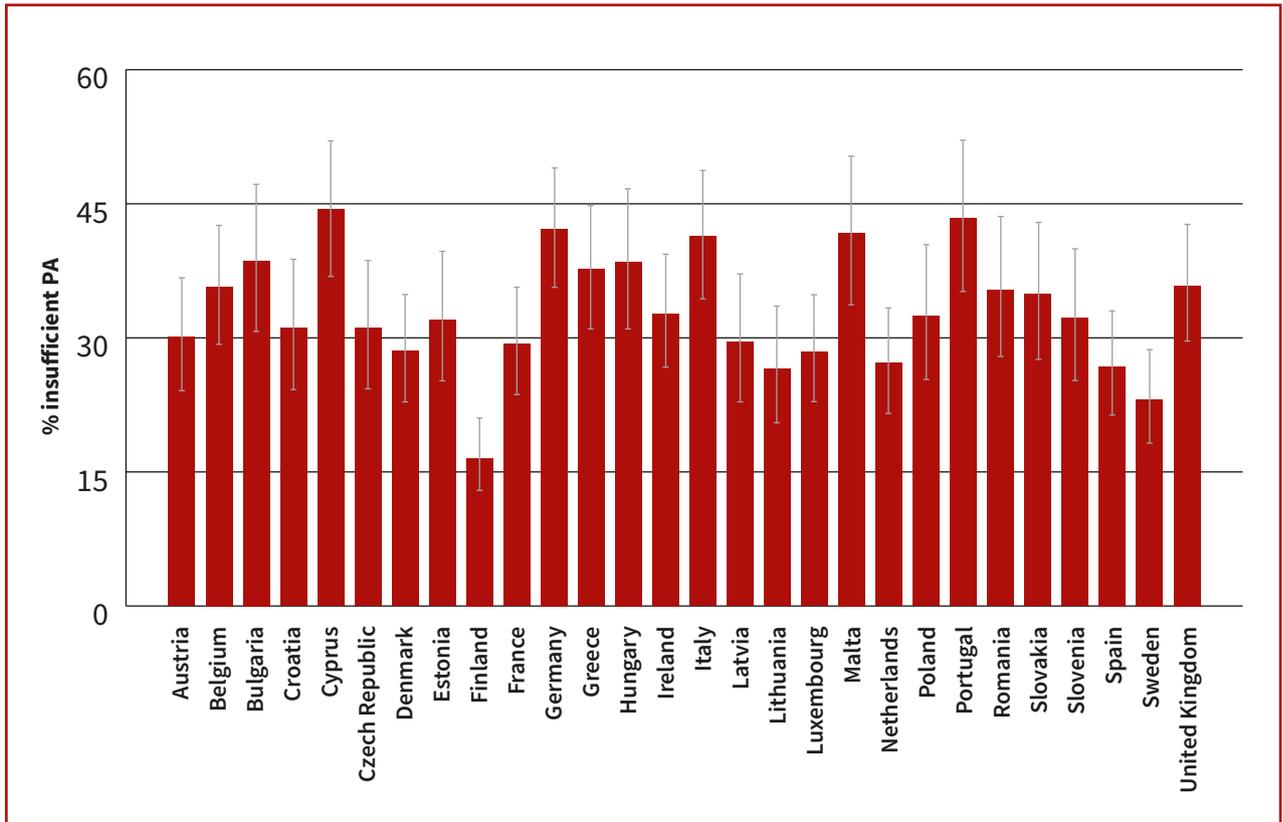


Figure 6 Insufficient Physical Activity in EU countries (males) Guthold et al 2018<sup>6</sup>

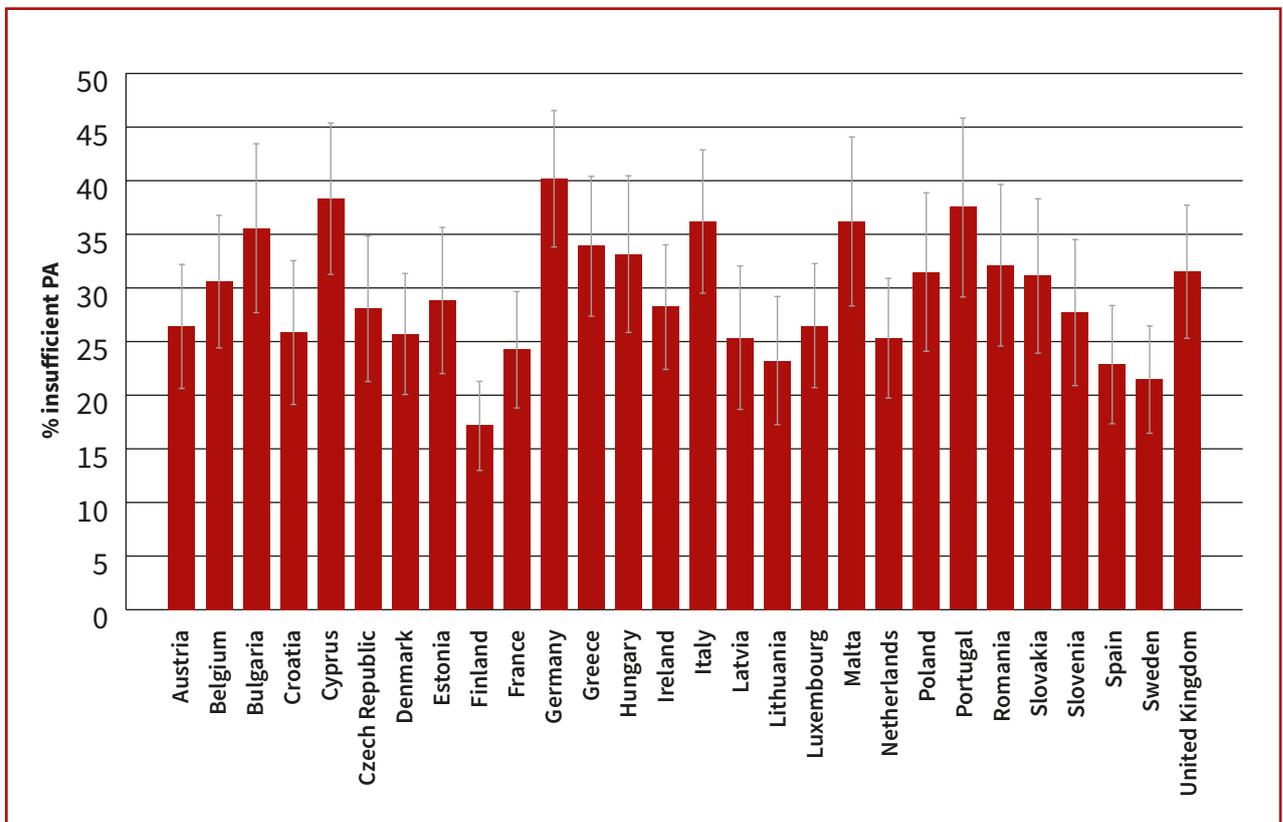


Figure 7 Insufficient Physical Activity in EU countries (females) Guthold et al 2018<sup>6</sup>

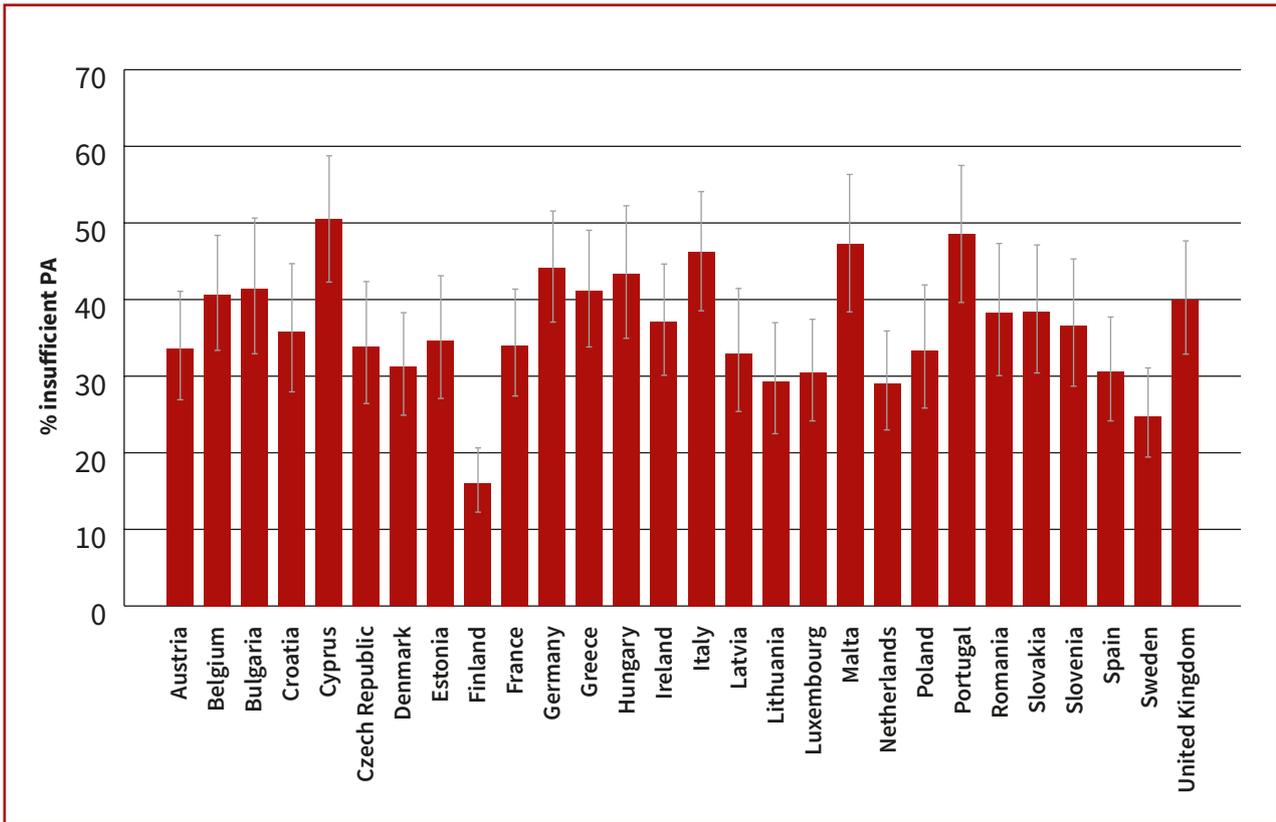


Figure 8 Insufficient Physical Activity in non-EU countries (both sexes) Guthold et al 2018<sup>6</sup>

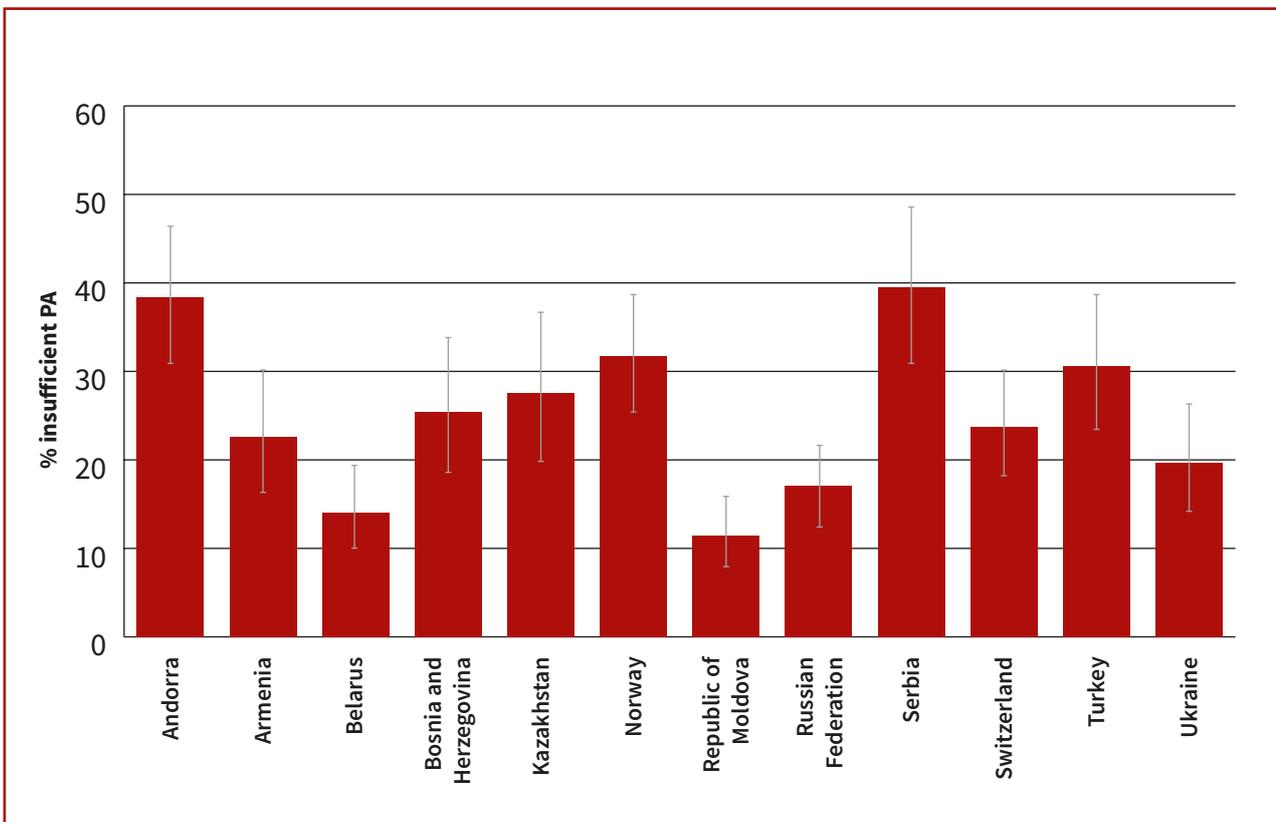


Figure 9 Insufficient Physical Activity in non-EU countries (males) Guthold et al 2018<sup>6</sup>

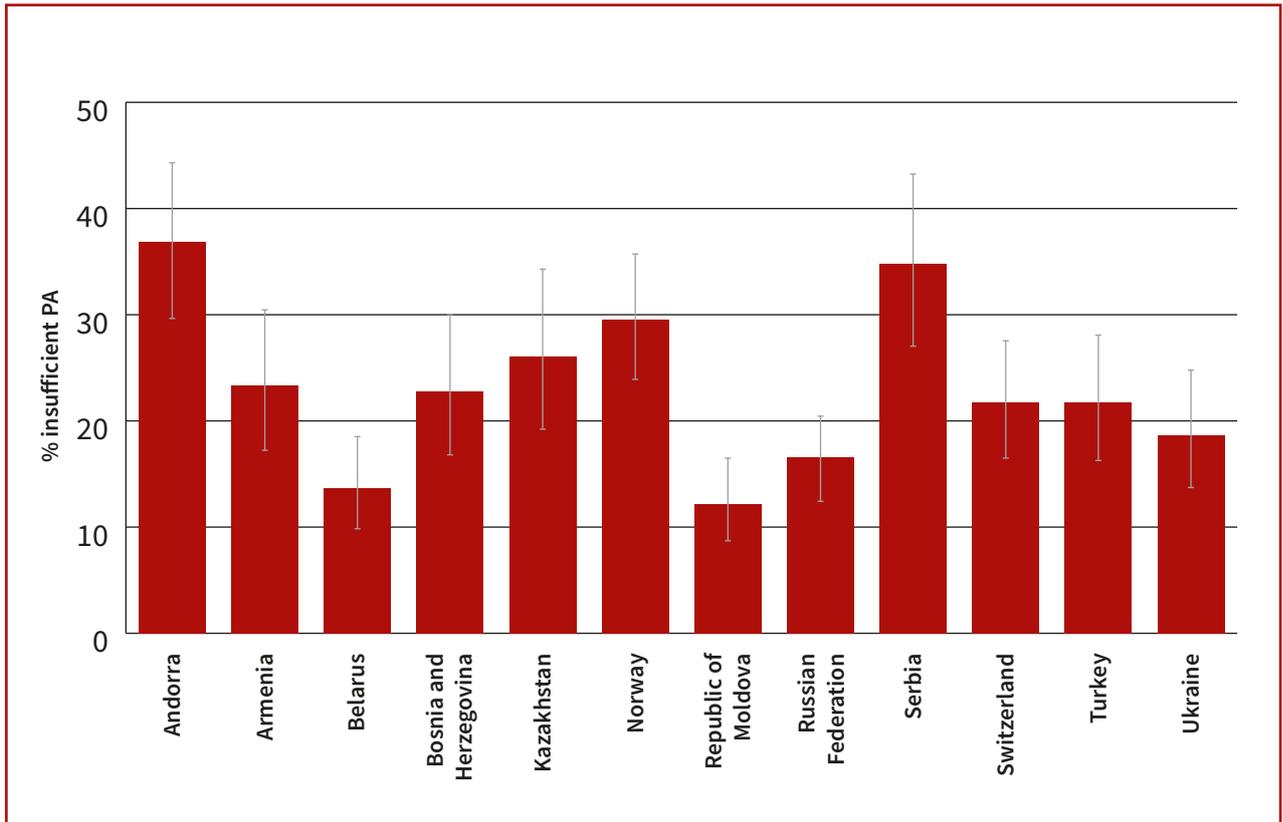
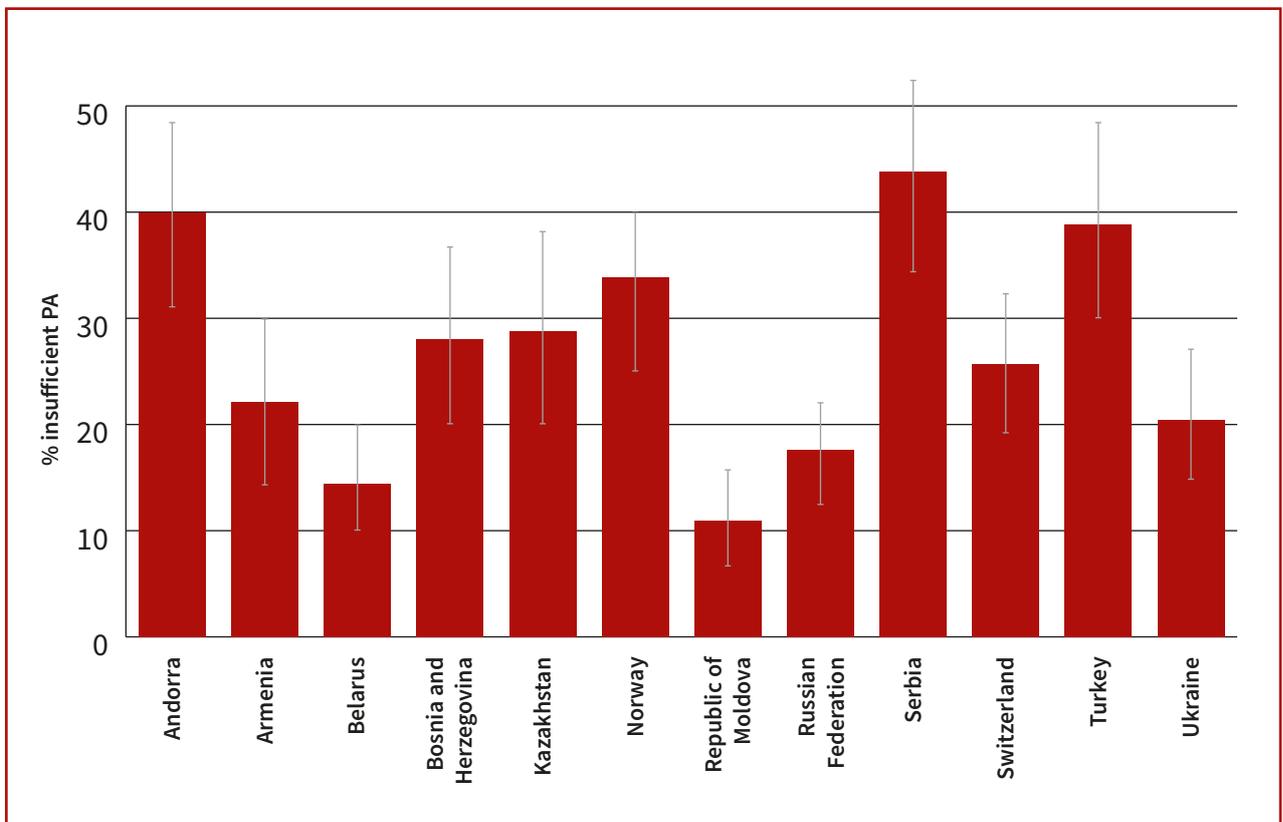


Figure 10 Insufficient Physical Activity in non-EU countries (females) Guthold et al 2018<sup>6</sup>



## Physical activity in children and adolescents (5–17 years)

Physical activity levels in children have been assessed in many countries using self-report. This data can provide information on types of physical activity, such as sports and active travel, but children have poor recall of the amount of moderate intensity activity, and it is therefore difficult to quantify and determine if they fulfil physical activity guidelines of 60 minutes of moderate to vigorous physical activity (MVPA) per day. It is also difficult to compare physical activity levels in different countries using self-report.

The two most comprehensive sources of data for adolescent physical activity levels are the Global School-based Student Health Survey (GSHS)<sup>21</sup> and the Health Behaviour in School-aged Children (HBSC) survey.<sup>22</sup> With publicly available data from HBSC reports, Hallal et al. estimated the prevalence of 13 to 15-year-old adolescents in 38 European countries of mostly low and middle income reaching the public health goal of 60 minutes per day or more of moderate to vigorous physical activity.<sup>13</sup> The

European data is close to the international average. Globally, 80.3% of 13 to 15-year-olds do not accumulate 60 minutes of moderate to vigorous physical activity per day. Girls are less active than are boys. Estimates of insufficient physical activity were much higher than were those reported in adults mainly because official guidelines for the physical activity children should engage in is 60 minutes of MVPA per day.<sup>13</sup> Quantification of physical activity is best done by objective measurements, such as accelerometers. Cooper et al described levels in children from 20 studies using the International Children's Accelerometer Database (ICAD) (Figure 11 A and B).<sup>23</sup> Boys were less sedentary and more active than girls at all ages. After five years of age there was an average cross-sectional decrease of 4% in total physical activity with each additional year of age, due mainly to lower levels of light-intensity physical activity and greater time spent sedentary. Physical activity varied between samples from different countries, with a 15–20% difference between the highest and lowest countries at age 9–10 (Figure 11 A) and a 26–28% difference at age 12–13 (Figure 11 B). However, only seven European countries were included in the analysis, and these showed an increasing trend of physical activity from south to north.

Figure 11 A: Average activity counts across selected countries. Level of physical activity at age 9-10

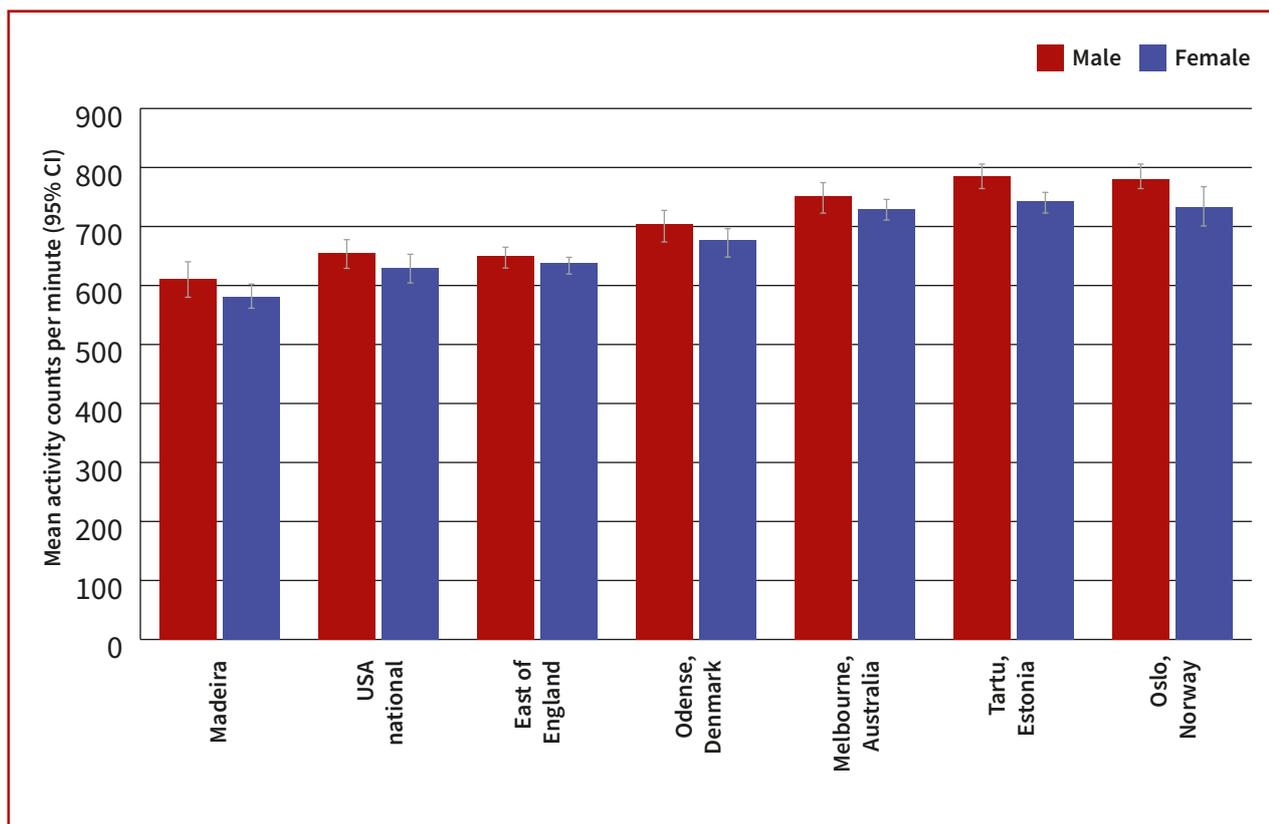
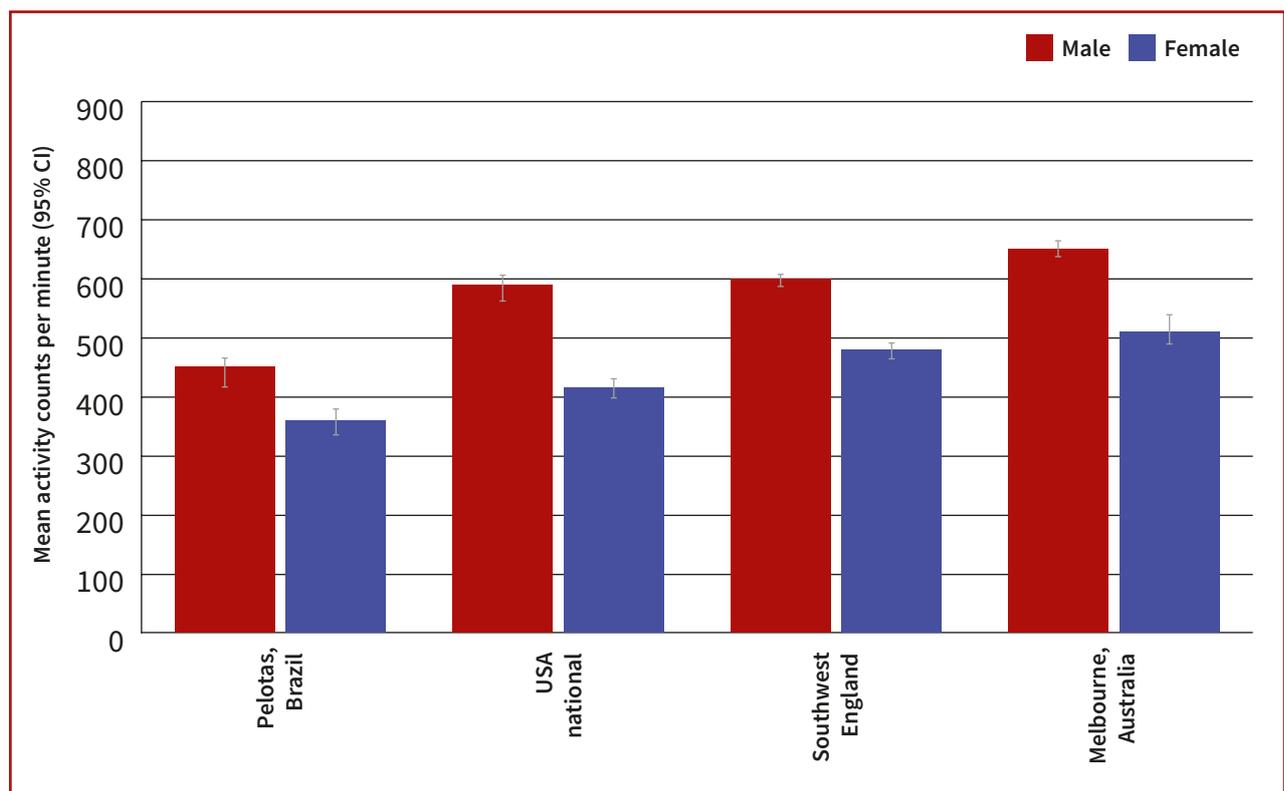


Figure 11 B: Average activity counts across selected countries. Level of physical activity at age 12-13



### The influence of physical activity assessment methods on guidelines and recommendations for health

The current physical activity guidelines and recommendations are based largely on repeated observations of physical activity and the development of various health outcomes in large numbers of people in population or epidemiological studies.<sup>24</sup> Until recently physical activity in these studies has been assessed by various methods of reporting past or current activity, usually by the people themselves. These ‘subjective methods’ include several sources of potential inaccuracies and errors. Furthermore, different methods give different results, and it is difficult or impossible to make the results obtained by different methods comparable with each other. Despite these methodological challenges, reliable associations between a great number of health outcomes and physical activity have been gradually established and even quantified to express the dose-response relationship between the health outcomes and characteristics of physical activity.

Physical activity is increasingly being assessed by methods based on technological devices. These ‘objective’ methods give

reliable information on various aspects of physical activity such as its distribution during the day, total duration and duration of episodes (bouts), intensity, and even the locations of the activity. Different methods give different results, but they can usually be calibrated against each other.

One major consequence of the change of physical activity assessment from reported to measured is that a number of dose-response associations of various aspects of physical activity with health outcomes may have to be determined once more. On the basis of the new studies,<sup>25</sup> new guidelines and recommendations of various aspects of physical activity for various health outcomes will probably have to be constructed. Thus, there may be two sets of recommendations that are based on two ‘currencies’ of PA, estimated subjectively by self-report and measured objectively by devices. Both sets are valid, when the right currency of activity is used to obtain the desired health outcome. In some cases, there will be valid ways to exchange the currencies in order to obtain a given health benefit. The changes of the guidelines and recommendations will be gradual, but there remains a risk that this might lead to some confusion and misunderstanding among professionals and the public.

## 4 The importance of physical activity for primary prevention of cardiovascular disease

### Role of physical activity in prevention of cardiovascular disease

The figures cited in the previous sections of this document show that cardiovascular disease (CVD) remains one of the leading causes of death, low functional capacity and poor quality of life in all European populations. The high prevalence of cardiovascular disease means that a high proportion of people across Europe are at risk of developing one or more of them during their lifetime. However, it is not possible to predict accurately which individuals will suffer from CVD. Therefore, everyone in Europe and all organisations and institutions created and maintained by European people have reasons to participate in the prevention of these diseases.

Cardiovascular disease is caused by gradual obstruction of the arteries by atherosclerotic processes. These can be deterred or prevented by many means, including physical activity.<sup>26</sup> Strong scientific evidence from many studies in which large populations or population groups have been followed for many years shows convincingly that physically active people have a lower risk than physically inactive people for cardiovascular disease mortality and clinical events. These findings are based on just observing the participants of the studies without attempts to change their physical activity habits by interventions. The lack of intervention studies (such as randomised controlled trials) precludes direct proof that more physical activity is the cause of the lower risk. However, taken together the observational studies on the relationship between physical activity and cardiovascular disease meet well the criteria defined by Hill<sup>27</sup> on the causality between the exposure (physical activity) and the outcomes (cardiovascular disease). The strength of the

associations is sizeable; similar associations are found in studies conducted by different researchers on various populations in different parts of the world; the associations have been seen in specific populations at specific sites, and other explanations for the associations have been ruled out or are unlikely; physical activity has preceded the outcomes; the strength of many of the key associations depends on the physical activity dose; there are several biological mechanisms which offer plausible explanation for the association; the findings from the population studies are coherent with those from laboratory studies; similar associations are seen between physical activity and many other biological outcomes, and the associations disappear with time when physical activity decreases considerably or ceases. On these grounds it is justified to use the word 'effect' in many instances when we examine the relationships between physical activity and cardiovascular health outcomes.

On the basis of this strong evidence, physical activity is recommended for prevention of cardiovascular disease (CVD) as well as a great number of other diseases and their risk factors. Physical activity is beneficial when taken up at any age, but the maximum benefits accrue from a lifetime of being active. Specifically, it is recommended for cardiovascular disease prevention by the leading scientific organisations of the field including the European Society of Cardiology<sup>28</sup> and the American College of Cardiology jointly with the American Heart Association.<sup>29</sup> The most recent guideline, The Physical Activity Guidelines for Americans,<sup>30</sup> give more general physical activity recommendations for a number of health conditions (Table 1). The evidence for these recommendations, however, is strongly based on the studies of the effects of physical activity on cardiovascular outcomes.

**Table 1 Physical Activity-Related Health Benefits for the General Population and Selected Populations Documented by the 2018 Physical Activity Guidelines Advisory Committee (<https://health.gov/paguidelines/second-edition/report/>).**

Adults, all ages	
All-cause mortality	Lower risk
Cardiometabolic conditions	Lower cardiovascular disease incidence and mortality (including heart disease and stroke) Lower incidence of hypertension Lower incidence of type 2 diabetes
Cancer	Lower incidence of bladder, breast, colon, endometrium, oesophagus, kidney, stomach, and lung cancers
Brain health	Reduced risk of dementia; improved cognitive function Improved cognitive function following bouts of aerobic activity Improved quality of life Improved sleep Reduced feelings of anxiety and depression in healthy people and in people with existing clinical syndromes Reduced incidence of depression
Weight status	Reduced risk of excessive weight gain Weight loss and the prevention of weight regain following initial weight loss when a sufficient dose of moderate-to-vigorous physical activity is attained An additive effect on weight loss when combined with moderate dietary restriction
Older adults	
Falls	Reduced incidence of falls Reduced incidence of fall-related injuries
Physical function	Improved physical function in older adults with and without frailty
Women who are pregnant or postpartum	
During pregnancy	Reduced risk of excessive weight gain Reduced risk of gestational diabetes No risk to foetus from moderate-intensity physical activity
During postpartum	Reduced risk of postpartum depression

The key points recommending physical activity for primary prevention of cardiovascular disease in the 2016 European Society of Cardiology guidelines<sup>28</sup> and in the American College of Cardiology/American Heart Association guideline<sup>29</sup> are as follows:

### European Society of Cardiology Guidelines

- It is recommended for healthy adults of all ages to perform at least 150 minutes a week of moderate intensity or 75 minutes a week of vigorous intensity physical activity or an equivalent combination.
- For additional benefits in healthy adults, a gradual increase of aerobic activity to 300 minutes a week of moderate intensity, or 150 minutes a week of vigorous intensity aerobic activity, or an equivalent combination is recommended.
- Multiple sessions of physical activity should be considered, each lasting at least 10 minutes and evenly spread throughout the week – i.e. on 4 – 5 days a week and preferably every day of the week.

### American College of Cardiology/American Heart Association Guideline

- Adults should engage in at least 150 minutes per week of accumulated moderate-intensity or 75 minutes per week of vigorous-intensity aerobic physical activity (or an equivalent combination of moderate and vigorous activity) to reduce ASCVD (atherosclerotic cardiovascular disease) risk.
- For adults unable to meet the minimum, engaging in some moderate- or vigorous-intensity physical activity, even if less than this recommended amount, can be beneficial to reduce ASCVD risk.

- Decreasing sedentary behaviour in adults may be reasonable to reduce ASCVD risk.

### Discussion of the physical activity guidelines

In the following section we examine and comment on these guidelines for two main reasons. First, scientific knowledge related to physical activity and health evolves continuously. Newly published studies may have caused some changes in the evidence base for some of the statements or at least for some wordings of the latest guidelines. This evidence should be considered, especially if it influences the content and wording of the advice on physical activity given to the public. Second, the content and tone of the messaging of the current guidelines has been criticised claiming that they are expert-driven, prescriptive, and health and threshold centred. It has been suggested that they imply that ‘one size fits all’ and that people are being told it is ‘all or nothing’. Finally, it has been claimed that the formulation of the guidelines is partly based on incorrect translation of the evidence.<sup>31</sup> In this section we present the most recent published evidence of the characteristics of effective, feasible and safe physical activity for the primary prevention of cardiovascular disease. This can then be used as the basis for sufficiently flexible interpretation of the guidelines, and their application to the intended populations and conditions.

The scientific knowledge, published up to April 2018, on the association of physical activity with cardiovascular disease (CVD), especially on ischaemic heart disease and stroke (cerebrovascular disease) has been reviewed by Kraus et al.<sup>32</sup> The analysis combines the results of 33 studies that included 1.68 million participants followed up on average for a period of 12.8 years. The data show that the risk of death caused by CVD was 23% lower and the incidence of CVD (myocardial infarction, heart failure or stroke) was 17% lower in the participants who

met the recommended 150 minutes of moderate intensity aerobic physical activity per week compared to the physically inactive participants. The risk for various CVDs was very similar to CVD as a whole.<sup>33</sup>

The role of physical activity in preventing peripheral arterial disease, a condition that causes intermittent pain during effort in lower legs (intermittent claudication), has not been convincingly shown. However, a recent systematic review found that in cross-sectional studies the individuals with peripheral arterial disease were less physically active than those without this disease. More importantly, the findings from longitudinal studies showed that more intensive physical activity was associated with lower risk of developing peripheral arterial disease.<sup>34</sup> One possible reason for the scarcity of evidence of the eventual preventive effect of physical activity on this atherosclerotic disease may be that in most mobile people the lower leg activity is sufficient for producing a preventive effect.

The importance of physical activity for primary prevention of CVD is emphasised by many aspects related to its effectiveness and its applicability.

First, the preventive effect of physical activity depends on its amount, intensity, frequency and duration in predictable ways. The pooled results of 13 studies show the relationship between the amount of aerobic physical activity and **all-cause mortality**. All the included studies showed similar inverse relationships between moderate-to-vigorous physical activity and all-cause mortality in a dose-response fashion. The meta-analyses of Blond et al. (2019)<sup>19</sup> and of Ekelund et al. (2019)<sup>25</sup> based on physical activity assessed by accelerometric methods show corresponding association between all-cause mortality and PA.

The dose-response between moderate-to-vigorous physical activity and **CVD-mortality** is very similar to that of all-cause mortality because most of the deaths in the populations of the included studies were caused by CVD.<sup>19</sup> The curves show that the beneficial effect of physical activity begins with small amount of activity without any apparent lower threshold, and the effect increases steeply upon moving from the least active category to the next category of moderate-to-vigorous physical activity. There is no apparent upper threshold for the preventive effect of physical activity, but the risk reduction diminishes continuously at high volumes. There is no increased risk of death until the activity level of seven times the recommended amount.<sup>19</sup> The risk-reducing effect of physical activity was observed similarly in women and men, and in participants of different races and in different BMI (body mass index) categories.

Also the dose-response relationship between moderate-to-vigorous physical activity and the development of **ischaemic heart disease** shows the same type of dose response relationship as described above.<sup>19,35</sup> It can be seen that the risk of developing ischaemic heart disease begins to decrease without any lower threshold of leisure time physical activity, and those participating in moderate-intensity physical activity at the lower limit of the recommended amount had a 14% lower risk of developing ischaemic heart disease compared to the physically inactive participants. Those engaging in the equivalent of 300

minutes per week of moderate-intensity physical activity had a 20% lower risk. The risk continues to decrease with increasing amount of physical activity with no upper limit. However, it is interesting to note that there is less gain in health at the higher levels of activity compared to an increase in the low end of physical activity. The effect of physical activity on ischaemic heart disease incidence was stronger for women than for men, but there were no differences in this effect in the different BMI categories.

Physical activity decreases the events of **ischaemic stroke** caused by atherosclerosis of the brain arteries in the same curvilinear dose-response fashion as for cardiovascular disease mortality, but the effects for stroke are less than for ischaemic heart disease at both low and high amounts of physical activity.<sup>36</sup> In the 26 studies included, the physically highly active participants had 26% lower risk of an ischaemic stroke event compared with the physically inactive participants.

The association of strength or resistance training with all-cause and CVD mortality is scarcely studied. A study on around 28 900 elderly women followed up for 12 years found that strength training showed a J-shaped association with all-cause and CVD mortality independent of aerobic activity.<sup>37</sup> Thus strength training up to about 150 minutes a week was beneficial for longevity, but any potential risk with more than about 150 mins/week of strength training in older women should be further investigated.<sup>37</sup> Women who engaged in both aerobic activity and strength training had a lower all-cause and CVD-specific mortality than those women who engaged in aerobic activity or strength training alone. Another study on around 12 600 middle-aged participants followed up for 5.4 or 10.5 years found that even once or less than one hour a week of resistance exercise, independent of aerobic activity, was associated with reduced risk of CVD and all-cause mortality.<sup>38</sup>

On the basis of current evidence it seems justified to agree with the comments of Handy and Blaha (2017)<sup>39</sup> that the benefits of strength training on all-cause or CVD-mortality are still up for debate, and whether it is important in CVD is still an unanswered question. However, it is reasonable to continue to recommend that healthy people engage in small amount of strength training because of its beneficial effects on some cardiovascular risk factors and other health-related outcomes, especially in combination with aerobic physical activity. Currently, strength training is recommended for heart disease prevention by the American Heart Association<sup>40</sup> and the National Comprehensive Cancer Network guidelines, although not by many other societies and organisations.

The effect of physical activity on the risk of **heart failure** was analysed by Pandey et al<sup>41</sup> in 12 studies on 370 460 participants who were followed on average for 13 years. Physical activity decreased the risk of heart failure events significantly but only by 10% in those engaged in the recommended amount of activity compared with the inactive participants. The risk reduction was 19% in individuals who engaged in physical activity at twice the recommended level, and 35% in those at four times the minimum recommended levels. In another meta-analysis including 10 studies the relative risk of incident heart failure was 28% lower in the most active women and men

as compared with their least active counterparts.<sup>42</sup> In women aged 50 to 79 the amount of physical activity in general and the amount of walking were inversely and in dose-response fashion related to the risk of various forms of heart failure.<sup>43</sup>

The potential of physical activity as a measure to prevent cardiovascular disease is strengthened by the following facts:

- Even **low volumes** of leisure time physical activity decrease the risk of cardiovascular deaths as described above. This effect is seen especially in people over 65 years of age.<sup>44-45</sup> The effect is larger if part of the activity is vigorous instead of moderate.<sup>46</sup>
- Even **light physical activity** decreases the risk of cardiovascular disease including ischaemic heart disease, at least in women,<sup>47</sup> and light-intensity physical activity is associated beneficially with cardiovascular risk factors such as obesity and markers of lipid and glucose metabolism.<sup>48</sup> Thus, all physical activity in daily life may play a role in the prevention of CVD in people of retirement age and above. Moreover replacing sitting with light-intensity activity may provide significant health benefits. However, increasing the proportion of higher intensity activity increases the risk reduction.<sup>49</sup>
- The same amount of moderate-to-vigorous physical activity taken in **bouts** or in a **sporadic pattern** was similarly related to mortality risk as continuous activity,<sup>50</sup> and accumulating 150 minutes per week moderate-intensity physical activity in bouts greater than a minute or in bouts greater than 10 minutes decreased cardiovascular risk by a similar amount.<sup>50</sup> Thus, the current evidence supports the notion that physical activity of any duration is associated with improved cardiovascular health outcomes.<sup>52</sup> This view is supported by a recent meta-analysis that compared the effects of continuous and accumulated exercise on a number of cardiovascular risk factors. The results showed that adults are likely to accrue similar health benefits from exercising in a single bout or accumulating the same amount of activity from shorter bouts throughout the day.<sup>53</sup> Thus, physical activity performed in short bouts is also worth promoting and performing.<sup>54</sup> It is also worth noticing that for older people domestic chores, for example, include bouts of activity that are of moderate or even vigorous intensity in relation to their capacity and thus sufficient to bring health benefits.<sup>55</sup> The flexibility offered by the short bouts of activity may be particularly valuable for the least active and for those with high risk or existing chronic conditions.
- Even **infrequent** physical activity (once or twice a week) reduces the risk of cardiovascular disease: vigorous physical activity once a week decreased the risk of heart disease by 20% and moderate-intensity activity the risk of stroke by 17%.<sup>56</sup> Physical activity once or twice a week (e.g. over the weekend) decreased the risk of all-cause mortality<sup>57</sup> and cardiovascular mortality risk similarly to regular (at least three times a week) physical activity whether or not the volume of activity was sufficient to meet the recommended amount.<sup>58</sup>
- In people older than 60 – 65 years of age **recent** physical activity levels are more strongly associated with a number of health variables<sup>59</sup> and recent activity is a stronger indicator of subsequent cardiovascular mortality risk<sup>60</sup> than physical activity in the past. Thus, it is not too late to engage in physical activity even in late life in order to improve health and decrease cardiovascular risk.
- Physical activity in **all domains** (leisure time, transport, domestic and occupation) decreases the risk of CVD mortality and events.<sup>33,36,61</sup> However, the type, patterns, intensity and daily and long-term duration of occupational physical activity, and consequently its health-related effects, vary widely,<sup>62,63</sup> and especially intense occupational physical activity has not been found to be protective against CVD but to increase the risk.<sup>64-66</sup>
- **All commonly practiced physical activities**, especially walking,<sup>49,67,68</sup> running<sup>69</sup> and cycling<sup>17</sup> reduce the risk of CVD, but evidence of the effectiveness of a large number of sports is lacking.<sup>70,71</sup> However, this is mainly due to lack of adequate research on this issue, and absence of evidence is not evidence of absence. It is reasonable to state that any mostly aerobic activity that meets the physiological criteria of effectiveness reviewed above decreases the risk of CVD.
- Physical activity decreases the risk of CVD also in people who have **elevated risk** for these diseases due to genetic risk<sup>72,73</sup> obesity<sup>35,74,75</sup> or metabolic factors such as glucose intolerance.<sup>76</sup>
- Physical activity, especially walking and cycling, meets the APEASE-criteria<sup>237</sup> for public health measures to be promoted: affordability, practicability, effectiveness and cost effectiveness, acceptability, side effects/safety and equity, meaning that physical activity can be promoted by means that are affordable, practical, effective, acceptable, safe and equal to all parties involved.

### Role of physical activity in prevention of cerebrovascular disease (stroke)

The two main types of cerebrovascular disease are ischaemic stroke, caused by obstruction of a brain artery due to atherosclerotic process, and hemorrhagic stroke due to the rupture of a cerebral vessel. About 85% of all strokes are ischaemic. Physical inactivity is an established risk factor of the ischaemic stroke but only indirectly associated with the risk of the hemorrhagic stroke by increasing the possibility of elevated blood pressure, the main risk factor for rupture of a cerebral vessel.

The relationship between physical activity and risk of stroke has been studied much less than that between physical activity and heart disease. The last published meta-analysis included 26 studies on ischaemic stroke.<sup>36</sup> The risk for ischaemic stroke is generally 25% to 30% lower in the most physically active compared with the least active individuals,<sup>84,85</sup> and the relationship between the amount of physical activity and risk of stroke shows the same type of curvilinear dose-response curve as for total or cardiovascular disease mortality. This effect appears to hold for leisure time, occupational, and transport activity including walking, and it is seen in women and men of different ages.

More recent studies strengthen these findings and provide some new information. Thus, the protective effect of physical activity disappeared over 10 years when its amount decreased to lower than the recommended level.<sup>86</sup> A large follow-up study found that the risk of stroke was 16% lower in the participants who engaged only once or twice a week in moderate-intensity physical activity as compared with inactive participants.<sup>87</sup> The same size of risk difference between active and inactive individuals was observed also in a recent meta-analysis that examined the relationship between physical inactivity and risk of dementia in 19 studies including over 400 000 participants.<sup>88</sup> Also in adults older than 75 years, a lower risk was associated with higher amount and intensity of leisure-time physical active as well as with a higher pace and distance of walking.<sup>89</sup> In another follow-up study that included nearly 500 000 participants, higher amounts of both occupational and non-occupational physical activity were independently of each other related to lower risk of all major cardiovascular events including ischaemic and hemorrhagic stroke.<sup>90</sup> In a European study including 65 000 participants physical activity was associated with reduced risk of death caused by seven major cardiovascular diseases including cerebrovascular events, and the protective benefits were apparent even at levels of activity below the current recommendations.<sup>91</sup>

Physical activity is found to be also associated with decreased risk of hemorrhagic stroke. In a prospective population-based study on around 65 500 participants the risk of hemorrhagic stroke decreased linearly with increasing leisure time and commuting activity in women and men, in all age groups and in participants with or without hypertension. However, participants with moderate and high occupational physical activity had an elevated risk of hemorrhagic stroke.<sup>92</sup> Also in another study an increased risk of hemorrhagic stroke was associated with a large volume of daily physical activity that included a large portion of vigorous activity.<sup>85</sup>

As a whole, the cited studies strengthen the evidence regarding the protective effect of physical activity on the risk of stroke, and the findings corresponds well with those related to cardiac disease and physical activity.

## Safety of physical activity and exercise training

Physical activity is a safe means for prevention of cardiovascular and many other common diseases. Aerobic physical activity practised in any mode within the recommended volume, frequency or intensity limits does not cause cardiovascular risks to healthy individuals. Increasing amounts of leisure time physical activity until at least seven times more than the generally recommended volume are associated with continuously decreasing risk of all-cause and CVD-mortality in general populations.<sup>19</sup> This volume corresponds to 10–12 hours of weekly vigorous activity such as running.

However, even larger volumes of activity at high intensities practised for many years as sports increase the risk of negative effects on cardiovascular health such as atrial fibrillation, myocardial fibrosis, hypertrophy of left ventricular wall, coronary artery calcification and sudden cardiac death.<sup>77–80</sup> Despite the increased risk of negative health effects caused by extremes of physical activity, the positive effects largely

outweigh the negative ones as seen e.g. in the longevity of endurance athletes.<sup>77</sup>

Further, it is important to acknowledge that physical activity is known to trigger serious cardiovascular incidents including sudden cardiac death. This risk increases with the intensity of the activity and is higher in individuals who are unaccustomed to exercise and/or have low cardiovascular fitness. However, the risk of serious cardiovascular events during or immediately after physical activity and exercise training, including exercise-based cardiac rehabilitation, remains extremely low – well below 0.01 per 10 000 participant hours. In most cases of exercise-related sudden cardiac death occult CVD, most often ischaemic heart disease is present and the death is typically the first clinical event. The risk of serious cardiac events in physical activity and exercise is much lower in fit and regularly active individuals than those who are less fit and sedentary.<sup>81,82</sup>

A thorough review by Mills et al.<sup>83</sup> summarises the balance between cardiovascular and other benefits and risks on health of different modes of physical activity and exercise training as follows: it is apparent that the benefits of walking and running for the musculoskeletal, cardiovascular, respiratory, metabolic, endocrine and immune systems outweigh the risks of harm.<sup>83</sup> Participation in multidirectional sports such as ball games includes substantial risks of sustaining an acute musculoskeletal injury. However, the more widespread biological benefits of multidirectional sports, especially in sub-elite populations, mean that the benefits of participation in these sports do appear to outweigh negatives. The benefits of resistance exercise extend beyond the musculoskeletal system, with evidence of improvements in cardiovascular, respiratory, metabolic, endocrine and immune systems. However, it appears that many of these benefits are not realised if individuals are not working hard enough or if they participate too frequently. As long as individuals are well instructed and do not exceed recommendations for resistance training load, it appears that benefits far outweigh potential harms.

## Population attributable risk (PAR)

PAR is the theoretical number of cases which could be avoided if everyone had the optimal level of the risk factor. This is of course not realistic, but it shows the potential for prevention, and it makes it possible to compare different risk factors in order to prioritise when creating prevention strategies. It is calculated from the prevalence of people at risk and the increased risk these people have compared to those non-exposed (the relative risk (RR)). For a risk factor such as smoking, it is calculated how many CVD deaths had been saved if all had been ‘never-smokers’. However, published calculations of PAR for physical activity normally uses PA-guidelines as reference, and as described above this level is not the optimal risk level. Risk decreases further with higher levels of physical activity.<sup>19</sup> In order to compare PAR for different risk factors, calculations should be done with the lowest risk groups as reference. Using this approach we found a PAR of 23.3% for physical inactivity from the meta-analysis of Blond et al.<sup>19</sup> This is comparable for what has been reported for smoking.<sup>93</sup> It is unrealistic to expect all people can achieve this risk level, and more realistic scenarios are therefore often calculated such as a certain percentage of the population at risk improves from sedentary to moderately active.

## Mechanisms of action of physical activity

Atherosclerotic cardiovascular disease, ischaemic heart disease, cerebrovascular disease (stroke) and peripheral arterial disease, develop gradually during many decades. The basic pathological change leading to the symptoms and clinical events is the development of plaques inside the arteries. The plaques develop especially at sites where the blood flow is disturbed due to elevated blood pressure, for example. The plaques decrease the blood flow to the heart muscle, the brain, or other organs, such as the muscles of the lower legs. When a plaque or group of plaques grow to obstruct half of the diameter of the coronary artery, blood flow to the heart decreases so much that the heart muscle does not get enough oxygen especially when its demand is increased, e.g. during physical activity. The consequences are pain in the chest, angina pectoris, and decreased pumping ability of the heart leading to laboured breathing (dyspnea) and decreased working capacity. The plaque can also break, parts of it can tear away to the blood stream, or the plaque can cause a lesion in the arterial wall. In all cases blood clots (thrombosis) develop at these sites, the lumen of the artery is obstructed, and the blood flow in this artery can cease totally, resulting in damage of the heart muscle (myocardial infarction) or disturbances of the heart rhythm including cardiac arrest and death. Similar processes can take place in the arteries of the brain or lower extremities leading to ischaemic stroke or intermittent claudication.

Many theories have been proposed to explain the development of the plaques in the coronary and other arteries. The current leading theory highlights the key role played by fats, especially so-called low-density lipoprotein or LDL-cholesterol. A major mechanism in the plaque development is accumulation of LDL-cholesterol in the arterial wall. If the amount and blood content of LDL-cholesterol is low, as it is in some small exceptional populations, arterial plaques do not develop. The higher the LDL-content, the greater the risk of arterial atherosclerotic disease. Therefore, one of the key targets in the prevention of these diseases is to keep the cholesterol content of the blood low, mainly through diet or drugs.

Quite recently the role of another factor, permanent low-grade inflammation in the arteries, has been emphasised. The inflammation takes place in the cholesterol-filled plaques leading to the development of thrombosis that obstruct the blood flow in the artery. This low-grade inflammation can be decreased by a drug, and the result is decreased risk of clinical events such as myocardial infarction.<sup>94</sup> Thus, it seems that atherosclerosis is an inflammatory disease elicited by cholesterol accumulation. This means that both LDL-cholesterol and inflammation play key roles in the development of atherosclerotic diseases.

A third factor, the inner surface layer of all arteries, veins and capillaries called the endothelium, has an important part to play in the development and expression of coronary and other arterial diseases. Endothelium is a highly metabolically active organ that is adaptive, flexible, and critical to many physiological processes. Endothelium functions as a partial barrier between the arterial lumen and arterial wall controlling the passage of materials and cells into and out of the arterial blood flow. In this way endothelium protects the artery against harmful factors. Endothelium normally prevents thrombosis, development of blood clots inside the arteries. Endothelium has an important function in the control of the diameter of the artery,

vasoconstriction and vasodilation that influence the blood flow and blood pressure in the artery. Further, endothelium takes part in formation of new blood vessels (angiogenesis) and in repairing damaged or diseased tissues. One result of the functions of healthy endothelium is decreased risk of atherosclerotic plaque formation.

Endothelial functions can be maintained at a normal level or be improved by a range of factors: regular physical activity; a diet high in fruits and vegetables and omega-3 fatty acids and low in cholesterol; maintaining healthy weight; not smoking; and avoiding stress and sleeping sufficiently. Endothelium can become dysfunctional meaning that one or more of its functions get disturbed or ceases to operate. Endothelial dysfunction is characterised by a shift in the actions of the endothelium towards reduced vasodilation, a proinflammatory state, and properties favouring development of thrombosis. Endothelial dysfunction can be caused by several factors such as obesity, smoking, sleep deprivation, acute microbial infections, high glucose intake and air pollutants. Endothelial dysfunction is associated with most forms of cardiovascular disease, such as hypertension, ischaemic heart disease, chronic heart failure, peripheral vascular disease, diabetes, chronic kidney failure, and with severe viral infections. In the context of this review, it is important to point out that endothelial dysfunction is one of the first phenomena in the development of atherosclerotic plaques.<sup>95</sup>

The potential effects of physical activity for primary and secondary prevention of ischaemic heart disease can be examined according to the outline below. The preventive effects of physical activity are most thoroughly studied in relation to ischaemic heart disease. Some of these effects are seen also in cerebral and peripheral arteries and in their functions. All listed effects are based on strong or at least moderate evidence, but the effects that can be seen at an individual level depend strongly on the individual characteristics such as age and risk factor profile and on the characteristics of the physical activity.

Potential preventive effects of physical activity on ischaemic heart disease include

- Effects on the development of the atherosclerotic plaques
- Effects on the vasculature and blood circulation of the heart
- Effects on the metabolism of the heart
- Effects on the autonomic regulation of the heart
- Effects on other organs and tissues

**Effects of physical activity on the development of the atherosclerotic plaques.** As discussed above, the risk and extent of the plaque development is increased by several factors: high blood LDL- and low HDL (high-density lipoprotein)-cholesterol (hyperlipidemia); high blood glucose (hyperglycemia); decreased sensitivity of muscular and other tissues to the effect of insulin in the up-take and use glucose from blood (insulin insensitivity); diabetes; elevated blood pressure (hypertension); overweight and obesity (especially visceral obesity in which much of the fat is stored around and within the intra-abdominal organs); smoking; low cardiorespiratory fitness; and physical inactivity. Further, the risk of plaque development is increased by dysfunction of the endothelium of the coronary arteries and

by low-grade inflammation. All of these factors can be decreased or even eliminated by appropriate physical activity, particularly by systematic exercise training.<sup>96-98</sup> It is worth noting that for obese people physical activity has a positive influence on several risk factors, also without loss of weight.<sup>98</sup> This indicates the importance of physical activity for obese people, which might aim to increase cardiovascular fitness and reduce risk of CVD, without necessarily helping to reduce body weight.

**Effect of physical activity on plaque regression.** Some studies in the 1990s provided suggestive evidence that intensive long-term exercise training can lead to regression of the atherosclerotic lesions in the coronary arteries. However, in the light of the accumulated and partly conflicting findings it has been concluded that the degree of the regression of the coronary artery stenosis seems to be almost negligible and most likely does not explain the massive improvement in myocardial blood flow as a result of exercise training in ischaemic heart disease patients.<sup>97</sup>

**Effects on the vasculature and blood circulation of the heart.** Regular exercise improves the endothelial function of the coronary arteries that allows their increased dilation when more blood is needed to the heart muscle as during exercise thus increasing functional capacity. Regular exercise training also induces transformation of the capillaries and other myocardial vessels to larger small arteries. These changes decrease the resistance to and allow augmented blood flow within the heart muscle without increase of stress on the vascular wall. These changes are seen especially in patients with ischaemic heart disease, and the effects decrease the risk of cardiac events such as myocardial infarction.<sup>97,98</sup> Although exercise training leads to increased formation of collateral vessels, current evidence is not sufficient to conclude that exercise training leads to a clinically significant increase of collateral blood flow.<sup>97</sup>

**Effects on the metabolism of the heart.** Exercise increases the number of new mitochondria in the heart muscle and their ability to oxidise fatty acids. This adaptation increases the capacity of the heart muscle to produce energy for the contractions, and after ischaemia in cardiac patients the injury of the heart muscle is reduced and the risk of cardiac dysfunction and death are decreased.<sup>98,99</sup>

**Effects on the autonomic regulation of the heart.** Decreased heart rate and lower blood pressure at rest and at each level of physical activity as a result of exercise training in both healthy individuals and in cardiac patients are some of the early findings of exercise physiology. The lower heart rate also enables enhanced diastolic coronary artery blood flow due to the shorter time of compression of the arteries inside the heart wall. This leads to a 'double benefit', given that the combined result of the lower heart rate and blood pressure means that the cardiac load and oxygen demand of the heart muscle are decreased at each workload. In ischaemic patients the lower cardiac load may lead to less ischaemia and anginal pain and may decrease the risk of arrhythmias. These effects are reflections of the increased vagal activity and decreased sympathetic tone caused by exercise training.<sup>99</sup>

**Effects on other organs and tissues.** Exercise increases the number of mitochondria and thus capacity for energy production in skeletal muscles and in adipose tissues in

the same way as in the heart muscle. Skeletal muscles can produce and secrete substances called myokines that mediate communication between organs such as muscles, liver and adipose tissue. The protective effects of exercise, such as the anti-inflammation and angiogenic effects, are partly mediated by myokines.<sup>98,99</sup>

## Sedentary behaviour

Sedentary behaviours are defined as those which involve being in a sitting, reclining or lying posture during waking hours, undertaking little movement or activity and using little energy above what is used at rest. In other words, being physically inactive. Research over the past few decades has provided increasing evidence that sedentary behaviour, especially time spent sitting, is associated with all-cause and cardiovascular mortality, and it is a risk factor for many outcomes of poor health.<sup>100,101</sup> The CVD mortality risk related to sedentary behaviour is greatest among the least physically active people, the risk decreases gradually with increasing amount and intensity of physical activity and the risk is abolished in the most active people.<sup>102</sup> Therefore, it is advised to minimise the amount of time spent sedentary and to break up extended periods by at least some light physical activity.<sup>103</sup> However, the current scientific evidence is not sufficient to make specific recommendations on the time limit or a minimum threshold of sedentary time.

## Conclusion

Physical activity and particularly systematically practised exercise prevents or deters the development and progress of ischaemic heart disease and stroke and other cardiovascular disease by many scientifically proven biological mechanisms. It is not known precisely which aspects of physical activity lead to optimal preventive effects. However, it is safe to state that overall the amount, intensity, frequency, type and patterns of physical activity that meets the current guidelines is needed and is sufficient to bring a major part of the potential benefits produced by most of these mechanisms. Furthermore, it is clear that people who are (or have been) less physically active will benefit more from low amounts of physical activity.

# 5 Children, young people and cardiovascular disease

## Introduction

Physical inactivity is associated with atherosclerotic cardiovascular disease (CVD), type 2 diabetes, and many other diseases. Physical inactivity has also been linked with a number of biological risk factors for these diseases, such as hypertension, hyperlipidemia, and insulin resistance. These diseases are not usually manifested in children and young people, (0–17 years) but precursors of atherosclerosis such as fatty streaks in the arteries can be seen in children and the degree of atherosclerotic precursors is related to the level of CVD risk factors.<sup>104,105</sup>

No studies have examined the progression of atherosclerosis from childhood until clinical manifestations in adults, thus the exact importance of this early atherosclerosis is not known. However, studies have found associations between physical inactivity and arterial stiffness and intima-media thickness.<sup>106,107</sup> Clustering of CVD risk factors (high levels of several risk factors in the same child) is apparent already at the age of nine<sup>108</sup> and it is associated with physical inactivity<sup>109</sup> and low fitness.<sup>110</sup> Therefore, even if clinical evidence for the long-term effect of a sedentary lifestyle is lacking, it is considered as poor health when many CVD risk factors are elevated in the same child over time. Further, it is possible and simple to assess children for a poor cardiometabolic state,<sup>111</sup> and interventions have shown that it is possible to improve CVD risk factors.<sup>112</sup>

## Current guidelines from WHO, 5–17 years old children (WHO 2010)

For children and young people of this age group physical activity includes play, games, sports, transportation, recreation, physical education or planned exercise, in the context of family, school, and community activities. In order to improve cardiorespiratory and muscular fitness, bone health, cardiovascular and metabolic health biomarkers and reduce symptoms of anxiety and depression, the following are recommended<sup>113</sup>:

- Children and young people aged 5–17 should carry out at least 60 minutes of moderate- to vigorous-intensity physical activity daily.
- Physical activity of duration greater than 60 minutes daily will provide additional health benefits.
- Most of daily physical activity should be aerobic. Vigorous-intensity activities should be incorporated, including those that strengthen muscle and bone, at least three times per week.

## Comments on guidelines for children

Recent studies have questioned the concept of merging moderate and vigorous physical activity into one level giving all minutes above the lower cut-point for moderate intensity the same weight. The lower cut-point for moderate physical activity compares to walking with a speed of 4 km/h. This intensity of physical activity is very low for an apparently healthy child, and new research

has shown that intensity matters. Aadland et al. developed new methods, which enabled them to analyse the importance of intensity of physical activity.<sup>114–116</sup> The lower intensities of moderate intensity physical activity did not explain any variance in CVD risk factors. The association between CVD risk factors and physical activity was strongest for the vigorous activity. This is hardly surprising giving the observed effect of interventions in children, which usually consist of quite high-intensity physical activity. The observation may impact international recommendations if the analysis is confirmed by other studies.

Habitual physical activity among young people is usually sporadic and with lower intensity. One type of habitual physical activity, which has been studied in recent years, is active travel, walking and cycling. Observational studies have shown higher cardiorespiratory fitness (CRF) and better metabolic risk profile (MetS score) in children who cycle to school.<sup>117–119</sup> A MetS score is a composite score of CVD risk factors, which is constructed as the mean of standardised risk factors.<sup>109</sup> Risk factors included are usually those defined by metabolic syndrome and often CRF is also included. The longitudinal development of CVD risk factors and CRF is also diminished in children cycling to school.<sup>119,120</sup> Many of the children cycled not much more than 1 km to school, but the mean fitness of all the children cycling to school was still around 9% better than children walking or using passive transport. A plausible explanation for the quite marked effect of cycling to school is that the activity is frequent: the trip is twice a day, five days a week. These observational studies have later been supported by a randomised trial of cycling to school.<sup>112</sup> In this trial, non-cycling children living more than 1 km from school were randomised to control or cycling groups. The intervention group improved on average 0.6 standard deviation in each risk factor after just eight weeks of commuting compared to the control group. It is very interesting that even a quite low, but frequent dose of physical activity, which can be integrated into everyday living, has measurable effects on cardiovascular risk factors in children. There is some health effect of walking, but it is less than that for cycling in both adults and children.<sup>121,122</sup>

Recently, several studies have attempted to increase physical activity during academic school lessons. This approach is promising, because children need to participate and the activity is teacher-led. Most of these interventions used executive function or academic performance as outcomes, but a few also assessed CVD risk factors as secondary outcomes.<sup>123</sup> The effects of the interventions on CVD risk factors depends on how successful the implementation of the extra physical activity has been and varies between no effect and an effect size of one standard deviation. One standard deviation is approximately 6 mmHg for blood pressure, 0.4 mmol/l for glucose, 0.7 mmol/l for total cholesterol, 0.4 mmol/l for triglycerides, 2.5 kg/m<sup>2</sup> for BMI and 7 ml/min/kg (or 15%) for aerobic fitness.<sup>109</sup>

In conclusion, contrary to what has been emphasised previously,<sup>124</sup> structured training is not the only way to improve cardiorespiratory fitness (CRF) and CVD risk factors in children.

Habitual physical activity such as commuter cycling can improve CRF and CVD risk factors even in healthy children with a relatively high CRF level. Intensity of these activities may be important, because cycling is more effective than walking to improve CVD risk factors, but even walking may have an impact, for example on the risk of obesity in children.<sup>121</sup>

### Which children have increased risk?

It is possible to identify children with increased CVD risk factor levels. The most commonly used tool is a composite CVD score constructed as the mean of standardised CVD risk factors. A high score indicates clustering of CVD risk factors.<sup>111</sup> Most of these children are insulin resistant. From a technical point of view the idea of screening in schools could be defended, especially as the recommended treatment is counselling and exercise, with few or no side effects. However, to take blood samples from all schoolchildren should not be recommended. Screening based on non-invasive measures such as an aerobic fitness test and waist-height ratio has shown high specificity and sensitivity against the IDF definition of metabolic syndrome for children, and adding systolic blood pressure improves the screening.<sup>111,125</sup> Further, prevention is possible in children on a population level, because school-based changes can include all children and can be decided at a national level. Interventions can also take place within families, as parents obviously have an interest in the health of their children.

The International Diabetes Federation has suggested a definition of metabolic syndrome for children.<sup>126</sup> However, many more children have clustered CVD risk than the number diagnosed with metabolic syndrome according to this definition. Clustered CVD risk is here defined as a condition where the risk factors included in the metabolic syndrome are not independently distributed in the population, but some children have elevated levels in many risk factors simultaneously compared to their peers. Often cardiorespiratory fitness is also included, because it is associated with other risk factors such as lipids and blood pressure and even stronger than fatness.<sup>111</sup> In European children it has been shown that 10–15% of children had clustering of CVD risk factors,<sup>108</sup> but less than 0.5% fulfilled IDF criteria.<sup>127</sup> The IDF criteria therefore only select a small fraction of the children who have a metabolic health problem resulting in elevated CVD risk factor levels.

### Conclusion

Clustering of CVD risk factors is apparent in children as young as 8–9 years. A simple fitness test and a measurement of their waist circumference and body height can, with good accuracy, identify children with an adverse CVD risk factor profile with the aim of improving their lifestyle.



# 6 The importance of physical activity for secondary prevention of cardiovascular disease

## Secondary prevention and rehabilitation

This chapter focuses on the effects, effectiveness and safety of physical activity and especially systematic exercise training as parts of secondary prevention and rehabilitation of ischaemic and other cardiovascular diseases (CVDs), stroke and lower leg arterial disease. The need, uptake, organisation and necessary measures to increase the availability and use of cardiac and stroke rehabilitation in general are dealt with in a recent paper from the European Heart Network (<http://www.ehnheart.org/patients/papers/1166.html>).

Secondary prevention aims to decrease the progression of an existing CVD and to decrease its effects on the physical, mental and social health, functioning and well-being of the people with these diseases. Secondary prevention has an important role in the management of cardiovascular disease for three main reasons.

First, the progression of the disease processes in the cardiovascular system continues after the appearance of the symptoms and clinical events resulting in a high rate of recurrent events and death among the patients.<sup>128</sup> Therefore, secondary prevention should be a lifelong process for all individuals with CVD.

Second, the physical, mental and social harms caused by these diseases are a great burden to the patients and need to be decreased or abolished by individually planned and applied measures. These needs are greatest immediately after the clinical event and during the following months. At this stage cardiovascular rehabilitation is the most appropriate way of providing the necessary secondary preventive measures. Cardiovascular rehabilitation is a category of secondary prevention that can be defined as a multi-factorial and comprehensive intervention designed to limit the physiological, psychological and social effects of cardiovascular disease, manage symptoms, restore functions, and reduce the risk of future cardiovascular events.<sup>128</sup>

Third, people with cardiovascular disease in many cases tend to reduce their physical activity, leading to the increased risk of development of other conditions such as obesity, diabetes, osteoarthritis and depression. Many of these conditions are highly prevalent in people with CVD.

### Physical activity

The effects on health, function and well-being of physical activity in persons with known cardiovascular disease have been studied much less than the effectiveness of physical activity in primary prevention. Further, the effects of physical activity are difficult to discern from those caused by drugs and other treatments used by most patients. However, an increasing number of studies show that the risk of recurrent clinical events and death is smaller among the physically active

compared with the inactive participants with ischaemic heart disease,<sup>129–133</sup> with both ischaemic heart disease and diabetes<sup>134</sup> or after percutaneous coronary intervention.<sup>135</sup> The relationship between physical activity level and risk of cardiovascular events shows similar features in subjects with cardiovascular disease as in healthy subjects: the difference in relative risk is seen already between sedentary and somewhat active participants,<sup>130</sup> the risk reduction for a given increase in physical activity is larger at low than high levels of physical activity and larger between lower than higher risk participants,<sup>130</sup> the risk reduction continues to high levels of physical activity,<sup>129,130</sup> but may again increase at very high levels of activity,<sup>129</sup> and the risk changes inversely to physical activity changes.<sup>76,136,137</sup> These observations have been made in women and men of different ages.

In practical terms the findings described above suggest that individuals with cardiovascular disease can decrease the risk of an unfavourable course of their disease by becoming physically active or by increasing their activity and maintaining it. This behaviour may benefit mostly those who are sedentary and have a high risk of their disease worsening.

### Exercise-based cardiac rehabilitation

Exercise is a critical component of secondary prevention of cardiovascular disease and is a core aspect of rehabilitation. Medically supervised exercise training is one of the core components and often the main component of cardiac rehabilitation especially in phase II,<sup>128,138</sup> when the patient has been discharged from the hospital (phase I) and has become ambulatory. After phase II rehabilitation continues as phase III, which in practice is continuing secondary prevention.

Traditionally the main aim of cardiac rehabilitation has been to prevent the recurrence of cardiovascular clinical events and death. A number of systematic reviews and meta-analyses have analysed and summarised the clinical effects of rehabilitation in several cardiovascular conditions, particularly in ischaemic heart disease. As in secondary prevention in general, in rehabilitation the effects of the exercise training alone are difficult to discern from the effects of the other components. This notion is supported by the analyses showing that exercise training is a key component of cardiac rehabilitation in terms of reducing the rate of clinical events and deaths, but also all other components contributed significantly to these results.<sup>139,140</sup> Further, because new drugs and procedures have come into use, the course of cardiovascular disease has improved and the relative contribution of physical activity and exercise training in the management of this disease has decreased. The effects of cardiac rehabilitation have changed rapidly and significantly.

This development is seen in the partly discrepant results of currently published reviews and meta-analyses. The Cochrane review analysing the effectiveness of randomised controlled

trials of exercise-based cardiac rehabilitation<sup>141</sup> found that rehabilitation reduces the risk of cardiovascular mortality but not total mortality, and causes significant reduction in the risk of hospitalisation but not in the risk of myocardial infarction or revascularisation. When the results of the same studies except those that had recruited the participants before the year 2000 were analysed, no effect on all-cause mortality or cardiovascular mortality found but just small reduction in hospital admissions.<sup>142</sup>

In an analysis of randomised controlled trials that were published in the period 2010 to 2015, cardiovascular mortality was reduced by 58% and myocardial infarction by 30% but all-cause mortality was not.<sup>139</sup> However, a subgroup analysis showed that programmes that managed six or more cardiovascular disease risk factors reduced total mortality by 37%, but less comprehensive programmes did not. This study showed also that comprehensive rehabilitation decreased cerebrovascular events by 60%. The authors emphasise that comprehensive prevention and rehabilitation programmes that manage six or more risk factors and those prescribing and monitoring blood pressure and lipid lowering medications continue to reduce all-cause mortality.

This notion is supported by an analysis of the effect of dose, i.e. duration multiplied by frequency/week, on the results of cardiac rehabilitation in randomised and non-randomised studies.<sup>143</sup> The results showed that greater dose was significantly related to lower all-cause mortality and to fewer percutaneous coronary interventions when compared to low dose. However, no dose-response association was found for cardiovascular mortality, myocardial infarction, all-cause hospitalisation or coronary artery bypass graft surgery. This analysis indicates that there is a further need to study the effect of dose on different outcomes of cardiac rehabilitation.

When the prognostic effect of multi-component cardiac rehabilitation after acute myocardial infarction was analysed by including not only randomised but also non-randomised controlled studies (thus reflecting better routine clinical care), reduced total mortality among the participants of rehabilitation programmes was seen.<sup>144</sup> The only included randomised study showed neutral results. The effects of rehabilitation on cardiovascular mortality and on hospital readmission could not be reliably analysed due to the small number of studies with different designs and contents.

Another analysis including only non-randomised studies that recruited the participants from the year 2000 onwards found that cardiac rehabilitation reduced the risk of all-cause and cardiac-related mortality and improved health-related quality of life in at least one domain.<sup>145</sup> The benefits in terms of recurrent myocardial infarction were inconsistent and no significant effects were found regarding revascularisation or re-hospitalisation following acute myocardial infarction.

One systematic review and meta-analysis has analysed specifically and thoroughly the effectiveness of exercise training and the contributions and roles of its various modes and components on the clinical outcomes of cardiac rehabilitation.<sup>146</sup> The material for the analyses comprised of 72 exercise interventions in 69 trials. The interventions showed extensive variations in practically all aspects. In general, this

meta-analysis showed that cardiac rehabilitation in which exercise training was a key or main component was effective in reducing cardiovascular mortality significantly by 26%, total mortality by 10% and myocardial infarction by 20%. The exercise-based cardiac rehabilitation did not decrease significantly the frequency of coronary bypass grafting or percutaneous coronary intervention events. The observed effects generally remained the same independent of the cardiac condition of the participants, type of the comparison condition (usual care), or whether the amount of the exercise was more or less than 150 mins/week. No single exercise component such as intensity, frequency, session time or type was found to be a significant predictor of the mortality outcomes except adherence to the prescribed exercise regime. High levels of adherence were related to a 28% lower risk of cardiovascular and a 19% lower risk of total mortality compared with low adherence. The likely reasons for the importance of the adherence are that the total volume and often also the duration of the rehabilitation become sufficient;<sup>143</sup> that the more frequent sessions promote changes also in other health habits; and that compared with poor adherers, good adherers are in general more compliant to the offered rehabilitation measures such as medications. In general, the results of the analyses described above agree with those of earlier studies.

The analysis of Abell et al. revealed also that some aspects of the exercise programme are related to increased cardiovascular risks.<sup>146</sup> Thus, a dose-response relationship was observed between an increasing exercise session time and an increasing risk of myocardial infarction, such that for every minute increase in time (between 25 and 90 minutes), the relative risk of myocardial infarction with exercise intervention vs usual care increased by 1%. Further, the relative risk of percutaneous coronary intervention increased by 5% for every 1% increase in maximal heart rate prescribed (between 60 and 91% of maximal heart rate).

The practical implications of the findings of the study of Abell et al. are important.<sup>146</sup> They indicate that exercise-based cardiac rehabilitation programmes can still be effective in reducing cardiac events, and that the effectiveness of the programmes is largely independent of the setting and mode of their delivery and of the detailed contents of the exercise training per se – but on the condition that the participants adhere to the prescribed exercise regime and complete it. These findings support the current views that emphasise flexible, individualised and ‘menu-based’ programmes that are tailored to the circumstances and individual patient needs. In the design and delivery of the programmes it is important to focus on factors that will increase adherence to the exercise interventions regardless of the formats they take.

In conclusion, the review of the effectiveness of cardiac rehabilitation shows that it can still lead to important clinical benefits even in the era of improved cardiovascular therapy. However, positive results require multiple measures applied in a sufficiently large dose. Exercise training continues to be an important part of cardiac rehabilitation, although its relative contribution to traditional clinical outcomes has decreased. Instead, the role of exercise training is more important in furthering patient-centred outcomes such as functional capacity.

## Additional goals of exercise-based cardiac rehabilitation

Traditionally the main aim of rehabilitation has been to prevent the recurrence of cardiovascular clinical events and death. Gradually more patient-centred outcomes have gained weight as rehabilitation goals. These goals include maintenance or improvement of functional capacity and quality of life, changes in risk factors of cardiovascular and other diseases and health behaviours, and prevention and alleviation of symptoms and diseases secondary to the cardiovascular disease. Because physical activity has an important role in secondary prevention and physical inactivity is commonly found in individuals with cardiovascular disease, one important goal of cardiovascular rehabilitation is to induce a permanent increase of physical activity among participants.

Exercise practised as the traditional moderate-intensity continuous training causes a great number of health-enhancing physiological and psychological effects (see Table 1). Accumulated evidence shows that training composed of short periods of high-intensity exercise and rest, high-intensity interval training, causes corresponding cardio-metabolic effects both in healthy people of various ages and in people with high cardiovascular disease risk<sup>147</sup> and with ischaemic heart disease and heart failure<sup>148</sup> for example. However, it is worth being cautious when assuming that the effects of short-term intensive exercise training as a sole intervention translate into clinically significant, lasting changes as a result of cardiac rehabilitation. Many factors in the participants of the exercise-based rehabilitation programmes as well as in the contents and delivery of the programmes may decrease the amount, intensity and the duration of the exercise training to low or insufficient levels. Therefore, reliable information of the effects caused by exercise-based cardiac rehabilitation can only be gained by examining the actual effects of these programmes.

Successfully completed exercise-based cardiac rehabilitation programmes lead to improved cardiorespiratory fitness.<sup>149</sup> This effect can be more than a 20% increase in the peak oxygen uptake in ischaemic heart disease patients of various ages,<sup>150</sup> and the effect is larger after high-intensity interval training than after continuous moderate-intensity training.<sup>148,151</sup> The improved fitness may decrease the strenuousness of everyday chores. An earlier systematic review comparing centre-based and home-based cardiac rehabilitation programmes found that both modes improved physical, psychological and social well-being in the same degree.<sup>152</sup> Further, exercise-based cardiac rehabilitation, conducted as randomised controlled trials<sup>141</sup> or as non-randomised controlled studies,<sup>145</sup> is associated also with improved quality of life. In comprehensive cardiac rehabilitation all core components contributed to the improvement of different domains of health-related quality of life.<sup>153</sup> A systematic review found that aerobic exercise training as part of rehabilitation, or in other contexts, has led to improved cognitive functions in participants with cardiovascular and cerebrovascular disease.<sup>149</sup> Exercise-based cardiac rehabilitation has not improved significantly patient's chance of returning to work.<sup>154</sup>

Cardiac rehabilitation has been found to be cost effective,<sup>155</sup> and exercise-based cardiac rehabilitation is a potentially cost-effective use of resources in terms of costs per year of life saved<sup>141</sup> and in gains in quality-adjusted life years.<sup>156</sup>

The analyses of the impact of cardiac rehabilitation programmes on the physical activity level of the participants have provided variable results. Two recent systematic reviews and meta-analyses on randomised controlled trials in cardiac patients provide evidence that these programmes can be effective for increasing significantly the physical activity of the participants for on average 12 months,<sup>157</sup> and that the interventions aimed at long-term maintenance of the physical activity change have been effective.<sup>158</sup>

## Exercise intensity and type in cardiac rehabilitation

Moderate-intensity aerobic activity is the most commonly recommended and used exercise mode in cardiac rehabilitation. Comparing the cardio-protective effects of moderate and vigorous intensity exercise at the same total energy expenditure in clinical trials generally shows that there is no difference on the effects in systolic blood pressure, lipid profile or body fat loss, but vigorous intensity exercise causes greater improvements for diastolic blood pressure, glucose control and aerobic capacity.<sup>159</sup>

The development of high-intensity interval training has increased interest in also using this mode of exercise training in cardiac rehabilitation. In patients with cardiovascular disease, especially ischaemic heart disease, high-intensity interval training has shown to be superior compared with moderate-intensity continuous training in improving cardiorespiratory fitness and in eliciting favourable effects in heart and endothelial function, insulin sensitivity and glucose regulation, HDL-cholesterol, blood pressure and deep abdominal adiposity.<sup>151</sup> The superior effect of high-intensity interval versus moderate-intensity continuous training on cardiorespiratory fitness has been emphasised because an increase in fitness is associated with decreased all-cause mortality and improved prognosis in ischaemic heart disease patients, and prescribing rehabilitative exercise that increases cardiorespiratory fitness to the greatest extent could have superior influence in reducing all-cause and cardiovascular mortality.<sup>151</sup> In 17 studies comparing the effects of moderate-intensity continuous and high-intensity interval training in cardiac rehabilitation, there were no deaths or cardiac events requiring hospitalisation in any of the studies, and overall there were more adverse effects in the moderate-intensity continuous than in the high-intensity interval training.<sup>151</sup> However, there is small transient risk of cardiovascular events in sedentary subjects in unaccustomed vigorous physical exertion.<sup>160</sup> This risk can be effectively reduced by gradual increase of exercise intensity.<sup>161</sup>

Resistance or strength training enhances muscular strength and endurance, functional capacity, independence and quality of life and reduces disability in persons with and without cardiovascular disease.<sup>162</sup> Further, resistance training decreases systolic and diastolic blood pressure both in normotensive and hypertensive participants, increases HDL- and decreases LDL- and total cholesterol as well as triglycerides, improves glucose control, increases mitochondrial oxidative capacity,<sup>163</sup> and improves aerobic fitness. The size of most of these effects are comparable to those of aerobic training, and low-to-moderate intensity (30–69% of one repetition maximum) resistance training seems to be as effective as high-intensity resistance training. In adults aged 60 and over with cardiovascular disease the rate of adverse cardiovascular effects of low-to-moderate intensity resistance training was lower than in aerobic

training.<sup>164</sup> Resistance training is currently included in most guidelines and recommendations related to prevention and rehabilitation of cardiovascular disease, but it is emphasised much less than aerobic training. Because both modes of training add to the cardiovascular effects of exercise training in primary and secondary prevention, their combined use is recommended.

Regarding the types of exercise, the most common modes are various forms of walking and cycling, but many other whole-body exercise modes can be used. Thus, for example, Tai Chi<sup>165</sup> and Traditional Chinese Exercise<sup>166</sup> have led to beneficial effects in primary and secondary prevention of cardiovascular disease.

### Mode of delivery of rehabilitation

Improved treatment options, faster recovery, lack of availability and accessibility of services, difficulties to retain the benefits of rehabilitation and opportunities offered by new technologies are some of the reasons that have challenged the position of the traditional centre-based rehabilitation and brought new options such as home-based and tele-based cardiac rehabilitation. The European guidelines on cardiovascular disease prevention state that “home-based rehabilitation with and without telemonitoring holds promise for increasing participation and supporting behavioural change”.<sup>128</sup>

Several systematic reviews and meta-analyses have compared the effectiveness and feasibility of the different rehabilitation types. Home-based rehabilitation was found to be slightly more effective than centre-based rehabilitation in terms of maintaining exercise capacity for at least 12 months in ischaemic heart disease patients, but there was no difference in the adherence to the recommended physical activity level between the rehabilitation types.<sup>167</sup> A Cochrane review of 23 trials, including 2 890 ischaemic heart disease, revascularisation or heart failure patients, found no difference between centre-based and home-based rehabilitation in total mortality or exercise capacity up to 12 months, but the programme completion was slightly better in the home-based programmes.<sup>168</sup> The authors conclude that this updated review supports previous views that home- and centre-based forms of cardiac rehabilitation seem to be similarly effective in improving clinical and health-related, quality-of-life outcomes in patients after myocardial infarction or revascularisation or heart failure. This finding supports the continued expansion of home-based cardiac rehabilitation programmes that are based on scientific evidence. An analysis of 60 randomised clinical trials and 19 411 ischaemic heart disease patients compared the efficacy of centre-based, home-based, tele-based, and combined exercise-based cardiac rehabilitation.<sup>169</sup> Only centre-based rehabilitation significantly reduced total mortality, but in the other rehabilitation modes this outcome was not significantly different from usual care.

The most recent and most comprehensive review comparing the effectiveness and the potential advantages and disadvantages of the centre-based and home-based cardiac rehabilitation is included in the scientific statement from several American cardiologic and pulmonary organisations.<sup>170</sup> The potential advantages of the home-based mode of cardiac rehabilitation include expanded access and capacity of the services, faster enrolment, individually tailored programmes, flexible and convenient scheduling, greater privacy while receiving the

services, and the possibility to integrate rehabilitation with regular home routines. The potential disadvantages include less intensive exercise training; less face-to-face monitoring of the exercises being carried out; less social support; and safety concerns, especially among higher-risk patients. In order to guide the rehabilitation professionals to adjust the progression of the training scheme to meet the individual needs and possibilities, the American Association of Cardiovascular and Pulmonary Rehabilitation has published a statement on the progression of exercise training in early outpatient cardiac rehabilitation.<sup>171</sup>

The studies cited by Thomas et al. did not show any significant difference in all-cause mortality between the centre-based and home-based rehabilitation, but only one of the included studies had a follow-up longer than 12 months.<sup>170</sup> Also the effects of the two rehabilitation modes on exercise capacity, body weight, blood lipids, blood pressure, and smoking behaviour were of equal size. Most included studies reported improvements in health-related quality of life for both home-based and centre-based rehabilitation. Seven included studies found no significant difference in the level of adherence between the compared rehabilitation modes, but in three studies the level of adherence and completion of the prescribed rehabilitation sessions were higher in the home-based compared with the centre-based rehabilitation. Equal adherence rate to the centre-based and home-based exercise programmes for patients with cardiovascular disease was found also in a recent meta-analysis.<sup>172</sup> The safety of the home-based rehabilitation, especially for high-risk patients, could not be reliably assessed in this study due to the insufficient number of patients and length of follow-up.

The primary difference between home-based and centre-based cardiac rehabilitation is that the centre-based mode requires direct face-to-face observation of patients, whereas the home-based mode does not. Home-based rehabilitation relies on remote coaching and supervision. The rapid development of technology tools, such as mobile phone applications, text messaging, websites and sensors for physical activity, heart rate, ECG, and other health-related measures, offer the potential to increase the volume and applications of home-based rehabilitation and to improve its effectiveness and safety. However, recent reviews that have assessed the benefits, feasibility and other aspects of the use of tele-rehabilitation technologies,<sup>173,174</sup> text messaging,<sup>175</sup> mobile phone applications<sup>176,177</sup> and activity monitors<sup>178,179</sup> conclude that the results are mainly positive, but due to the small number of studies and subjects, short duration and other deficiencies of the included studies, technical challenges in the functionality of the devices and methods, more research is needed before a comprehensive evaluation of the practical value of the technologies can be done.

### Rehabilitation of various cardiac conditions

**Stable angina.** The effectiveness of exercise-based cardiac rehabilitation has been assessed separately in adults with stable angina.<sup>180</sup> Due to the small number of studies, their small size and other deficiencies of the included studies the authors were uncertain of the effects of the rehabilitation compared to a control condition on mortality, morbidity, cardiovascular hospital admissions, adverse effects, return to work or quality of life in this patient group.

**Heart failure.** Heart failure is a common but not widely known debilitating condition that is most often caused by ischaemic heart disease and high blood pressure.<sup>181</sup> In this condition the heart is not able to pump sufficient amounts of blood to the organs of the body. Recent reviews have analysed the effects of exercise-based cardiac rehabilitation in patients with various types of heart failure. The Cochrane review of Long et al. (2019) included 44 randomised controlled trials (5 783 participants) with a median of six months' follow-up.<sup>182</sup> Compared to control interventions that include no exercise, exercise-based cardiac rehabilitation appears to have no impact on mortality within 12 months. However, rehabilitation probably reduces the risk of all-cause hospital admissions and may reduce the hospital admissions due to heart failure by 12 months. Exercise-based cardiac rehabilitation may also confer a clinically important improvement in health-related quality of life.

Another analysis included 19 randomised controlled trials (3 990 participants).<sup>183</sup> In this study the analyses were based on the data of individual patients. Also this study showed that exercise-based cardiac rehabilitation does not have an impact on the risk of death or hospitalisation of heart failure patients. However, participation in rehabilitation may cause some improvement in physical fitness and quality of life at 12 months' follow-up, and these effects are independent of a patient's age, sex, ethnicity, initial level of fitness or disease severity. The authors state that the results on exercise capacity and quality of life support the recommendation of current international clinical guidelines that exercise-based cardiac rehabilitation should be offered to all heart failure patients.

Rehabilitation provided as centre-based or home-based mode similarly improved functional capacity and health-related quality of life.<sup>184</sup>

**Atrial fibrillation.** The authors of a Cochrane review including six randomised controlled trials and 421 patients were not able to evaluate the real impact of exercise-based cardiac rehabilitation on mortality or serious adverse events. The rehabilitation was not found to have a clinically relevant impact on quality of life, but it may increase exercise capacity.<sup>185</sup> A less formally conducted review states that cardiac rehabilitation with concomitant regular moderate physical activity reduces the time in arrhythmia of patients with paroxysmal and persistent atrial fibrillation. In chronic atrial fibrillation rehabilitation may decrease the resting ventricular response rate and therefore decrease symptoms related to arrhythmia. Further, the authors state that the reviewed studies have demonstrated that cardiac rehabilitation is safe and feasible for patients with atrial fibrillation.<sup>186</sup>

**People with implantable ventricular assist devices.** The Cochrane review of Yamamoto et al. (2018) included only two studies with 40 participants.<sup>187</sup> This evidence base was insufficient to come to any conclusions on the efficacy or safety of exercise-based cardiac rehabilitation in this patient group.

**Patients with an implantable cardioverter defibrillator.** The review was based on eight randomised controlled trials including 1,730 patients.<sup>188</sup> Due to a lack of evidence, the authors were unable to definitively assess the impact of exercise-based cardiac rehabilitation on all-cause mortality, serious adverse effects and health-related quality of life in this group of patients. However, there was a slight increase of exercise capacity in the patients that had participated in the exercise training.

**Patients early after cardiac surgery.** The systematic review and meta-analysis by Doyle et al. (2018) included all studies that reported efficacy and safety outcomes of aerobic exercise commenced within two weeks after cardiac surgery.<sup>189</sup> Compared with usual care, the exercise training significantly improved functional and aerobic capacity of the patients. Safety of exercise training early after cardiac surgery must be assessed in larger studies that also include higher-risk patients.

**Heart transplant recipients.** The analysis done by Anderson and coworkers (2017) included 10 randomised controlled trials (330 participants).<sup>190</sup> The findings showed that exercise-based cardiac rehabilitation improves exercise capacity, but exercise had no impact on health-related quality of life over 12 weeks of follow-up. Exercise training appeared to be safe for these patients.

**Adults after heart valve surgery.** The authors could identify only two randomised trials (in total 148 participants) that compared the effects of exercise-based interventions compared with no exercise intervention control in adult patients after heart valve surgery.<sup>191</sup> The results suggest that exercise training may improve exercise capacity in these patients, but no conclusions on the effects of exercise on mortality or quality of life could be made due to the limited amount of data.

Clinical practice guidelines recommend that cardiac patients participate in rehabilitation programmes. However, only a small portion of eligible patients utilise rehabilitation. Furthermore, adherence to the programmes and their completion remain major challenges of cardiac rehabilitation. A Cochrane review assessed the interventions provided to increase patient enrolment in, adherence to, and completion of cardiac rehabilitation. The review found that enrolment was increased in interventions which were targeting health-care providers, training nurses, or allied health-care providers to intervene face-to-face, and the effects of interventions to increase adherence were larger in studies that tested interventions delivered remotely, such as home-based programmes.<sup>192</sup>

### **Exercise-based rehabilitation of cerebrovascular disease (stroke)**

Stroke is an atherosclerotic disease of the arteries leading to obstruction and decreased blood flow within the brain. In most strokes (ischaemic strokes) blood flow in an artery is obstructed by a blood clot. In hemorrhagic strokes obstruction of blood flow to the brain is caused by a rupture of a vessel. A transient ischaemic attack (TIA) or 'mini stroke' is caused by a temporary clot. The insufficient blood flow causes deficiencies in motor, cognitive and communication functions such as impaired balance, walking and upper extremity function on one side, memory problems, executive dysfunctions and reduced attention, problems of understanding or speaking and loss of vision on one side.

Stroke has many negative impacts on health, calling for comprehensive rehabilitation provided by a multidisciplinary team of professionals and supported by peers.<sup>193</sup> The goals of rehabilitation and secondary prevention related to physical activity and exercise training after stroke can be set out in four groups.<sup>194</sup> Immediately after an acute stroke the first goals are aimed at preventing complications of prolonged inactivity, regaining voluntary movement, and recovering basic activities of daily living. Therefore, bed rest is minimised and early mobilisation within 24 hours after the event is begun

by intermittent sitting or standing and light movements. This practice has been shown to lead to faster recovery of walking ability, as well as to higher functional independence and shorter stays in hospital.<sup>195</sup> This first phase of stroke rehabilitation is managed by professional medical staff.

The second phase of the stroke rehabilitation begins once the patient is medically stable. Exercise training is begun with the first goal to regain the levels of pre-stroke physical activity as soon and as completely as possible. The goals of the physical therapy and exercise are to improve gait, balance, muscle strength and upper extremity function, and therefore the exercise programme includes aerobic activity in various forms, strengthening exercises and practice of various functions. The active role of the patient, supported by a multidisciplinary team of professionals, is essential for achieving good results of the rehabilitation process.

In the third phase after stroke the goal is to facilitate the patients to develop and maintain an active lifestyle that meets the requirements for effective secondary prevention of stroke and other cardiovascular and also other chronic diseases related to physical inactivity. The importance of secondary prevention is shown by the finding that it can reduce stroke recurrence by 80%.<sup>193</sup> In the fourth phase of stroke rehabilitation the goal is to maintain the amount and types of physical activities at levels that meet the individual requirements for health and functions. At these stages the independent role of the patient as an active partner of the rehabilitation grows further.

Systematic exercise training can have favourable impacts on a number of deficits in persons surviving stroke. It is worth emphasising that many of these improvements can be beneficial in direct and indirect ways.

The findings of systematic reviews and meta-analyses on the effects of various exercise training modalities on functional aspects of stroke survivors can be summarised as follows:

- Cardiorespiratory fitness: aerobic or endurance training, most often walking increases cardiorespiratory fitness or capacity.<sup>196,197</sup> The effect increases with the intensity of the exercise.<sup>198,199</sup> This effect is especially important for patients whose aerobic capacity has decreased to levels that seriously limit performance of daily activities and ordinary walking because the reduced ability to carry out these activities can precipitate and exacerbate a sedentary lifestyle that increases the risk of additional health problems such as obesity and arthritis.<sup>200</sup>
- Walking endurance and speed is increased especially by walking training<sup>201</sup> as well as by strength training.<sup>197,202</sup> The effect increases with the intensity of the exercise.<sup>198</sup> Both outdoor and treadmill training improve walking, but the effects are not well maintained after the training period.<sup>203</sup> A meta-analysis that aimed to determine the effectiveness of interventions to improve real-world walking found that interventions that included exercise training combined with behaviour change techniques were more effective than exercise alone.<sup>204</sup> Exercise and gait training modes that include dual-task intervention may improve dual-task gait speed after stroke.<sup>205</sup> Aerobic training as assisted walking and ergometer cycling can be used effectively and safely in non-ambulatory stroke survivors to increase walking endurance, maximum walking speed,

independent walking and mobility.<sup>206</sup> Treadmill training with or without body weight support increased walking endurance and speed in short term especially in people who were able to walk independently, but this type of intervention did not increase walking ability in people who were dependent on assistance when walking at the start of the treatment.<sup>207</sup>

- Balance capacity can be increased<sup>197,201</sup> especially by balance and/or weight shifting and gait training<sup>208</sup> and by treadmill training.<sup>209</sup>
- Exercise training has not been shown to prevent falls or decrease the number of people falling following stroke.<sup>210</sup>
- Exercise-based rehabilitation has been shown to be effective in reducing systolic blood pressure, fasting glucose, and fasting insulin, and increasing high-density lipoprotein cholesterol after stroke or transient ischaemic attack.<sup>211</sup>
- A systematic review and meta-analysis of 13 randomised controlled trials showed that exercise resulted in less depressive symptoms immediately after the exercise programme ended across both the subacute ( $\leq 6$  months post stroke) and chronic stage of recovery ( $> 6$  months). These effects were small and were not retained with longer term follow-up. The effects were larger in studies using higher than lower intensity exercise. Unfortunately the use of antidepressant medication was not documented in the majority of studies and thus, its potential confounding interaction with exercise is not known.<sup>212</sup>
- A systematic review and meta-analysis of nine randomised controlled trials provided evidence that exercise can have a small to medium effect on health-related quality of life at the end of the intervention but this effect was not maintained at follow-up after exercise was terminated.<sup>213</sup>
- Several systematic reviews have provided evidence for the effectiveness of aerobic and especially of combined aerobic and resistance exercise training to improve cognitive functions in stroke survivors.<sup>149,197,214–217</sup>
- Disability of the stroke survivors can be reduced by aerobic training.<sup>201</sup>

Several structural and functional changes in the brain and in the brain vessels have been identified that can give plausible explanations for the changes caused by physical activity/exercise training in stroke survivors.<sup>214,218</sup>

Exercise-based rehabilitation for stroke can be effective only if the participants adhere to the prescribed exercise training. A systematic review and meta-analysis of randomised controlled cardiovascular rehabilitation trials found that the average adherence rate to prescribed exercise training was 90% and drop-out-rate 4%.<sup>172</sup> These figures reflect ideal rather than real-world conditions. However, they suggest that high adherence and low drop-out rates to exercise training in rehabilitation programmes are attainable.

Maintenance of exercise training or regular physical activity is a challenge in cardiac and stroke rehabilitation. A systematic review of 18 randomised controlled trials showed that in half of the trials that aimed to improve physical activity after stroke the interventions were effective, but in the other half the interventions were not effective.<sup>219</sup> A number of factors

that facilitate or deter continuing participation in exercise training have been identified.<sup>220</sup> Exercise programmes should be tailored to individual preferences in order to improve adherence, and a simple questionnaire tool can be helpful.<sup>221</sup> The role of technological devices such as activity monitors in stroke rehabilitation is presently not known due to the small number of adequate studies.<sup>178</sup>

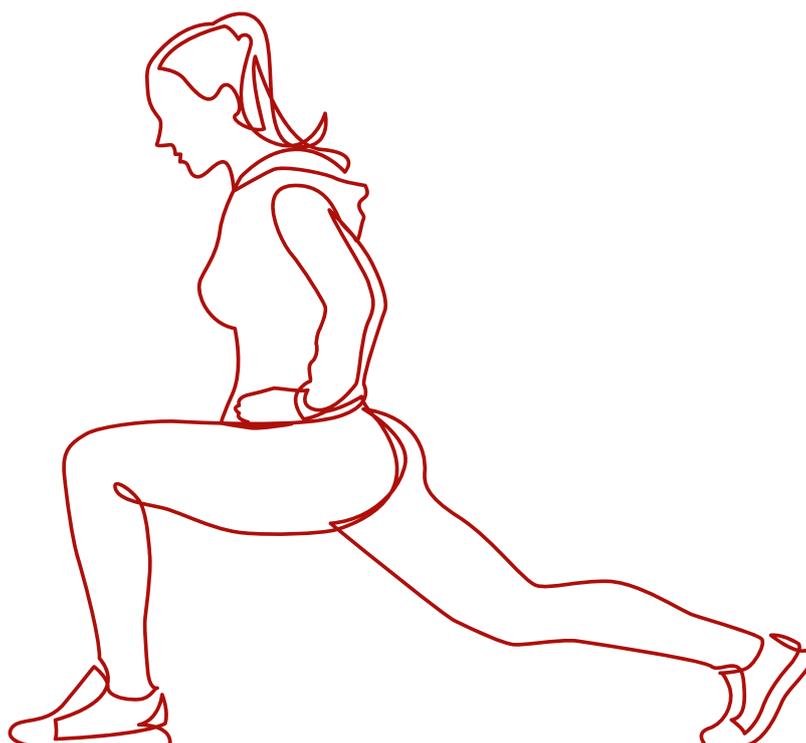
### **Exercise-based treatment and secondary prevention of lower extremity artery disease (intermittent claudication)**

Lower extremity artery disease is the most common form of peripheral atherosclerotic arterial diseases. The basic pathology is atherosclerotic obstruction of one or more arteries of the lower extremity. The obstruction causes restriction of the blood flow to the muscles of the extremity during effort, typically during walking. The resulting lack of oxygen causes pain in the extremity corresponding to angina in ischaemic heart disease. The pain disappears during rest. Patients with this pattern of pain, intermittent claudication, begin to avoid physical activity. Consequently their mobility, functional capacity and quality of life decrease. Gradual progression of the atherosclerotic process causes further decrease of blood supply to critical levels leading to gangrene of the peripheral parts of the extremity, for example. Atherosclerosis is often generalised, and patients with peripheral arterial disease have increased risk of manifested cardiovascular disease such as ischaemic heart disease and stroke. Therefore, secondary prevention is an essential part of the management of the patients with lower extremity artery disease.

International guidelines recommend supervised exercise as the first-line treatment for patients with peripheral arterial disease.<sup>222</sup> Supervised exercise training is more effective than unsupervised<sup>223</sup> or home-based exercise training.<sup>224</sup> Supervised exercise training increases maximal and pain-free walking distance and improves symptoms and quality of life.<sup>225</sup> Exercise

training may decrease systolic blood pressure<sup>226</sup> or systolic and diastolic blood pressure and blood cholesterol levels,<sup>227</sup> but it had no effect on other cardiovascular risk factors. However, the data base in both studies was rather small and heterogeneous. The effects of exercise training may not persist for long if the training discontinues.<sup>228</sup> Thus, the long-term benefits of exercise training largely depend on the continuation of the training. It is not yet known whether exercise training reduces cardiovascular events, but it is effective in preventing invasive treatments.<sup>229</sup> Supervised exercise training is safe. Compared with supervised exercise training, endovascular revascularisation does not provide significant benefits in terms of improvement in functional performance or quality of life, but endovascular revascularisation combined with exercise training may have a synergetic effect.<sup>230</sup>

In most studies the amount of exercise has been at least three hours a week, the exercise has been continued to the maximal or submaximal level, and the training has been continued for at least three months. Initial evidence from small number of studies suggests that high-intensity interval training may provide similar benefits in terms of walking distances, for example, as traditional exercise training but in shorter time.<sup>231</sup> The most used exercise mode has been walking, but alternative modes such as cycling, strength training and upper-arm ergometry have also been shown to be effective. They may be useful when walking training is not an option for the patient.<sup>232</sup> The adherence to the alternative modalities of exercise has shown to be at least as good as to the traditional walking exercise.<sup>233</sup> Although home-based walking exercise training is not as effective as supervised exercise training, it is a useful alternative, with positive effects on quality of life and functional walking capacity.<sup>234</sup> However, home-based exercise training without periodic contacts with health-care personnel may be ineffective even when supported by wearable technology and mobile coaching.<sup>235</sup>



# 7 Summary: Evidence-based physical activity for primary and secondary prevention of cardiovascular disease

The evidence accumulated from a large volume of research over many years allows for some conclusions on amounts and types of effective, practical and safe physical activity (PA) for primary and secondary prevention of cardiovascular disease (CVD). This evidence is strongest for primary prevention and for ischaemic heart disease (IHD).

It is important to point out that most of the evidence on the dose and other characteristics of PA for prevention of CVD is based on studies done on populations. This means that the reported results are mean values calculated from large numbers of people. Therefore, any result of these kind studies related to PA – e.g. minutes on moderate-to-vigorous PA in a week to gain a given preventive effect – is exact or ‘optimal’ for only a small part of the population. Due to variations such as differences in genetic factors and body composition, some parts of the population gain the preventive benefit with less than the PA recommended by the guidelines and others need more than the recommended PA for the same benefit. Further, individuals with high risk of CVD need more than the average amount of PA to decrease the risk of developing CVD or clinical events caused by it, but people with small risk of CVD need less than the average amount of PA for the preventive purpose. The PA recommended in the guidelines is actually for populations and not for individuals. However, because it is difficult to be sure what PA would be right for a given person, the PA recommendations for populations are in the customary communication ‘translated’ – some researchers argue wrongly – to the individual level, and according to the principle used in public health the same preventive means is offered for large population groups.

In individual counseling it is possible to adjust the recommended PA to correspond more closely to the probable ‘real’ need of the individual. This individually customised approach is generally used in secondary prevention of CVD as part of exercise-based cardiac rehabilitation and it can be used in individual counseling of healthy people.

On the basis of the evidence presented in various parts of this document the following guidance for especially primary prevention of CVD is presented:

- Intensity of PA: moderate intensity in relation to the capacity, familiarity to PA and health of the population, group or person is sufficient to give a major part of the preventive effect. Further, this intensity can be attained and maintained by a large proportion of the participants, and for healthy participants and for most individuals with cardiovascular and other diseases it is safe. With increasing intensity above the moderate level, the number of people in a population willing and able to begin and continue PA decreases progressively. Very high intensity of PA, especially as sudden bouts in persons unaccustomed to habitual PA increase the risk of cardiovascular events, but nearly exclusively in persons who have latent or clinically manifested CVD.
- Frequency of PA: several options, from PA only at the weekends to daily PA, give nearly equal preventive benefit so long as the total weekly amount is the same. However, for practical reasons and to avoid symptoms and injuries caused by low or high frequency of PA, two to three times a week is in general advisable.
- Duration of PA in a day: the duration can vary in wide limits depending on the frequency and intensity of the weekly PA, for example. For efficiency and practical reasons 30 to 60 min PA a day is in general advisable. Traditionally, and based on the major part of the related research, it has been recommended that PA for this duration is done as continuous activity or as sessions of alternating short effort and rest periods – i.e. as interval activity. However, increasing evidence indicates that also PA in short periods of some minutes of sufficient intensity accumulated over a day may have preventive effect especially for individuals who are unfit or unaccustomed to PA.
- Total volume of PA (as a product of frequency, duration and intensity of the sessions): a major part of the preventive effect of PA is gained on average by about 150 minutes a week of moderate intensity PA. If the PA is of vigorous intensity such as jogging the same preventive effect is gained by activity lasting about half of this time. However, even smaller amounts may have some preventive effect in populations and individuals which are sedentary or not very physically active. Thus, even a small amount of daily PA that exceeds the habitual level of an individual may have preventive effect in sick and old people.
- The preventive effect of PA above 150 minutes a week increases continuously to at least seven times the recommended amount without evidence of cardiovascular harm. However, the gain of preventive effect for a given increase of PA decreases continuously, and more and more PA is needed for less and less additional preventive benefit. It is also important to notice that practice of high amounts of strenuous PA for many years as recreational or competitive sports includes also the risk of development of adverse structural and functional cardiovascular changes.
- A large amount of scientific evidence indicates that both aerobic and resistance physical activity have preventive effects against CVD but aerobic activities are more effective. Therefore, it is suggested that a major part of the PA for prevention of CVD is aerobic. Further, accumulated evidence on the risks of PA suggests that in general it is advisable to limit the amount of resistance exercise training to about one hour a week.

- A large variety of physical activities that include mainly aerobic muscular work can be used to accumulate the volume needed for prevention of CVD. The most feasible and safest mode of PA especially for middle aged and older people and for people who have various diseases is walking. However, the intensity of ordinary modes of walking on the street, for example, does not reach the level for optimal effectiveness for young and physically fit individuals. In certain environments cycling offers a feasible, effective and relatively safe mode of PA for large population groups.
- PA that fulfils the conditions for preventive effectiveness of CVD can take place as leisure activities, as a mode of transport especially for commuting to work, as part of domestic chores, and as part of one's occupational work activities. The role of leisure time physical activities in the prevention of CVD is often emphasised in communication, but in order to widen the reach of PA to populations and population groups other possibilities for preventive PA, such as transport and domestic chores, are also worth pointing out and conditions to practice them should be increased and improved.
- PA for prevention of CVD is roughly equally effective for women and men, and it is effective in decreasing the development of the risk of CVD from childhood on, continuing to be effective for decreasing the risk of cardiovascular events until old age. It is never too late to engage in physical activity even late in life in order to improve health and decrease cardiovascular risk.

An important aspect of recommending physical activity for the prevention and treatment of CVD is considering the size of the 'dose' – in other words, how much and what type of physical activity do people need to do to optimise health benefits? As many people tend to do less physical activity than is optimal, defining this amount more precisely may help to increase adherence and maximise health benefits. Another aspect is the possible detrimental effect of too much sedentary time, which can be relevant even in physically active people.

As pointed out above, the dose-response relationship between moderate-to-vigorous physical activity and CVD mortality is very similar to that of all-cause mortality, so many of the more general recommendations developed for population health improvement are appropriate here.

In general, it is not possible to set a cut-off point for what amount and intensity of physical activity is enough to prevent cardiovascular disease or other health parameters. A little physical activity is better than none even if it is lower than official guidelines. There is a graded association between the amount of physical activity and the health (mortality and CVD) benefit.<sup>19</sup> The association is not linear, so an increase from nothing to a little bit gives more benefit than an increase from a lot to even more. The guidelines for physical activity differ fundamentally from guidelines for smoking. For smoking, it is recommended to eliminate the risk factor, i.e. stop smoking completely or, even better, never start. For physical activity, the recommendations are a balance between recommending a level where there is evidence for a health effect, but not so high a level that it is unachievable for many people.



However, increasing physical activity above the recommended level results in increased benefit. A recent meta-analysis including 48 population studies with over 2 million participants found CVD and IHD (Ischaemic Heart Disease) benefits increased until a physical activity level of 5–7 times the recommended amount of 150 minutes MVPA per week. There was no detrimental effect of physical activity even at the extreme levels. This means that there is no upper limit of physical activity for healthy people where it becomes hazardous for cardiovascular disease.<sup>19</sup> Blond et al found an inverse relationship between physical activity and CVD mortality (see Figure 12).<sup>19</sup> The CVD and IHD mortality risks were lower for all physical activity levels above the recommended level compared to the recommended level. With 750 MET-minutes as the reference level (same as WHO recommendation of 150 min MVPA), the hazard ratio (HR) at 2 000 MET-minutes was 0.81, while the HR at 5 000 MET-minutes

was 0.73 (almost seven times the level of WHO guidelines). Blond et al found larger HR differences in studies using accelerometers compared to studies not using accelerometers, which means that earlier estimates underestimate the true effect of physical activity because of misclassification. The HR differences also appeared larger in studies of participants of at least 60 years of age compared to studies including younger participants.

Blond et al. found an inverse relationship between physical activity and IHD mortality throughout the range of physical activity.<sup>19</sup> With 150 minutes of MVPA as the reference level (this is the guidelines and not physical inactivity), the benefit of physical activity increased until a level seven times higher than the guidelines with a HR of 0.65. This is more than two hours of at least moderate intensity physical activity daily.

**Figure 12 Dose-response relationship between physical activity and cardiovascular disease (CVD) mortality. Dose-response relation between metabolic equivalent of task (MET) mins/week (with 750 MET mins/week as the reference) and mortality risk estimated with restricted cubic spline regression and generalised least square trend estimation for summarised dose-response data.<sup>19</sup>**

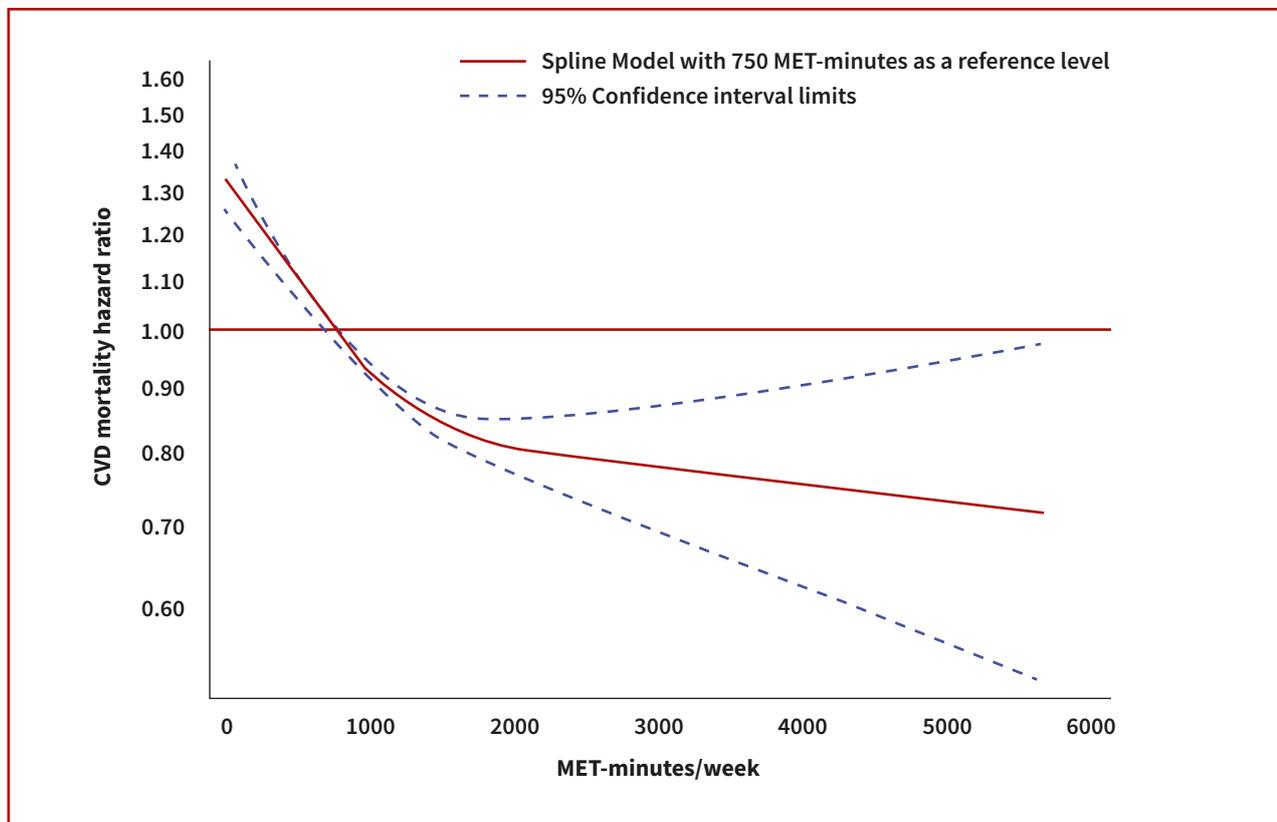
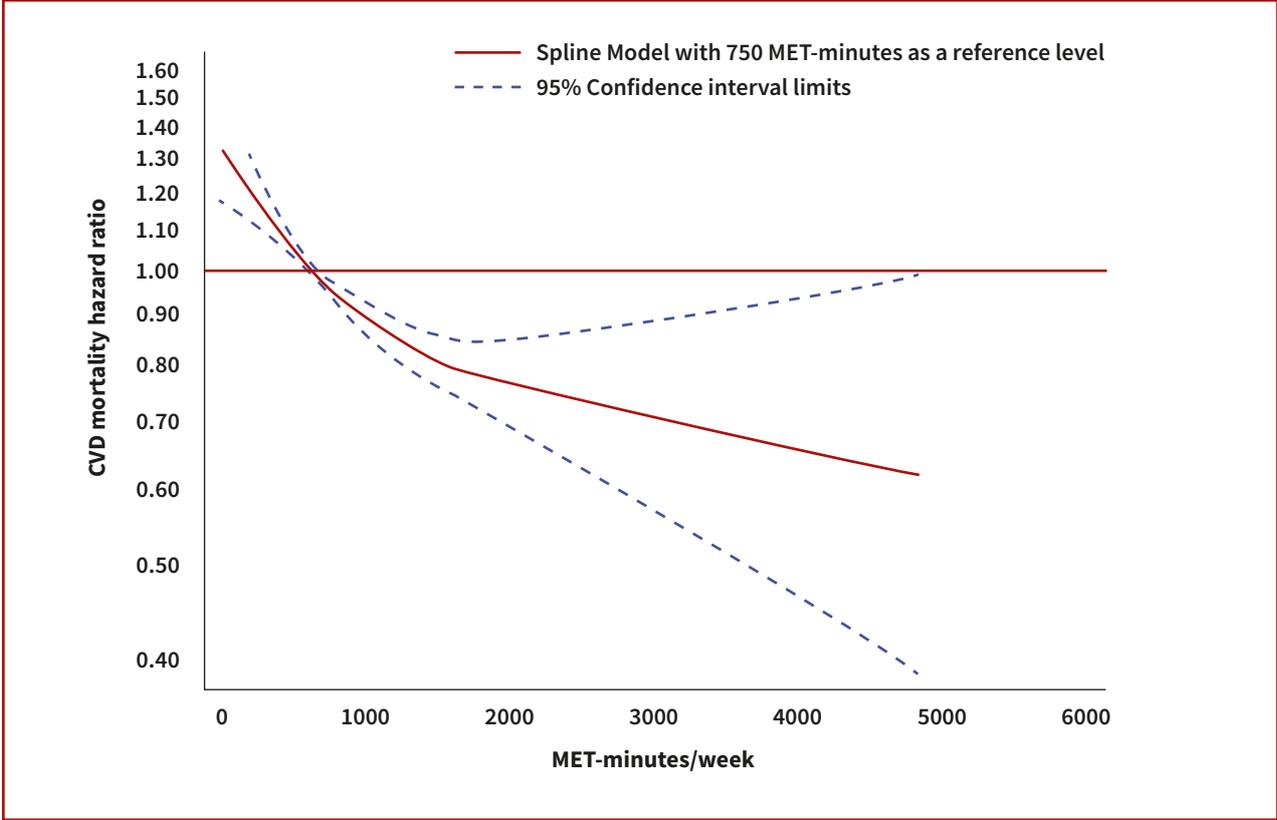


Figure 13 Dose-response relationship between physical activity and ischaemic heart disease mortality. Dose-response relation between metabolic equivalent of task (MET) mins/week (with 750 MET mins/week as the reference) and mortality risk estimated with restricted cubic spline regression and generalised least square trend estimation for summarised dose-response data.<sup>19</sup>



# 8 Recommendations for policy-makers

## Context

The data presented in this document show convincingly the need for effective primary and secondary prevention of cardiovascular disease (CVD). It is clear that physical activity – and especially systematic exercise training – are effective means of CVD prevention, and critical components of promotion of good health more generally. However, the potential public health impact of physical activity is not maximised due to the high prevalence of sedentary lifestyle in most European populations.

It is obvious that there is great need to increase physical activity in the European populations. However, vast experience shows that changing living habits, physical activity included, is very challenging and occurs slowly at best.<sup>236</sup> Therefore, it is important to focus efforts and resources in attempts to increase physical activity in modes that are likely to result in the widest effects. One set of criteria for this purpose are the APEASE-criteria<sup>237</sup> affordability, practicability, effectiveness and cost-effectiveness, acceptability, side-effects/safety and equity considerations. Applying these criteria to physical activity, it is clear that among the physical activity modes walking in various forms best fulfils most of these criteria. Therefore, in general walking should be the primary mode of preventive and health-enhancing physical activity to be increased. Walking has been referred to as the ‘best buy in public health’.<sup>238</sup> This is followed by cycling as, like walking, it can be integrated into daily lifestyles. Other forms of deliberate leisure-time physical activity are then recommended, as long as they are affordable, practical, effective and safe.

## Primary prevention of cardiovascular disease through increasing physical activity

### Global Action Plan

Policy-makers across Europe have a rich menu of options for ways that they might influence public policy to enhance population levels of physical activity and reduce the risk of CVD. As pointed out above, the dose-response relationship between moderate-to-vigorous physical activity and CVD mortality is very similar to that of all-cause mortality, so many of the more general recommendations developed for population health improvement are appropriate here.

The most recent and focused evidence-based collection of policy recommendations for increasing physical across populations has come from the 2018 World Health Organization Global Action Plan on Physical Activity (GAPPA) 2018–2030.<sup>239</sup>

The GAPPA presents 20 clear recommendations for strategic and high-level actions that countries can take to enhance population-level physical activity. These include actions to:

- **create active societies** (through initiatives including communication campaigns and mass participation initiatives);
- **create active environments** (through, for example, work with the transport and environmental sectors);
- **create active people** (through, for example, physical education and primary care programmes); and
- **create active systems** (including policy frameworks, data systems and research capacity).

These recommendations were the output of an extensive and thorough evidence review and consensus process at a global level.



### Case study example – walking in Vienna

Vienna is one of the best European examples of a city-wide approach to promoting walking. The city authorities have focused on walking for many years and have been monitoring walking rates in the city centre since the 1970s. They have made extensive adaptations to the fabric of the city to create environments where people are more likely to choose to walk. Since 2003 the proportion of pedestrian zones and pedestrian surfaces in the City has risen by 30%.

Alongside this has been extensive policy development and promotion and marketing. 2015 was designated the ‘Year of Walking’ in Vienna. This involved multimedia promotion together with events and initiatives such as the publication of a pedestrian route map, competitions and Apps. Around 66% of Viennese citizens supported the year of walking.

More information is available from:

[http://www.mobilitaetsagentur.at/wp-content/uploads/2016/06/Fussgeh\\_Report\\_155x200\\_Englisch\\_RZ.pdf](http://www.mobilitaetsagentur.at/wp-content/uploads/2016/06/Fussgeh_Report_155x200_Englisch_RZ.pdf)

## European Strategy

For policy actions at a European level, more focused recommendations come from the **WHO Physical activity strategy for the WHO European Region 2016–2025**.<sup>240</sup> The strategy aims

*“to inspire governments and stakeholders to work towards increasing the level of physical activity among all citizens of the European Region by:*

- Promoting physical activity and reducing sedentary behaviours;
- Ensuring an enabling environment that supports physical activity through engaging and safe built environments, accessible public spaces and infrastructure;
- Providing equal opportunities for physical activity regardless of gender, age, income, education, ethnicity or disability; and
- Removing barriers and facilitating physical activity.

The strategy lists five priority areas, including 14 objectives. Many of these are highly relevant to the prevention of CVD through increased physical activity and are highlighted below along with a selection of good practice examples from around the region.

### Providing leadership and coordination for the promotion of physical activity

- Ensure that there is high level leadership for physical activity and CVD prevention from the health sector, ideally led by the national ministry of health.
- Establish coordinating groups or committees that bring together diverse sectors with an influence on physical activity, such as health, sports, education, transport, urban planning, environment and social affairs.



#### Case study example – Iceland

In 2005, a project manager responsible for the comprehensive promotion of health-enhancing physical activity (HEPA) was employed for the first time. A national-level expert group has been established involving relevant stakeholders and experts from, for example, universities, ministries, agencies and non-governmental organisations (NGOs). Another valuable step for HEPA promotion in Iceland was the establishment of the multisectoral Health Promoting Community (HPC) steering group and the HPC consultation platform in 2018, which currently comprises representatives from more than 30 stakeholders. These include six ministries, the prime minister’s office and nine governmental agencies.

## Supporting the development of children and adolescents

- Promote physical activity during pregnancy and early childhood. As noted in Chapter 5, this is important to prevent the early development of CVD risk factors.
- Promote physical activity in preschools and schools. This includes an appropriate quantity of high-quality physical education lessons (based on an intersectoral approach that involves the education, sports and health sectors) as well as initiatives to promote physical activity in the school day such as active travel to school and active breaks.

Promote recreational physical activity for children and adolescents including out-of-school physical activity programmes and membership of sports and fitness clubs.



#### Case study example – The city of Novi Sad

Novi Sad is the flagship ‘Healthy City’ in Serbia, where more than 90 km of bicycle paths have been constructed, along with the establishment of public rental schemes and mountain bike routes on the nearby Fruska Gora mountain. In addition, the Novi Sad Biking Initiative, an NGO established in 2011, advocates for cycling as a healthy and sustainable form of urban mobility. For members of its Bikecity (Biciklograd) programme, some discounts are provided by partners of the programme (in theatres, cinemas, libraries, bookstores, and on cycling equipment, etc.).

## Promoting physical activity for all adults as part of daily life, including during transport, leisure time, at the workplace and through the health-care system

- Take action to promote human-powered transport, to increase physical activity in daily life, including in the community and at the workplace. This means specifically aiming to reduce car traffic and increase walking and cycling. This may involve innovative measures such as congestion charges; tax incentives to promote cycling and city cycle schemes; higher parking charges and motor vehicle taxes; revenue ringfenced for public transport and infrastructure systems.

- Provide opportunities for physical activity at the workplace. Active commuting could be promoted by regulations, guidelines or financial incentives for employers for cycle racks, changing rooms, showers and adequate public transport options. Other measures could include action to address the workplace layout, such as the provision of adjustable desks, prominent and promotional signs on staircases encouraging their use, regular breaks during the day to allow for physical activity and membership of a gym or sports club, or, for larger employers, company-run sports facilities and programmes. Changes to workplace culture might include allowing more flexible working hours and styles of working to include active breaks, and working from home policies that would allow more time for physical activity to be incorporated into the working day.



### Case study example – cycling policy in Copenhagen

Copenhagen has set itself the goal of becoming ‘the world’s best bicycle city by 2025’. Achieving this goal is also viewed as integral to the city’s health plan, to the environmental goal of making the city CO2 neutral by 2025, and to enhancing the liveability of the city.

Around 150 000 people cycle each day to work or educational institutions in the City of Copenhagen, representing a modal share of 36% of all trips. Copenhagen’s plan for achieving a greater proportion of daily journeys undertaken by bicycles includes increasing the capacity of the cycle tracks to the city centre, in order to accommodate an additional 60 000 cyclists by 2025.

According to the City of Copenhagen’s Bicycle Strategy 2011–2015:

- The number of kilometres cycled [in Copenhagen] has risen by around 30% since 1998.
- The bicycle’s modal share for trips to work or educational institutions has risen to over a third [since 1998].
- The bicycle [is now] the most popular form of transport for commuting in Copenhagen.

Many cities in Denmark have invested heavily in infrastructure for cycling and the government has financed part of the local investment. Copenhagen has managed to increase cycling by 30% over the past two decades despite an initial high level, while during the same period decrease cycle-related injuries to one third of their level.<sup>241</sup> The second and third city of Denmark have increased cycling 10–20% in the same period. This example from Denmark shows that it is possible to increase physical activity across the population even if global trends have shown no increase the past decade.<sup>16</sup>



### Case study example – Lithuania: Health Enhancing Workplace Awards

Health Enhancing Workplaces Award contest is used in Lithuania as an effective way of encouraging employers to provide better conditions for their employees’ physical and mental health. Health Enhancing Workplace award contest has taken place on regular basis since 2016. The first national award contest, Health Enhancing Company-2016, was organised, with its thematic motto: “Health promotion at any age.”

The contest aims to select the best examples of companies with health-enhancing policy for all age groups, paying particular focus to physical health promotion through physical activities at a workplace. Methodological tools are developed to help employers take action. Participating workplaces include public, business enterprises and companies, as well as non-governmental organisations.

An awards ceremony takes place usually during international conferences, organised by national and international stakeholders, and served as a good example for the other company administrations. Some examples of the type of activities previous award winners have implemented include: supplying workers with ergonomic and physical activity enhancing equipment such as height adjustable office table, active balanced ‘Sit Fit’ chairs, ergonomic back-support chairs, eye massagers working with computers, and providing employees with showers to use after conducting physical activity breaks.

- Integrate physical activity into prevention, treatment and rehabilitation, notably for CVD. The promotion of physical activity by health professionals should become the norm. Early identification, counselling and referral at the primary care level should be integrated into standard practice and should respond to the different needs of patients. For the general population, a simple assessment of the level of physical activity could be integrated into the ongoing risk factor assessment, followed by brief advice, if required. For patients with existing health conditions, including CVD, physical activity should be a core aspect of patient care and rehabilitation.
- Improve access to physical activity facilities and offers, particularly for vulnerable groups, including the unemployed, adults with low incomes and people with disabilities.

### Promoting physical activity among older people

- Improve the quality of advice on physical activity by health professionals to older people, tailored to their individual health needs, capacity and preferences.
- Provide infrastructure and appropriate environments for physical activity among older people, including barrier-free workplaces, flexible working hours and modified work environments for older people; well-lit footpaths and safe local neighbourhoods; and barrier-free access to health centres and rehabilitation programmes.
- Involve older people in social physical activity, particularly those from socially disadvantaged backgrounds. Actions might focus on settings such as community centres, social clubs, faith-based institutions and non-governmental organisations.



#### Case study example – England: Moving health care professionals

Moving health care professionals is a multi-component, partnership-based programme to increase the awareness and skills of health professionals and to change their clinical practice in promoting physical activity to patients at high risk of or with health conditions. The programme provided physical activity sessions to over 20 000 health care professionals, and its e-learning modules have been completed over 10 000 times by these professionals.

### Supporting action through monitoring, surveillance, evaluation and research

- Strengthen surveillance systems including ensuring that data on physical activity are collected and analysed to inform evidence-based actions.
- Strengthen the evidence base for physical activity promotion, notably evaluating the effectiveness of interventions to increase physical activity.

## Secondary prevention of cardiovascular disease through increasing physical activity, and rehabilitation after cardiovascular disease

### Cardiac rehabilitation

The importance of secondary prevention is made clear in the position papers from the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation<sup>156</sup> and the European Heart Network (<http://www.ehnheart.org/patients/papers/1166:revised-ehn-paper-on-cardiac-and-stroke-rehabilitation.html>). This points out that increasing awareness of the importance of cardiovascular prevention is not yet matched by the resources and actions within health-care systems. There is strong evidence for the effectiveness of exercise-based cardiac rehabilitation in helping to decrease morbidity and mortality in ischaemic heart disease, in particular after myocardial infarction but also incorporating cardiac interventions and chronic stable heart failure. However, integration of prevention strategies into daily practice is still inadequate. In Europe only about a third of ischaemic heart disease patients receive any form of cardiac rehabilitation, with considerable variation between European regions.<sup>242</sup>

- Health systems should ensure that systems are in place for routinely offering exercise-based cardiac rehabilitation to patients after ischaemic heart disease.<sup>243</sup>
- Rehabilitation programmes should be accessible for all eligible patients, regardless of gender, age, socio-economic status, ethnicity or location.<sup>243</sup>
- Such rehabilitation programmes should be based on best available evidence, and should focus on early risk stratification, use of referral services and initiation of treatment to stop the progress of an established disease process.<sup>128</sup>
- Consideration should be given to the development of home-based cardiac rehabilitation programmes, which can provide a viable alternative to programmes offered in a medical facility.<sup>170</sup>
- Specific programmes should be put in place to tackle common barriers to effective secondary prevention found across Europe: poor availability of structured secondary prevention programmes; low rates of referral to structured secondary prevention interventions; and lack of quality and minimum standards in the delivery of preventive programmes.<sup>128</sup>
- Health systems should ensure that peer support is included in cardiac rehabilitation programmes.



### Case study example – Sweden exercise referral (EU-PAP)

The aim of the EU-funded ‘physical activity on prescription’ programme is to transfer the ‘physical activity on prescription’ best practice to 10 other countries in Europe.

What is unique about the Swedish physical activity on prescription (PaP) method is that:

- the counselling and prescription are individualised, based on the patient’s circumstances;
- all licensed health-care professionals with adequate expertise may prescribe; and
- the patients participate in exercise activities outside the direction of health-care services – a central component in PaP is to integrate physical activity into everyday life.

The PaP method is built on five core components:

- An individualised/people-centred approach;
- A written prescription that states the type of physical activity, dose (frequency, relative intensity, and duration), prescribed activities, and contra-indication;
- Follow-up of both the health outcome and the level of physical activity;
- FYSS-a scientific handbook with physical activity recommendations for various diseases. <http://www.fyss.se/in-english/chapters-in-fyss/> Physical Activity in the Prevention and Treatment of Disease ([www.fyss.se/](http://www.fyss.se/)); and
- Collaboration with activity organisers to develop a supporting environment to help individuals to increase and maintain their activity level.

Research is indicating that:

- The method is effective primary health care measure for increasing physical activity for at least 12 months.
- The adherence to the method is as good as to other long-term treatments.
- PaP improves quality of life and cardio metabolic risk factors.

More info via <https://www.eupap.org/about>



### Case study example – France: Adapted physical activity

Adapted physical activity has been used in France to enable people with chronic diseases to have a physically active lifestyle in order to reduce their risk factors and the functional limitations due to their condition. Several local authorities have introduced ‘sport on prescription’, a similar concept, but with different approaches. The aim of all the schemes is to encourage people with long-term conditions to practise regular, sustainable, adapted physical activity. Usually, a general practitioner identifies a patient’s needs in terms of physical activity and prescribes it as part of care. The beneficiary is then referred to local sports associations that offer sport-health programmes supervised by trained educators, after an interview and physical tests to design a individualised programme. Once the programme is finished, personal follow-up and support are offered. Some of the results of this programme include increased physical activity time and less time spent on sedentary activities, improved physical capacity and more motivation to practise physical activity.



### Case study example – Spain

The ‘Live active’ (*Viu actiu*) programme is a local service in Benicarló Castellón in the autonomous community of Valencia. It comprises assessment and prescription of customised physical activity programmes in health and sport centres for patients with conditions or diseases, such as diabetes and obesity, which are supervised by health practitioners such as doctors, nurses and physiotherapists and by professionals in physical activity and sports. After diagnosis by a general practitioner a physical activity or sports professional interviews the patient and offers either an individual programme comprising local walks or group activities for muscle strengthening or aerobic activities. Patients are monitored annually and individual reports issued.

## Physical activity after stroke

The 11th World Stroke Organisation Congress in 2018 highlighted the urgent need for effective, equitable and sustainable interventions to improve life after stroke. Physical activity reduces modifiable risk factors for first and recurrent stroke, and it improves function and activity during rehabilitation and following discharge. This compelling evidence urgently needs to be translated into seamless pathways to enable stroke survivors across the world to engage in a more active lifestyle.<sup>244</sup>

- Health systems should ensure that there are seamless, sustainable, evidence-based physical activity pathways to support stroke survivors and their families.<sup>244</sup>

## Effectiveness of physical activity interventions

A recent review of interventions in the global literature on physical activity interventions included more than 200 reviews on thousands of single studies.<sup>245</sup> Around 20% of the reviews were geared primarily to adults with pre-existing diseases. This review made one clear evidence-based recommendation for promoting physical activity among adults with pre-existing disease:

- In the health-care setting, measures to promote physical activity in adults with pre-existing diseases must be (1) theory-based, (2) specific to physical activity behaviour and (3) tailored to the respective target group. In this context, exercise referral schemes have also proved recommendable.

In conclusion, there is a wide range of potential interventions and approaches that can be taken at local, national and European level. There is no single solution, but rather there needs to be action taken across the system, addressing the multiple determinants of physical activity behaviour. And interventions need to be designed and applied specifically according to the needs and circumstances of citizens and members of specific target groups.

## 9 Conclusion

As shown in this report regular physical activity plays a critical role in the prevention and treatment of cardiovascular disease (CVD) across Europe. The declining (age-adjusted) rates of cardiovascular disease across Europe show that we have had some successes with prevention efforts.

However, each year CVD disease still causes 3.9 million deaths across Europe and recent trends show there is a slowdown in CVD mortality improvements, leading to growing concern that the rate of CVD-related deaths may begin to increase again.

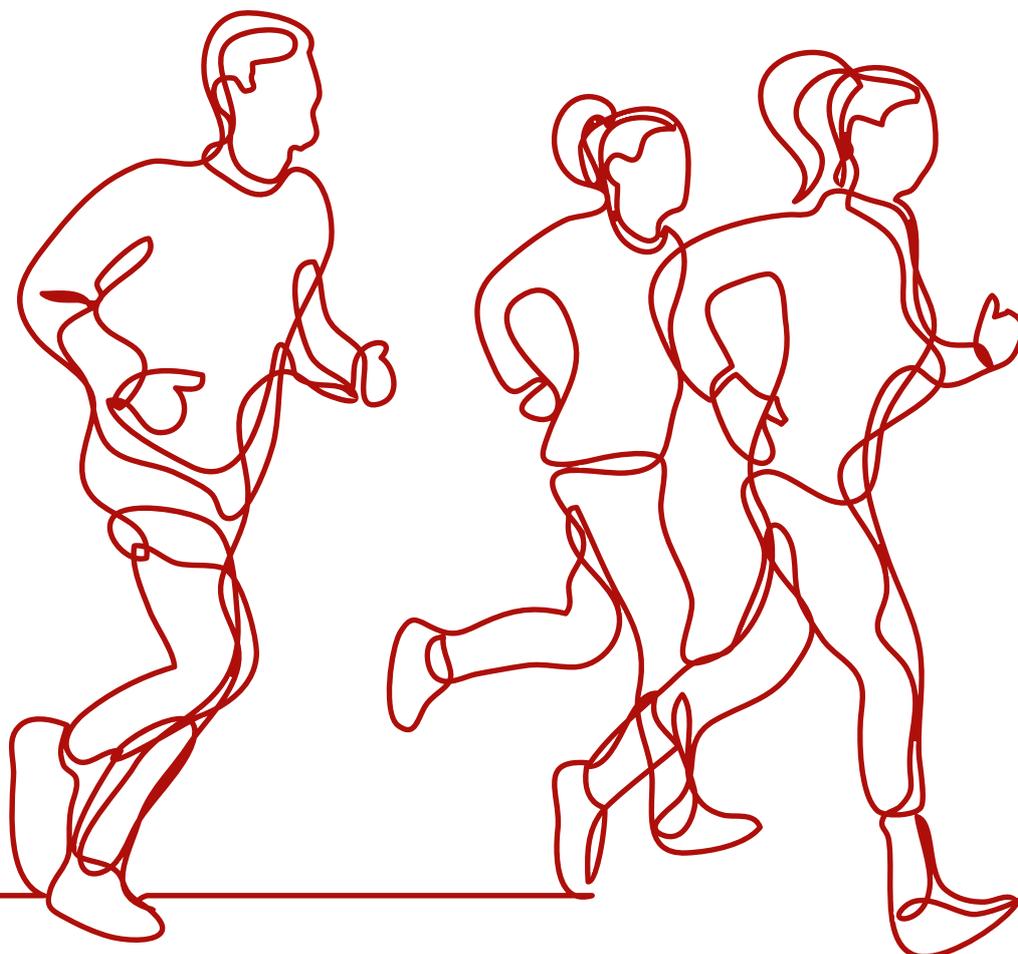
The wide variations in death rates across Europe show that significant challenges exist especially for those countries that (still) suffer from the highest burden of CVD mortality and morbidity.

Physical activity appears to have often been overlooked by policy-makers focused on CVD prevention. Yet it is a natural, universally accessible healthy behaviour with very few negative side-effects. In fact, the 'side-effects' (or 'by-products' of higher physical activity in a population) are also healthy and important:

cleaner air; reduced use of fossil fuels; lower carbon footprints; and greater social inclusion.

Physical activity also plays a critical role in secondary prevention and rehabilitation for a wide range of conditions. Physical activity can be the difference between people recovering from cardiovascular disease and returning to normal active life or continuing life as a patient. And yet again exercise-based cardiac rehabilitation appears to be being under-utilised, with insufficient policy actions being taken to integrate physical activity into normal care. And yet it does not have to be complex or over-demanding: even low levels of physical activity have health benefits; and rehabilitation programmes can be undertaken at home.

Action needs to be taken across the 'system' at all levels. Policy-makers should focus on ensuring physical activity is central to CVD prevention and treatment. There are clear recommendations from the European Union and WHO reports, and these should be the focus of a renewed effort to place physical activity on the 'top of the podium' across Europe.



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