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Physical Activity and Cardiovascular Health

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1. Introduction

The approach of this chapter makes the assumption that relationships between levels of physical activity and cardiovascular health are complex. The theoretical framework considers that physical activity can influence cardiovascular health by itself but can also influence health-related fitness, which in turn may be able to influence cardiovascular health and the level of habitual physical activity. To add more complexity, all these relationships are thought to occur in a reciprocal manner.

Cardiovascular disease corresponds to a group of disorders occurring in the heart and in the blood vessels. The various manifestations of the disease include sudden death, myocardial infarction, angina pectoris, stroke (ischemic or hemorrhagic), or peripheral vascular disease. The risk factors for the cardiovascular diseases are classified usually considering the positive or negative association with the disease and the modifiable or non-modifiable nature. On the other hand, the definition of criterions to some risk factors could be dependent of the context of prevention – primordial, primary, secondary, tertiary or even quaternary. Additionally, it is necessary the plausibility theoretic and biological, and the reversibility of the effect by the reduction or suspension of the risk factor. Modifiable risk factors like dyslipidemia, hypertension, diabetes, excess of adipose tissue, pro-coagulant state, pro-inflammatory state, ignorance, sedentariness or low fitness play alone or, more frequently, in conjunction with each others, augmenting exponentially the risk of disease.

White Paper on Sport (CEC, 2007) was released by the European Union (EU) to give strategic orientation on the role of sport in Europe. The document use the definition of "sport" established by the Council of Europe: "all forms of physical activity which, through casual or organized participation, aim at expressing or improving physical fitness and mental well-being, forming social relationships or obtaining results in competition at all levels." With the ratification of the Lisbon Treaty in late 2009, sport was assumed as contributing to the EU strategic objectives of solidarity and prosperity. This follows the Olympic ideal, born in Europe, of developing sport to promote peace and understanding among nations and cultures as well as the education of young people. Member States are encouraged to implement evidence-based policies in order to improve their provision of sporting facilities and opportunities. This means that for the first time the EU is actively

aiming to promote sport and physical activity at the policy level – not only with a view to improving physical wellbeing and health across the EU, which is the main focus of this chapter, but also to enhance the role of sport in boosting social cohesion and its educational value. This chapter will explore the relationship of cardiovascular health with sport, as the European understanding, or physical activity in the North American understanding. Physical activity concept, physical activity epidemiology and cardiovascular health, physical activity guidelines, prevalence of sedentariness in Europe and USA, physical activity and life expectancy, and pro-inflammatory state and physical activity are topics explored in this chapter.

2. Physical activity

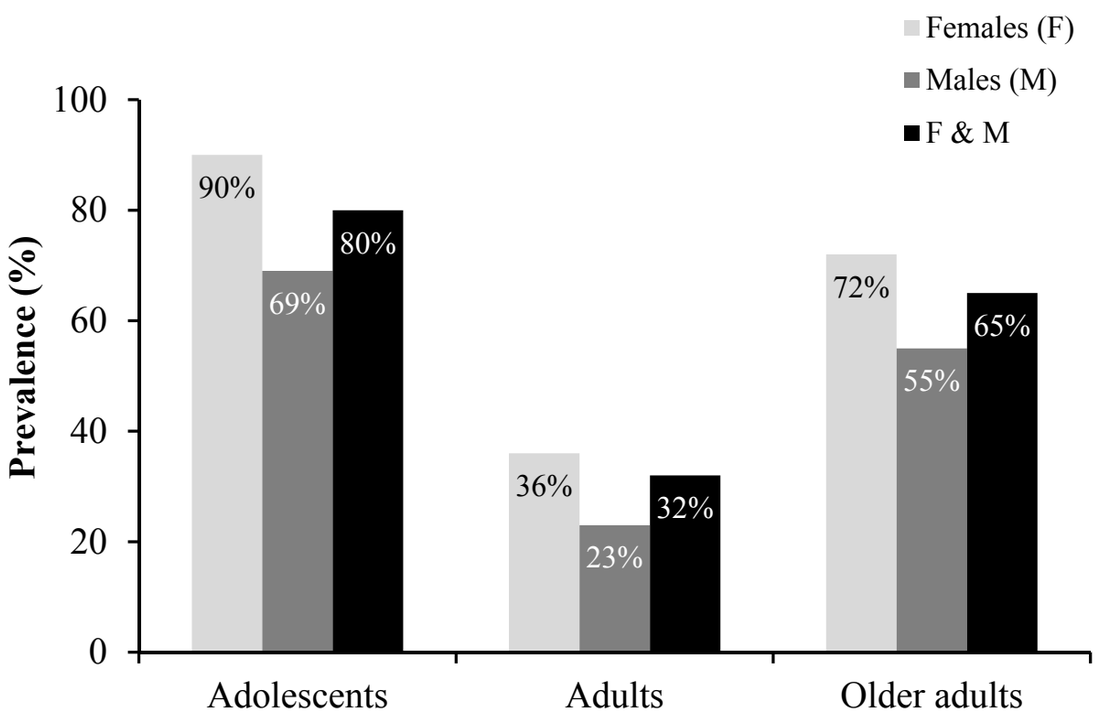
Physical activity comprises any body movement produced by the skeletal muscles that results in a substantial increase over the resting energy expenditure (Bouchard & Shephard, 1994). Included in this large umbrella is considered the leisure-time physical activity (LTPA), daily physical activities, intentionally practiced exercise (frequency, intensity, type, time) and sport, or occupational work, together with other physical expressions that modify the total energy expenditure. Within the concept of physical activity, physical exercise is a narrow concept, usually defined as planned and repeated movements intending to maintain or to improve one or more components of the health-related fitness or of the performance-related fitness. Physical activity has been understood as a behavior that could also change health-related or performance-related fitness. However, it is also taken in account as a determinant behavior to health and functionality. When one is talking about the potential benefits on health, obviously, all determinants of human energy expenditure should be under careful consideration. Contrarily, sedentariness refers that people remain sitting much of the labor and leisure times.

There are a lot of methods to characterize and measure the behavior *physical activity* including calorimetry (direct and indirect), physiologic markers (heart rate or maximal oxygen uptake) mechanical and electronic devices (pedometers and accelerometers), the observation of behaviors, or the caloric intake (Welk, 2002). Independently of the selected method, the investigator should consider the complex nature of the behavior physical activity and the errors derived from the method usually used with largest number of participants – the self-reported questionnaires. The use of questionnaires imply low costs but sometimes introduces considerable error because, for instance, could exist social tendency to associate physical activity to sport participation. It means that it is desirable to use direct methods as pedometers or accelerometers. Pedometers count the number of steps but are not able to distinguish different levels of activity. This limitation is overcome by the accelerometry, and the last National Health and Nutrition Examination Survey (NHANES) realized in 2003-2004 evaluated physical activity of around 4867 American citizens with accelerometry (Troiano et al., 2008).

3. Prevalence of sedentariness

A national representative study of Portuguese people has measured directly physical activity by accelerometry (Baptista et al., 2011). Volunteered to participate 5231 adolescents (10-17 years-old; 1456 males; 1755 females), adults (18-64 years-old; 441 males; 803 females),

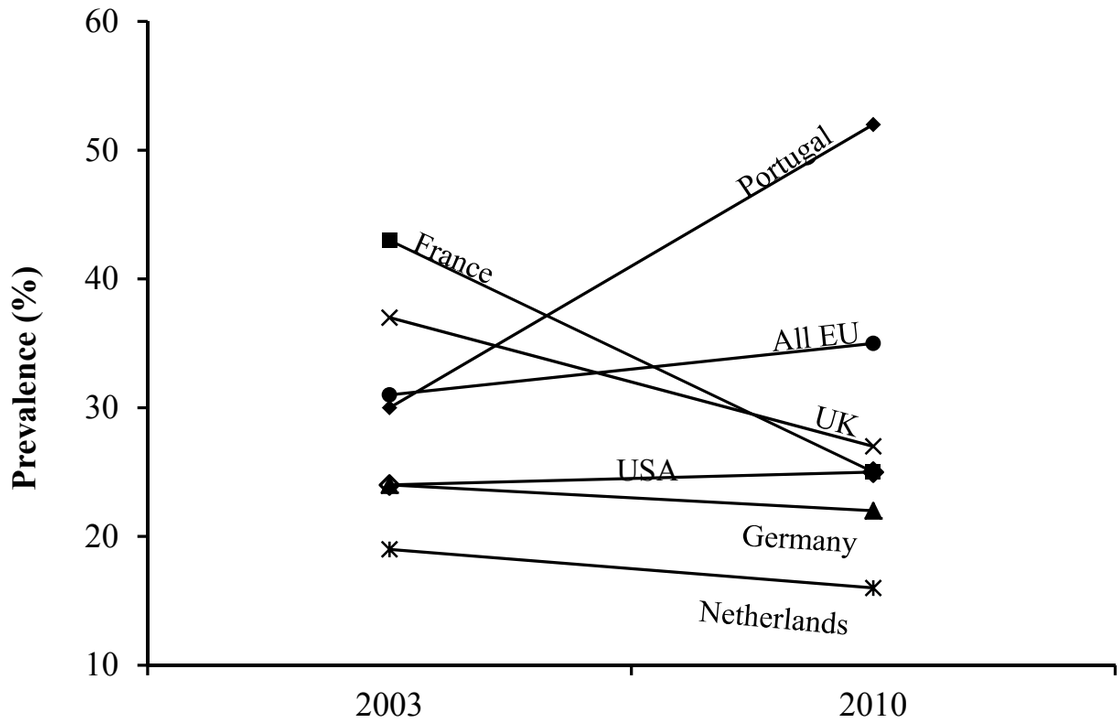
and older adults (65+ years-old; 303 males; 473 females). All participants were measured during four days (two week days and two weekend days). The cut-off points for moderate intensity were 3-5,9 METs (adults and older adults) and 4-6,9 METs (adolescents), and for vigorous intensity were 6+ METs (adults and older adults) and 7+ METs (adolescents). Adolescents with less than 60 minutes/day of moderate/vigorous physical activity on 5 days/week, and adults or older adults with less than 30 minutes/day on 5 days/week were classified as 'insufficiently active'.



Source: Baptista et al., 2011.

Fig. 1. Prevalence of 'insufficiently active' Portuguese people measured by accelerometry.

As illustrated by Figure 1, the prevalence of insufficiently active people was particularly high in the adolescents (80%) but also in the older adults (65%). The adult people (18-64 years old) attained only 32%, which represents the group with higher volume of moderate/vigorous weekly physical activity. The prevalence of insufficiently active in all the people evaluated was 67%. Males are more active than females, in each one of the three groups, with higher difference (21%) among adolescents and lower difference among adults (13%). One can speculate that the indirect methods like self-reported questionnaires tend to overestimate physical activity when compared with a direct measure (accelerometry), as seems to result when one compares these overall data (67%) with data provided from Eurobarometer 2003 (30%) and Eurobarometer 2010 (52%) on Figure 2. However, the high prevalence of insufficiently active, particularly in adolescents and older adults, claim for the adoption of specific strategies to change these sedentary behaviors.



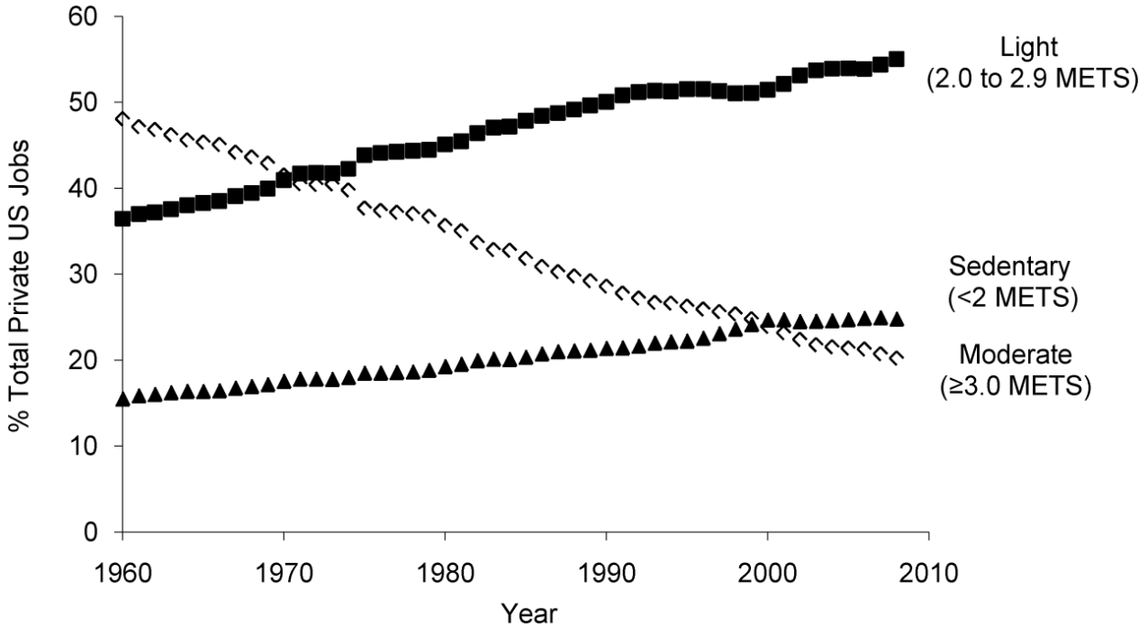
USA data is No Leisure-Time Physical Activity in 2003, and 2008.

http://www.cdc.gov/nccdphp/dnpa/physical/stats/leisure_time.htm. Extracted on 24/Oct/2011.

Fig. 2. Prevalence of the sedentariness in some EU Member States measured by self-reported questionnaires.

Data from the 2003 Eurobarometer (EC, 2003) are presented in Figure 2. Sedentary people are those not meeting the threshold for low activity. Cut-off points for low physical activity participation were 30 minutes of walking or moderate-intensity activity on at least 5 days/week, or 20 minutes of vigorous-intensity activity on at least 3 days/week. Participated people from each one of the EU Member States with 15+ years-old (N=16230), randomly sampling with probability proportional to population size (for a total coverage of the country) and to population density (metropolitan, urban, and rural areas). It was used the International Physical Activity Questionnaire (IPAQ) to characterize physical activity in a face-to-face interview in people's home and in the appropriate national language. Frequency of 5+ days/week of moderate intensity physical activity was not achieved by 72% of EU Member States citizens (equal for women and men) while 74% did not achieve 3+ days/week of vigorous intensity physical activity (81% on women, and 68% on men). Prevalence of people who do not practiced 3+ days/week of vigorous intensity increases with age from 66% (15-25 years) to 69% (26-44 years), to 76% (45-64 years), and to 89% (65+ years). Prevalence of people not engaged on 5+ days/week of moderate intensity also increases with age: 70% (15-25 years), 70% (26-44 years), 72% (45-64 years), and 79% (65+ years).

The 2010 Eurobarometer (EC, 2010) analyzed people with 15+ years-old of 27 EU Member States (N=26788), with a different self-reported questionnaire than IPAQ, and revealed a prevalence of 27% for people saying they engage in physical activity regularly at least 5 times/week, while 38% answered that exercising with some regularity (1-4 times/week) (Figure 2). The other 35% EU citizens never engage in any physical activity or engage below the desirable level (1-3 times/month). By analyzing data from some EU Member States it is possible to observe clear discrepancies in the values from 2003 to 2010. These discrepancies maybe is reflecting partially the utilization of different instruments with different self-reported answers. Sedentariness was considered in Eurobarometer 2010 to the people that engage only 1-2 times/month or even less in physical activities. With these cut-off points, sedentariness was respectively in 2003 and 2010: Portugal - 30% and 52%; France - 43% and 25%; Germany – 24% and 22%; UK – 37% and 27%; Netherlands – 19% and 16%; All EU – 31% and 35%.

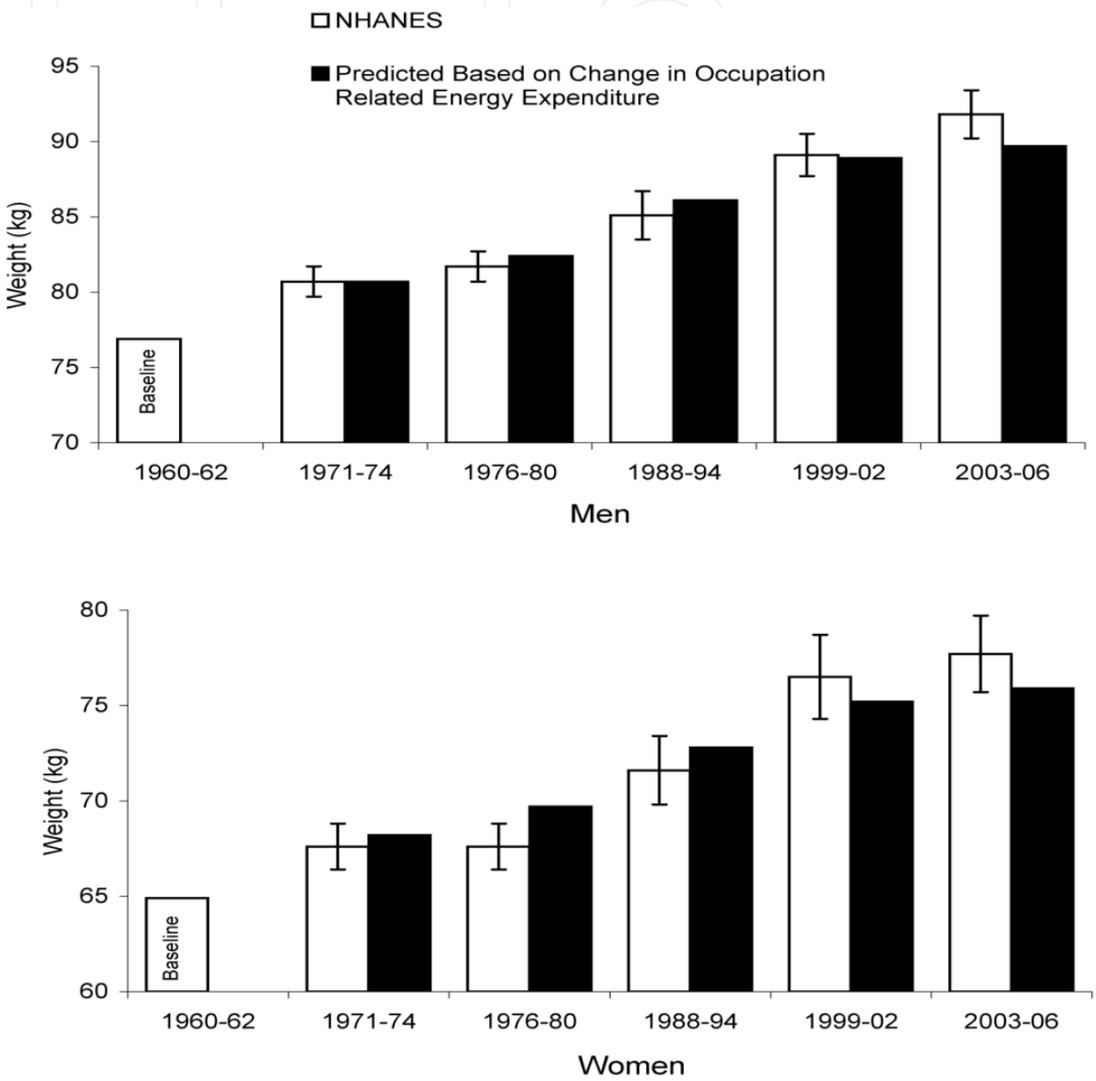


Source: Church et al., 2011.

Fig. 3. Trends in the prevalence of sedentary, light and moderate intensity occupations from 1960 to 2008.

Troiano and colleagues (2008) have described physical activity levels of children (6-11 years old), adolescents (12-19 years old), and adults (20+ years old), using objective data obtained with accelerometers from a representative sample of the U.S. population. The results were attained from the 2003-2004 National Health and Nutritional Examination Survey (NHANES), a cross-sectional study of a complex, multistage probability sample of the civilian, noninstitutionalized population. Data are described from 6329 participants who provided at least 1 day of accelerometer data and from 4867 participants who provided 4+ days of accelerometer data. Males were more physically active than females. Authors observed that physical activity declines dramatically across age groups between childhood (42% obtained the recommended 60 minutes/day) and adolescence (8% achieve 60

minutes/day) and continues to decline in adults (less than 5% attained 30 minutes/day). Objective and subjective measures of physical activity gave qualitatively similar results regarding gender and age patterns of activity. However, adherence to physical activity recommendations according to accelerometer-measured activity is substantially lower than according to self-reported questionnaire. Occupational work is also an important expression of physical activity contributing to energy expenditure and to the energy balance.



Source: Church et al., 2011.

Fig. 4. Predicted mean U.S. body weight based on change in occupation related daily energy expenditure since 1960 compared to mean U.S. weight gain based on the NHANES examination periods for 40–50 year old.

Trends in occupational physical activity during the past 5 decades (Figure 3), and the concurrent changes in body weight in the U.S. were explored by Church and colleagues (2011). Authors observed that in 1960 almost half the jobs (48%) in private industry in the

U.S. required at least moderate intensity physical activity whereas in 2008 less than 20% demand this level of energy expenditure. While there has been a steady increase in the prevalence of sedentary and light intensity physical activity occupations since 1960, the prevalence of moderate intensity physical activity occupations has decreased. At the same period (1960-2008) there was a drop in occupation-related daily energy expenditure of about 142 calories for men and 124 calories for women. Authors estimate that the decrease of 142 calories in men would result in an increase in mean weight from 76.9 kg (1960-62) to 89.7 kg (2003-06), with the results having similar pattern for women (Figure 4).

Over the last 50 years the prevalence of Americans in the labor force has increased approximately 40% to 50%, with women assuming a growing prevalence in the work force from 43% in 1970 to 60% in 2007. This fact helps to explain the decrease in the pattern of occupation-related energy expenditure (Lee & Mather, 2008). Given this, it is unlikely a return to occupations demanding moderate levels of physical activity, which addresses further strong evidence of the public health importance of promoting physically active lifestyles outside of the work day. The reduction of 124 (women) and 142 calories (men) per day in occupation-related energy expenditure over the last 50 years would have been adequately compensated for by meeting the 2008 Physical Activity Guidelines of 150 minutes/week of moderate intensity activity or 75 minutes/week of vigorous intensity activity (USDHHS, 2011). While it is often noted that the prevalence of Americans who achieve this recommendation has been constant over recent decades, the fact remains that based on self-report data only 25% adults achieve this level (CDC, 2008), but when physical activity is assessed with accelerometers the number of adult people achieving the recommendations drops dramatically to less than 5% (Troiano et al., 2008). Therefore, since energy expenditure of the labor activities has largely been removed, the relative importance of LTPA has increased and should be considered as a major focus of public health interventions and research.

Brownson and colleagues (2005) developed a revision to describe current patterns and long-term trends (up to 50 years when possible) related to (i) physical activity, (ii) employment and occupation, (iii) travel behavior, (iv) land use, and (v) related behaviors (e.g., television watching). Available data allows the following trends: relatively stable or slightly increasing levels of LTPA, declining work-related activity, declining transportation activity, declining activity in the home, and increasing sedentary activity. These reflect an overall trend of declining total physical activity, with large differences noted in the rates of walking for transportation across metropolitan areas, and a strong linear increase in vehicle miles traveled per person, coupled with a strong and consistent trend toward people living in suburbs. Authors concluded that although difficult to quantify, it appears that a combination of changes to the built environment and increases in the proportion of the population engaging in sedentary activities put the majority of the population at high risk of physical inactivity.

4. Physical activity guidelines

Vigorous activity was centrally considered to health promotion until 1995 when recommendations of the Center for Disease Control (CDC) and the American College of Sports Medicine (ACSM) pointed out for adults to accumulate at least 30 minutes of moderate-intensity physical activity on most days of the week (Pate et al., 1995). These

recommendations were described in the 1996 U.S. Surgeon General's Report on Physical Activity and Health (USDHHS, 1996), and served as cornerstone for the Healthy People 2010 (HP 2010) goals on physical activity (USDHHS, 2000), inspiring public policies and programs over the next years. The HP 2010 objectives stated that adults should engage in vigorous LTPA (60-84%VO_{2Res} or %HR_{Res}; 77-93%HR_{max}; >60%VO_{2max}; >6 METs) for at least 20 minutes, at least 3 times/week, or moderate LTPA (40-59%VO_{2Res} or %HR_{Res}; 64-76%HR_{max}; 40-60%VO_{2max}; 3-6 METs) for at least 30 minutes, at least 5 times/week.

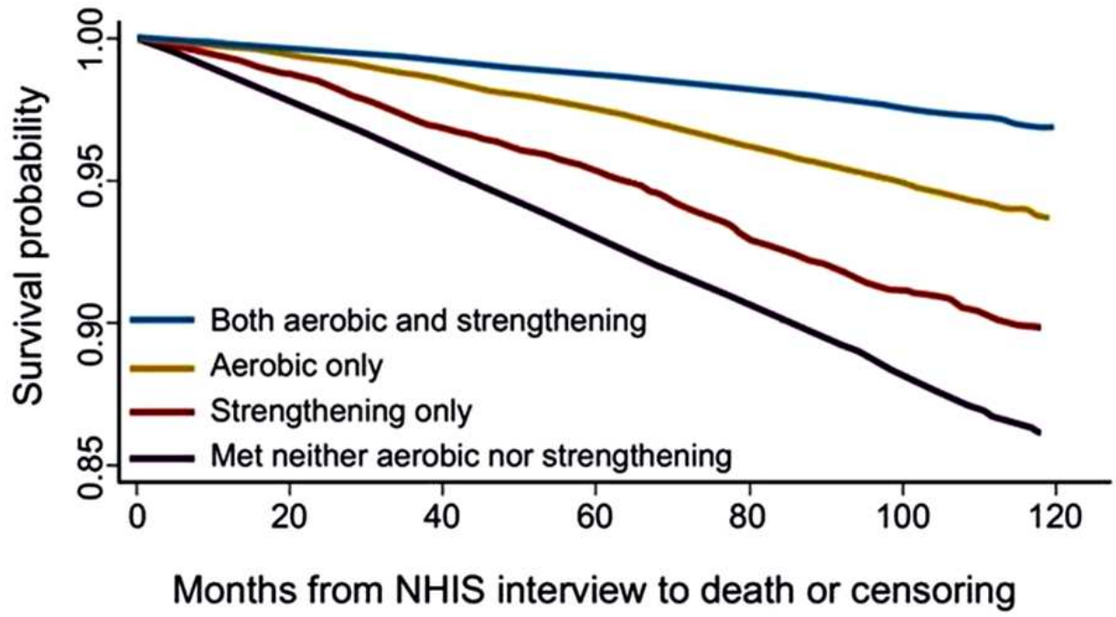
For the purposes of HP 2010, lesser amounts of vigorous and moderate activities could not be combined. In 2007, the CDC/ACSM recommendations published in 1995 were updated and clarified, emphasizing the potential health benefits of combinations of moderate and vigorous-intensity activities and of strengthening activities (Haskell et al., 2007). Meantime, the Healthy People 2020 (HP 2020) goals on physical activity were released (USDHHS, 2010) introducing some modifications, and establishing and encouraging to increase the prevalence of "sufficiently active" adults engaging in moderate-intensity aerobic physical activity of at least 150 minutes/week or vigorous-intensity aerobic activity of at least 75 minutes/week or an equivalent combination. The HP 2020 also pursue to increase the prevalence of "highly active" adults engaging in aerobic physical activity of at least moderate intensity for more than 300 minutes/week or more than 150 minutes/week of vigorous intensity or an equivalent combination. And, finally, to increase the prevalence of adults who perform muscle-strengthening activities on 2 or more days/week of 7 large muscle groups.

5. Physical activity and life expectancy

Mortality differentials by level and intensity of physical activity have been documented, with Lollgen and colleagues (2009) obtaining significant association of lower all-cause mortality for active individuals comparing with sedentary persons. Highly active men had a 22% lower risk of all-cause mortality (RR=0.78; 95% CI: 0.72 to 0.84), and women had 31% (RR=0.69; 95% CI: 0.53 to 0.90) comparing to mildly active men and women, respectively. The authors also found a similar and significant association of activity to all-cause mortality in older participants.

Schoenborn and Stommel (2011) studying the benefits of accomplish the 2008 Physical Activity Guidelines for Adults (USDHHS, 2011), which are similar to the HP 2020 goals, achieved 27% lower risk of all-cause mortality among people without existing chronic comorbidities, and by almost half among people with chronic comorbidities (such as heart disease, stroke, diabetes, cancer, respiratory conditions, or any functional limitation), regardless of age and obesity levels. Assuming several limitations present on causal interpretations, when examining for interactions of physical activity with smoking and alcohol consumption, data suggest that relative survival benefits associated with physical activity are largest among current smokers and light-moderate drinkers.

Figure 5 shows the survival curves associated with four types of adherence to the 2008 Guidelines for all adults: meeting both the aerobic and muscle-strengthening guidelines, the aerobic only, the muscle-strengthening only, and neither of the minimum recommendations. This figure suggests that meeting the 2008 Guidelines is associated with survival benefits, with stronger benefits for both the aerobic and muscle-strengthening exercises; also suggests that aerobic activity alone promotes stronger benefits than muscle strengthening alone.



Note: U.S. adults aged ≥ 18 years (weighted); respondents not linked to death records were considered "censored", meaning they were presumed to be alive as of December 31, 2006. NHIS, National Health Interviews Survey, 1997-2004.

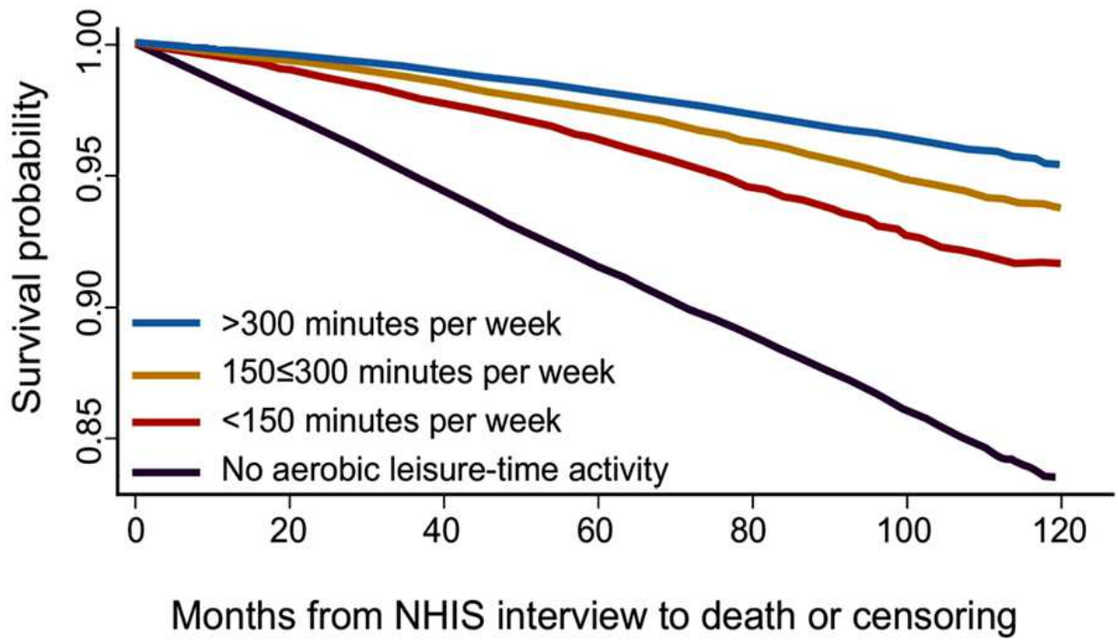
Adapted from Schoenborn and Stommel (2011)

Fig. 5. Survival probabilities by levels of adherence to 2008 Physical Activity Guidelines.

Figure 6 illustrates that higher volumes of aerobic exercise are associated with higher increase in survival probabilities. Those who engage in none aerobic leisure-time activity attained lower survival probability while people that engaged in more than 300 minutes/week have the higher survival probability. In other words, it means that additional survival benefits can be achieved with higher levels of aerobic leisure-time activity.

6. Epidemiology of physical activity and cardiovascular health

Epidemiology has been defined as "the study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to the prevention and control of health problems" (Last, 2001). When this definition considers 'health-related states or events' instead of the former 'disease frequency' is having in account the contemporary definition of health that considers positive health states, as a good quality of life, or well succeeded aging, and not only the absence of disease. The word 'epidemiology' is derived from the Greek words: *epi* "upon", *demos* "people", and *logos* "study". In fact, epidemiology origin based on Hippocrates observation, made more than 2000 years ago, that environmental factors could be determinant for the occurrence of a disease. However, it was only in second half of the XIX century when the first truly epidemiologic investigations appeared (Bonita et al., 2006).



Note: U.S. adults aged ≥ 18 years (weighted); respondents not linked to death records were considered "censored", meaning they were presumed to be alive as of December 31, 2006. NHIS, National Health Interviews Survey, 1997-2004.

Adapted from Schoenborn and Stommel (2011).

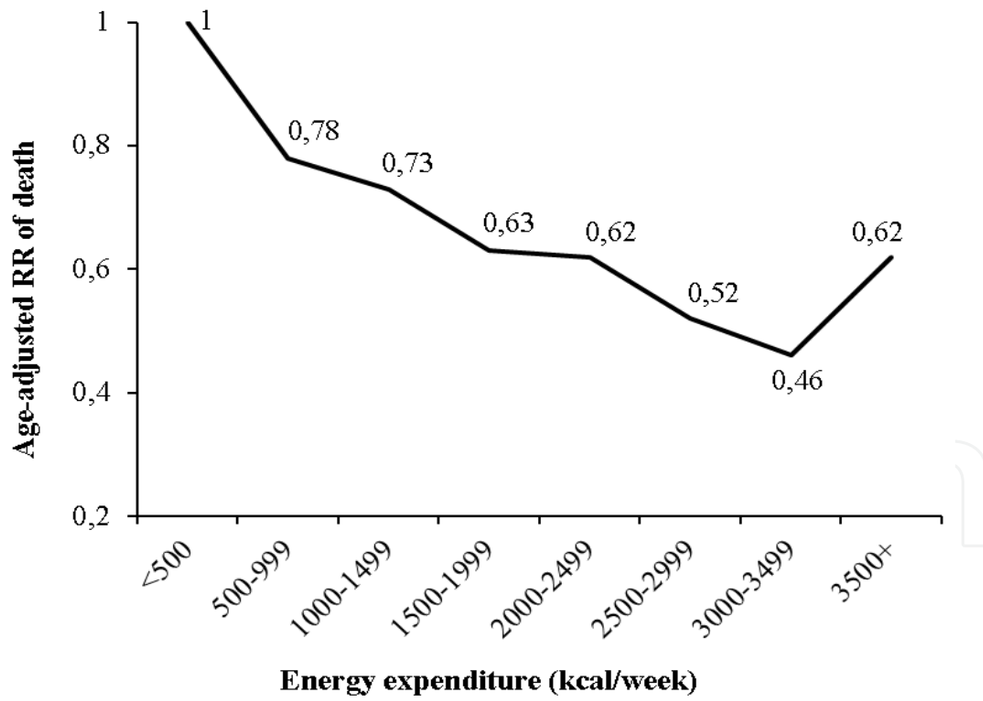
Fig. 6. Survival probabilities by levels of adherence to 2008 aerobic physical activity guidelines.

Physical activity and the relationship with cardiovascular health was firstly studied in an epidemiologic basis by Morris and colleagues (1953a,b). Works were conducted to understand how both vocational and LTPA relate to fitness and risk of coronary heart disease (CHD). Authors studied London transit workers, and other occupations as postal service employees and civil servants. Initially they found bus conductors on London's double-decker omnibuses to be at lower risk than bus drivers; what disease the conductors did develop was less severe, and they were more likely to survive an attack. The conductors, who walked up and down stairs in a daily basis, often for decades, experienced roughly half the number of heart attacks and sudden death as the drivers. After that, Morris and colleagues (1990) studied a random sample of 3591 British civil servants during a follow-up of 8-year period ending in 1977, during which time 268 men died. Subjects were classified as having engaged in vigorous activities (>6 METs), or not. Of the subjects 22% reported some kind of vigorous exercise and their death rate was 4,2%. The remaining 78% reported no vigorous exercise and their mortality rate was 8,2%, i.e., twice as high. This differential in death rates persisted when controlling for age, smoking, obesity and successive intervals of follow up.

Several other populations have been studied for physical activity and physiological fitness in relation to health and specifically cardiovascular health (USDHHS, 1996). One of the most remarkable studies was conducted with 17549 men who entered Harvard College between

1916 and 1950 (Paffenbarger et al., 1978), and when aged 55–84 years responded to a questionnaire on their personal characteristics, health status and lifestyle habits like current and former physical activity, as participation in student sport whilst at university. These patterns have been related to cardiovascular disease mortality over a 16-year follow-up period (1962 to 1978), during which 1413 men died (Paffenbarger et al., 1986a,b).

Among Harvard alumni there were strong significant inverse associations between death rates and levels of each of the following physical activity: walking, stair climbing, sports play and combinations of these activities, measured in kJ/week. Gradients of benefit from more active lifestyles were consistent throughout, and maintained after controlling for age, smoking, hypertension and obesity. As compared with the one-third of least active men, the middle third experienced a 23 % reduction in death rate during follow-up and the one-third of most active men, a 32 % reduction. Light activities (<4METs), moderate activities (4–5METs), and vigorous activities (>6METs) each predicted lower death rates. Physical activity related inversely to total mortality, primarily to death due to cardiovascular or respiratory causes. Death rates declined steadily as energy expended on such activities increased from less than 500kcal/week to 3500kcal/week, beyond which rates increased slightly. This relationship was independent of the presence or absence of hypertension, cigarette smoking, extremes or gains in body weight, or early parental death (Figure 7).



Source: Paffenbarger et al., 1986a.

Notes: Participated 16936 men. A total of 1413 alumni died during 12 to 16 years of follow-up (1962-1978). Exercise reported as walking, stair climbing, sports play, and combinations of these activities.

Fig. 7. Inverse association between weekly energy expenditure and RR of all-cause mortality.

Those men were studied for the effect on all-cause mortality from changing physical activity habits. Men who had increased or decreased their activity by less than 250kcal/week between the 1960s and 1977 were considered in an 'unchanged' category. Compared with their death rates, gradient reductions in mortality were observed with increased levels of physical activity, and gradient increases in mortality with decreased levels of activity. At the extremes of this gradient, men who had increased their energy expenditure by 1250kcal/week had a 20% lower risk of death than men in the unchanged category; men who decreased their activity by 1250kcal/week had a 26% higher risk (Paffenbarger et al., 1993, 1994).

Vigorous activity should be encouraged. Not only because in today's world, where time is a precious commodity, a short period of vigorous exercise expends as much energy as does moderate activity carried out for two or three times as long (Figures 8 and 9), but also because the kind of stimulation over tissues and systems could be more benefic to compensate lost, asymptomatic in an initial stage, that tends to occur with aging.

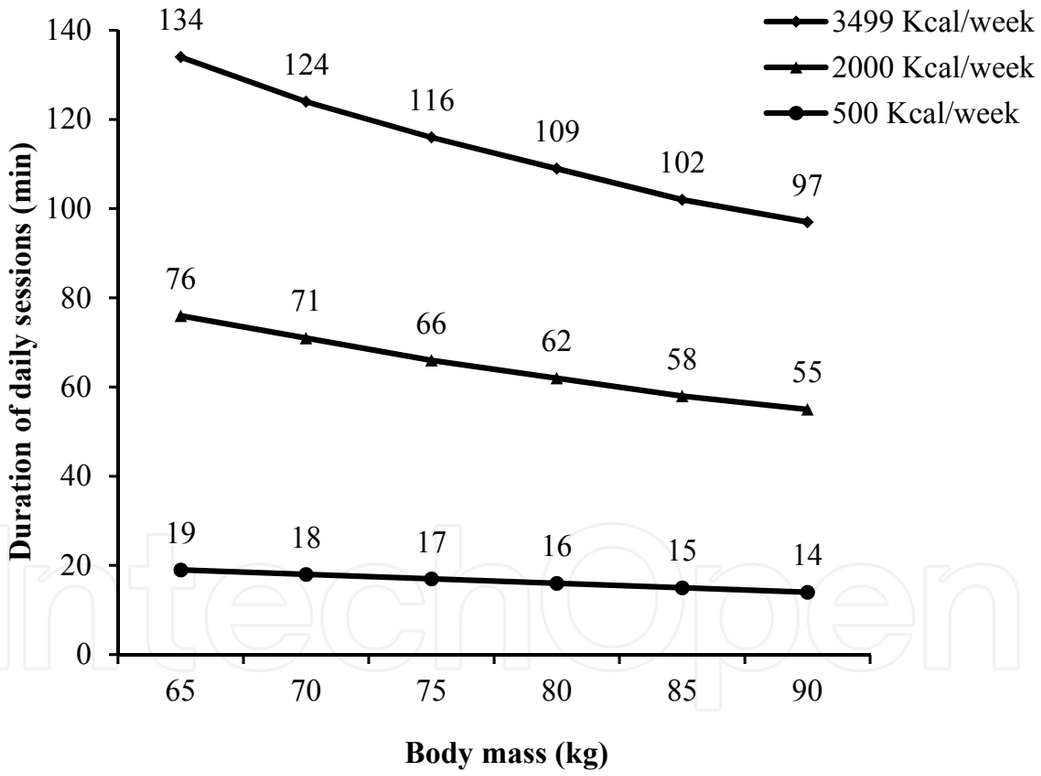


Fig. 8. Duration (min) of daily walking sessions, with moderate intensity (velocity of 80m/min; 3,3METs), for people with different body masses, to gain cardiovascular health (500kcal/week: RR=1,00; 2000kcal/week: RR≈0,62; 3499kcal/week: RR≈0,46).

Figure 8 illustrates time spent with walking at moderate intensity (velocity of 80m/min, or 4,8km/h) by people of different body masses, within the range 500-3499kcal/week (Paffenbarger et al., 1986a). A person weighting 75kg will needs to walk 116 minutes per

each one of the 7 days of the week to maximize the potential benefits of physical activity on cardiovascular health, i.e. to spend 3499kcal/week (RR=0,46). In other words, and taking in account the work of Paffenbarger and colleagues (1986a) illustrated by the Figure 1, a person of 75kg will obtain progressive cardiovascular gain from 17 minutes of horizontal walking (RR=1,0) to 116 minutes of daily horizontal walking (RR=0,46). However, if that same person of 75kg of body mass decides to exercise at vigorous intensity (Figure 9), 40 minutes of horizontal running at 150m/min (9km/h) will be enough to maximize the potential gains on cardiovascular health.

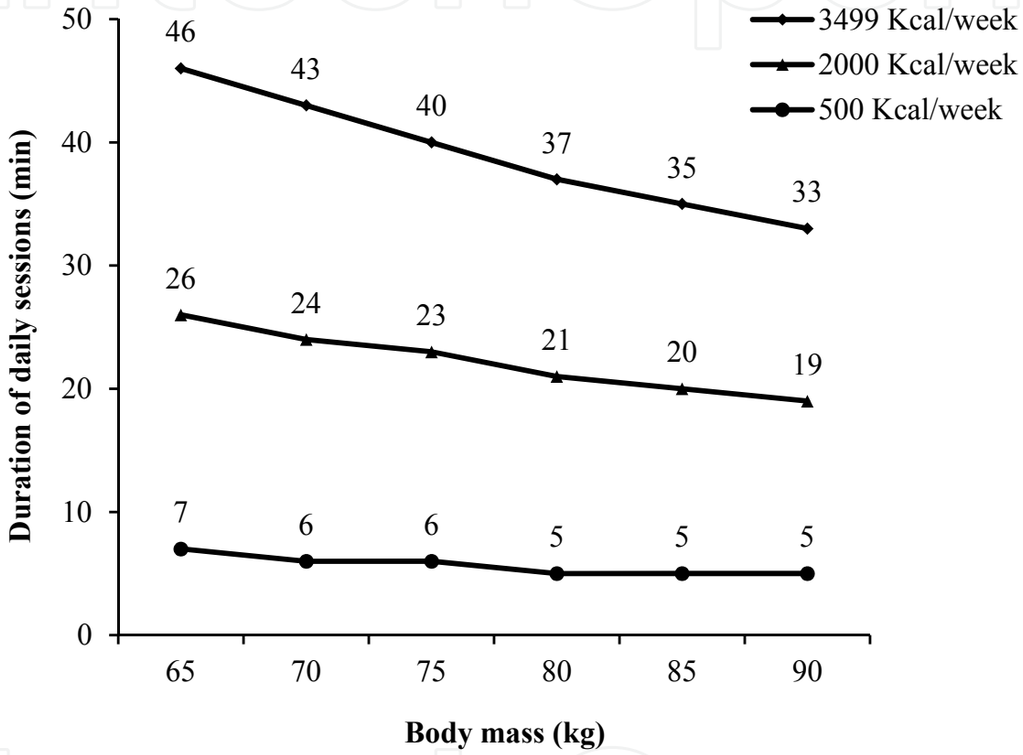
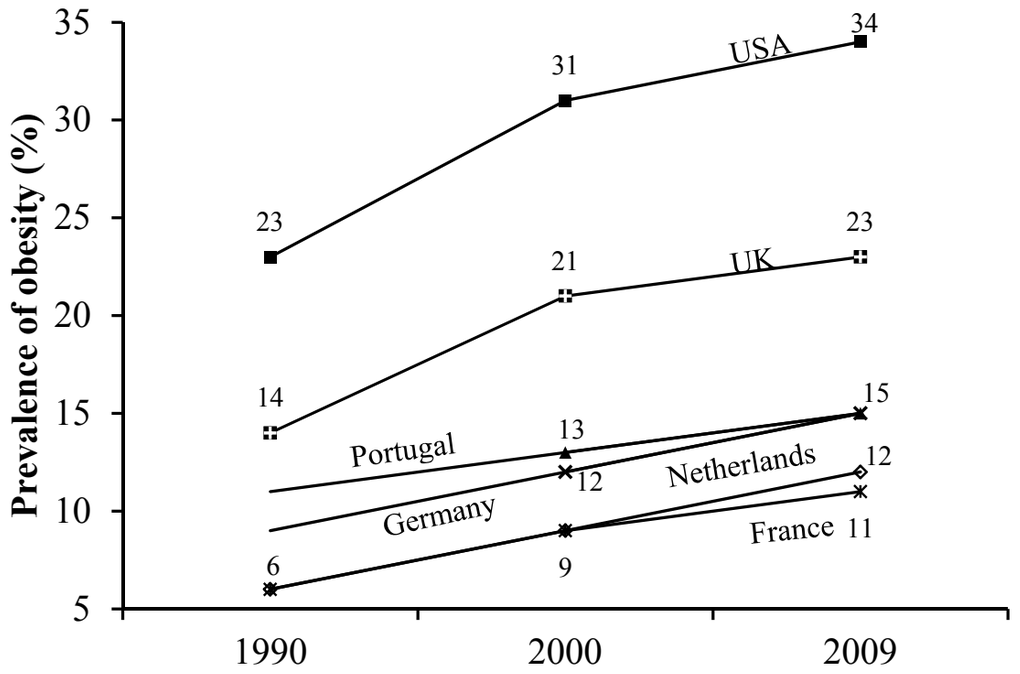


Fig. 9. Duration (min) of daily running sessions, with vigorous intensity (velocity of 150m/min; 9,6METs), for people with different body masses, to gain cardiovascular health (500kcal/week: RR=1,00; 2000kcal/week: RR≈0,62; 3499kcal/week: RR≈0,46).

7. Pro-inflammatory state and physical activity

Inflammation has emerged some years ago as a key pathophysiological event in vascular diseases and the consequent cardiovascular and cerebral injury. Inflammation is a complex process involving multiple cellular and molecular components, and is triggered by different pro-inflammatory mediators generated directly and indirectly by microbial invasion, endotoxins, immune complexes, and cytokines. Vascular endothelium is subjected to pro-inflammatory insults but fortunately is awarded with strong anti-inflammatory molecules that confer resistance to damage by transient pro-inflammatory attacks.

Inflammation is a natural response to infection or damage that intends to destroy or to inactivate the foreign agents permitting tissues repairing. Inflammation could be a local or systemic response, and the key mediators are the cells that act as phagocytes, with the most important being neutrophils, macrophages, and macrophages-like cells. The sequence of local events in a typical nonspecific inflammatory response includes: (i) vasodilatation of the microcirculation in the infected area, leading to increased blood flow; (ii) large increase in protein permeability of the capillaries and venules in the infected area, with resulting diffusion of protein and filtration of fluid into the interstitial fluid; (iii) chemotaxis: movement of leukocytes from the venules into the interstitial fluid of the infected area; (iv) destruction of bacteria in the tissue either through phagocytosis or by other mechanisms; (v) tissue repair (Widmaier et al., 2011). The events of inflammation, such as vasodilation, are induced and regulated by several chemical mediators including kinins, complement, products of blood clotting, histamine, eicosanoids, platelet-activating factors, cytokines, nitric oxide, C-reactive protein (CRP). CRP is an acute phase protein produced by the liver, always found at some concentration in the plasma, and act to minimize the extent of local tissue damage. CRP can bind nonspecifically to carbohydrates or lipids in the cell wall of microbes and facilitate opsonization to enhance phagocytosis.



Source: OECD Health Data 2011. Extracted on 25 Oct 2011 from:

http://stats.oecd.org/Index.aspx?DataSetCode=HEALTH_LVNG

Notes: Data of Portugal are self-reported, in 1999 and 2006; data of France are self-reported, in 1990, 2000 and 2008; data of Germany are self-reported, in 1999 and 2009; data of UK are measured in 1991, 2000 and 2009; data of Netherlands are self-reported, in 1990, 2000 and 2009; data of USA are measured in 1991, 2000 and 2008.

Fig. 10. Decennial evolution of obesity (BMI ≥ 30kg/m²) in % of total population.

There is scientific evidence indicating to atherosclerosis as an inflammatory disease (De Haro et al., 2008; Hamer & Stamatakis, 2008; Virani et al., 2008). In fact, some of the most prevalent risk factors for cardiovascular diseases have been shown to have a pro-inflammatory action including hypertension (Imatoh et al., 2007; Hamer & Stamatakis, 2008), diabetes (Porrini et al., 2007; Hwang et al., 2008), dyslipidemia (Kim et al., 2007), and overweight or obesity (Hamer & Stamatakis, 2008; Piestrzeniewicz et al., 2008). As high-sensitivity C-reactive protein (hs-CRP) is a sensitive marker of inflammation, it has been pointed as the golden marker of inflammation, with Berk and colleagues (1990) establishing for the first time a positive association between hs-CRP and angina pectoris. Other authors have also found positive association of the hs-CRP with risk of vascular disease (Koenig et al., 1999; Kuller et al., 1996; Ridker et al., 1998a; Ridker et al., 2002; Ridker et al., 2003). Since then, various investigations have concentrated on the effects of physical activity on hs-CRP (Church et al., 2002; Martins et al., 2010a; Martins et al., 2010b; Mora et al., 2006; Wannamethee et al., 2002).

Figure 10 illustrates decennial evolution of obesity, self-reported or measured, in different countries of Europe and North America. United States of America and United Kingdom attained higher values of obesity (BMI ≥ 30kg/m^2) prevalence, according to the Organization for Economic Co-Operation and Development (OECD) 2011 health data, with 34% and 23% in 2009, respectively. The importance of this risk factor in this context is related with pro-inflammation action, as referred above. One would yet speculate that self-reported data by people in Portugal, France, Germany, and Netherlands are below to the real prevalence, which addresses for a rise of prevalence of obesity in these countries to values close to the measured ones in the USA and UK.

	Before	After
Body weight (kg)	73 (11)	72 (11)*
Waist circumference (cm)	94 (10)	91 (10)**
Body mass index (kg/m^2)	30.6 (5.0)	30.3 (4.9)*
Blood pressure (mm Hg)		
Systolic	149 (21)	150 (19)
Diastolic	77 (10)	74 (9)*
Triglycerides (mmol/l)	1.35 (0.58)	1.20 (0.54)*
Total cholesterol (mmol/l)	5.64 (0.86)	5.29 (1.03)*
HDL-cholesterol (mmol/l)	1.31 (0.25)	1.37 (0.32)*
LDL-cholesterol (mmol/l)	2.36 (0.77)	2.05 (0.86)**
Total Cholesterol/HDL-cholesterol	4.40 (0.92)	4.02 (0.81)**
hs-CRP (mg/l)	5.4 (3.9)	4.0 (2.0)*
6-minute walk distance (m)	387 (76)	437 (83)**

Values are mean (SD). *p<0.05, **p<0.01 compared with before.

Source: Martins RA et al., (2010b).

Table 1. Exercising group.

Measurement of cholesterol by itself do not allow the recognition of about of the individuals who will present later with myocardial infarctions (Rifai & Ridker, 2001), and a number of studies (Ridker et al., 1998b; Ridker et al., 2001; Ridker et al., 2002; Onat et al., 2001; Torres & Ridker, 2003) reinforce the idea that introducing markers of inflammation in the models of

diagnosis, beyond the lipid profile, result in more accuracy to predict atherogenic events, comparing with lipid-based models only. High serum levels of CRP have also been found not only in patients with elevated blood pressure but also in those with congestive heart failure (Barbieri et al., 2003; Torre-Amione, 2005), type 2 diabetes, metabolic syndrome and obesity (Das, 2001; Pradham et al., 2001; Ridker et al., 2003). Therefore, factors that may impact negatively hs-CRP levels, like physical activity, should be further studied, particularly in populations at increased risk of the above diseases.

	Before	After
Body weight (kg)	71 (12)	70 (13)
Waist circumference (cm)	93 (10)	91 (10)**
Body mass index (kg/m^2)	29.0 (4.4)	28.8 (4.7)
Blood pressure (mm Hg)		
Systolic	146 (20)	142 (24)
Diastolic	76 (9)	75 (13)
Triglycerides (mmol/l)	1.10 (0.35)	1.15 (0.35)
Total cholesterol (mmol/l)	5.14 (0.94)	5.27 (1.02)
HDL-cholesterol (mmol/l)	1.33 (0.28)	1.32 (0.29)
LDL-cholesterol (mmol/l)	2.39 (0.86)	2.27 (0.61)
Total Cholesterol/HDL-cholesterol	3.99 (0.98)	4.07 (0.83)
hs-CRP (mg/l)	5.5 (3.5)	5.1 (2.3)
6-minute walk distance (m)	342 (126)	343 (170)

Values are mean (SD). *p<0.05, **p<0.01 compared with before.

Source: Martins RA et al., (2010b).

Table 2. Control group.

Inflammatory processes have been positively associated with aging (Pedersen et al., 2003), with studies suggesting that physical activity would benefit atherosclerotic disease, at least partially, by reducing the inflammatory level (Wannamethee et al., 2002; Reuben et al., 2003). Serum CRP levels has been negatively associated with physical activity or physical fitness, but also with BMI and other adiposity measures (Church et al., 2002; Wannamethee et al., 2002; Mora et al., 2006; Martins et al., 2010b). These studies suggest that regular physical exercise might lower CRP levels, acting as an anti-inflammatory agent, by the effects over adipose tissue and/or by the effects on the muscle mass.

Martins and colleagues (2010b) present results (Table 1) showing beneficial effects of two exercising programs (i.e., aerobic and strength-based) in older adults with significant differences on body weight (-1%), waist circumference (-3%), BMI (-1%), diastolic blood pressure (-4%), triglycerides (-11%), total cholesterol (-6%), HDL-cholesterol (5%), LDL-cholesterol (-13%), total cholesterol/HDL-cholesterol relationship (-9%), hs-CRP (-26%), and 6-minute walk distance (13%), while the control group (Table 2) only had significant differences on waist circumference (-2%). At baseline, BMI correlated with total cholesterol (r=0.35, p=0.007), triglycerides (r=0.38, p=0.004), and hs-CRP (r=0.46, p=0.001). Waist circumference correlated with total cholesterol (r=0.30, p=0.022), triglycerides (r=0.35, p=0.010), hs-CRP (r=0.38, p=0.010), and total cholesterol/HDL-cholesterol (r=0.38, p=0.005). Finally, body weight also correlated with total cholesterol (r=0.33, p=0.011), triglycerides (r=0.27, p=0.044), hs-CRP (r=0.40, p=0.006), and total cholesterol/HDL-cholesterol (r=0.33, p=0.016).

Studies examining the effects on cardiovascular health by endurance and strength training have generally found either positive changes in lipid profile or no changes at all. More pronounced dyslipidemia at baseline has been pointed has having more favorable changes after training (Laaksonen et al., 2000), mediated by the reduction of body fat (Leon & Sanchez, 2001). On the other hand, older people are known to be under the effects of sarcopenia, which is characterized by loss of skeletal muscle mass and strength weakness. Sarcopenia has been associated not only with functional fitness impairment (Reid et al., 2008) but also with systemic inflammation (Visser et al., 2002). Resistance training (Marini et al., 2008) has been suggested to be an effective way to prevent the adverse outcomes of sarcopenia whereas the effects of aerobic training are not as clear.

The mechanisms underlying the positive effects of the physical activity on inflammation remain under discussion, being considered the hypothesis of reduction of body fat, and/or the increase of muscle mass. Some have hypothesized about changes in circulating inflammatory cytokine levels alter hs-CRP hepatic production. Reductions of serum IL-18, IL-6 and CRP have been reported after 10 months of aerobic exercise but not after flexibility/resistance exercise (Kohut et al., 2006). However, others failed to obtain exercise-induced effects in plasmatic inflammatory cytokines, including IL-6, TNF-α and IL-1β after 12 weeks of combined aerobic/resistance and flexibility training (Stewart et al., 2007). Additionally, TNF-α may contribute directly to sarcopenia once can disrupt the differentiation process in cultured muscle cells and promotes catabolism in mature muscle cells. Muscle mass is a primary site for glucose and triglyceride disposal (Dinneen et al., 1992) and the major determinant of metabolic rate (Zurlo et al., 1994). Age-related muscle loss may contribute to insulin resistance, dyslipidemia and increased adiposity. IL-6 protein is expressed in contracting muscle fibers and released from skeletal muscle during exercise whereas this is not the case for TNF-α (Steensberg et al., 2002). IL-6 is able to inhibit TNF-α, and IL-1 production stimulates the production of IL-1ra and IL-10 and the release of soluble TNF-receptors (Steensberg et al., 2003). In synthesis, a chronic training-induced reduction on hs-CRP concentrations in older adults is supported by various studies having as key factors increase in muscular mass and reduction in body fat.

8. Summary

Exercise and physical activity, or a wide concept of sport as defined by the Council of Europe, are cornerstones to act at different levels of prevention for cardiovascular health. Physical activity comprises any voluntary movement that substantially increases oxygen uptake above the resting level. Prevalence of sedentariness should be considered as a key point for public health initiatives across all ages, with particular emphasis in older adults because not only they have the higher prevalence of inactivity, but also the higher costs of health services. On the other side, energy expenditure related with occupational work has been diminishing, which addresses more importance to the leisure-time physical activity to the energy balance. Physical activity and cardiovascular fitness, i.e. oxygen uptake capacity, are both risk factors for cardiovascular health. Sometimes, questions arise about the most appropriate kind of exercise to burn energy and enhance oxygen uptake. However, the question seems to be easily answered since all fuel used in the body is ultimately processed by the aerobic energy pathways. This means that we can use the amount of oxygen consumed during the activity to calculate caloric burn. The impact of physical activity on fat

mass is a sensitive point, and the question about the most appropriate intensity to burn fat also arises occasionally. Again, the answer seems to be very easy. Each individual should practice with the higher possible intensity, according to their risk stratification. The time necessary to reach the same level of energy expenditure is about one third when comparing vigorous intensity with moderate intensity, addressing for the lack of importance to discuss about the right zone to burn fat. Moreover, it is very well known that after about 2 minutes of exercising at high intensity the aerobic pathway (using fat free acids as fuel) becomes predominant over glycolytic pathway. Recent risk factors, as inflammation, have been considered. Again, exercise seems to be very promising in reducing the inflammatory processes, with the actual discussion centered on the acute and chronic effects of different modes of exercise, and on the underlying mechanisms.

9. References

Baptista F, Silva AM, Santos, DA, Mota J, Santos R, Vale S, Ferreira JP, Raimundo A, Moreira H (2011) Livro Verde da Actividade Física. Instituto do Desporto de Portugal, I.P. Lisboa

Barbieri M, Ferruci L, Corsi AM, Macchi C, Laurentani F, Bonafe M, Olivieri F, Giovagnetti S, Franceschi C, Paolisso G (2003) Is chronic inflammation a determinant of blood pressure in the elderly? American Journal of Hypertension 16:537-543

Berk BC, Weintraub WS, Alexander RW (1990) Elevation of C-reactive protein in "active" coronary artery disease. American Journal of Cardiology 65:168-172

Bonita R, Beaglehole R, Kjellstrom T (2006). Basic Epidemiology, 2nd edn. World Health Organization, Geneva

Bouchard C, Shephard RJ (1994) Physical activity, fitness, and health: the model and key concepts. In: Bouchard C, Shephard RJ, Stephens T (eds) Physical Activity, Fitness, and Health: International Proceedings and Consensus Statement. Human Kinetics Champaign, IL pp 77-88

Brownson RC, Boehmer TK, Luke DA (2005) Declining rates of physical activity in the United States: what are the contributors? Annual Review of Public Health 26:421-443

Center for Disease Control and Prevention (2008) U.S. Physical Activity Statistics: 1998–2007 No Leisure-Time Physical Activity Trend Chart, http://www.cdc.gov/nccdphp/dnpa/physical/stats/leisure_time.htm

Church TS, Barlow CE, Earnest CP, Kamper JB, Priest EL, Blair SN (2002) Associations between cardiorespiratory fitness and C-reactive protein in men. Arteriosclerosis, Thrombosis and Vascular Biology 22:1869-1876

Church TS, Thomas DM, Tudor-Locke C, Katzmarzyk PT, Earnest CP, Rodarte RQ, Martin CK, Blair SN, Bouchard C (2011) Trends over 5 Decades in U.S. Occupation-Related Physical Activity and Their Associations with Obesity. PLoS ONE 6:e19657. doi:10.1371/journal.pone.0019657

Commission of the European Communities (2007) White Paper on Sport. Commission of the European Communities, Brussels

Das UN (2001) Is obesity an inflammatory condition? Nutrition 17:953-966

De Haro J, Acin F, Lopez-Quintana A, Medina FJ, Martinez-Aguilar E, Florez A, March JR (2008) Direct association between C-reactive protein serum levels and endothelial

dysfunction in patients with claudication. European Journal of Vascular Endovascular Surgery 35:480-486

Dinneen S, Gerich J, Rizza R (1992) Carbohydrate metabolism in non-insulin-dependent diabetes mellitus. New England Journal of Medicine 327:707-713

EC (2003) Special Eurobarometer 183-6 on Physical Activity / Wave 58.2. European Opinion Research Group EEIG, European Comission, Brussels

EC (2010) Special Eurobarometer 334 on Sport and Physical Activity / Wave 72.3. TNS Opinion & Social, European Comission, Brussels

Hamer M, Stamatakis E (2008) The accumulative effects of modifiable risk factors on inflammation and haemostasis. Brain, Behaviour and Immunity 22:1041-1043

Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, Macera CA, Heath GW, Thompson PD, Bauman A (2007) Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Medicine and Science in Sports and Exercise 39:1423–1434

Hwang JS, Wu TL, Chou SC, Ho C, Chang PY, Tsao KC, Huang JY, Sun CF, Wu JT (2008) Development of multiple complications in type 2 diabetes is associated with the increase of multiple markers of chronic inflammation. Journal of Clinical Laboratory Analysis 22:6-13

Imatoh T, Miyazaki M, Une H (2007) Does elevated high-sensitivity serum C-reactive protein associate with hypertension in non-obese Japanese males? Clinical Experimental Hypertension 29:395-401

Kim ES, Im JA, Kim KC, Park JH, Suh SH, Kang ES, Kim SH, Jekal Y, Lee CW, Yoon YJ, Lee HC, Jeon JY (2007) Improved insulin sensitivity and adiponectin level after exercise training in obese Korean youth. Obesity 15:3023-3030

Koenig W, Sund M, Fröhlich M, Fischer HG, Löwel H, Döring A, Hutchinson WL, Pepys MB (1999) C-Reactive protein, a sensitive marker of inflammation, predicts future risk of coronary heart disease in initially healthy middle-aged men: results from the MONICA (Monitoring Trends and Determinants in Cardiovascular Disease) Augsburg Cohort Study, 1984 to 1992. Circulation 99:237-242

Kohut ML, McCann DA, Russell DW, Konopka DN, Cunnick JE, Franke WD, Castillo MC, Reighard AE, Vanderah E (2006) Aerobic exercise, but not flexibility/resistance exercise, reduces serum IL-18, CRP, and IL-6 independent of b-blockers, BMI, and psychosocial factors in older adults. Brain Behaviour and Immunity 20:201-209

Kuller LH, Tracy RP, Shaten J, Meilahn EN (1996) Relation of C-reactive protein and coronary heart disease in the MRFIT nested case-control study. Multiple Risk Factor Intervention Trial. American Journal of Epidemiology 144:537-547

Laaksonen DE, Atalay M, Niskanen LK, Mustonen J, Sen CK, Lakka TA, Uusitupa MI (2000) Aerobic exercise and the lipid profile in type 1 diabetic men: a randomized controlled trial. Medicine and Science in Sports and Exercise 32:1541–1548

Last JM (2001) A Dictionary of Epidemiology, 4th edn. Oxford University Press, Oxford

Lee MA, Mather M (2008) Population Bulletin: U.S. Labor Force Trends. www.prb.org

Leon AS, Sanchez OA (2001) Response of blood lipids to exercise training alone or combined with dietary intervention. Medicine and Science in Sports and Exercise 33:S502–S515, discussion S528–S529

Lollgen H, Bockenhoff A, Knapp G (2009) Physical activity and all-cause mortality: an updated meta-analysis with different intensity categories. International Journal of Sports Medicine 30:213–224

Marini M, Sarchielli E, Brogi L, Lazzeri R, Salerno R, Sgambati E, Monaci M (2008) Role of adapted physical activity to prevent the adverse effects of the sarcopenia. A pilot study. Italian Journal of Anatomy and Embryology 113:217-225

Martins RA, Neves AP, Coelho-Silva MJ, Veríssimo MT & Teixeira AM (2010a) High-sensitivity C-reactive protein, body fat and physical exercise in older people. European Journal of Applied Physiology 110:161-169

Martins RA, Veríssimo MT Coelho-Silva MJ, Cumming SP & Teixeira AM (2010b) Effects of aerobic and strength-based training on metabolic health indicators in older adults. Lipids in Health and Disease, 9:76

Mora S, Lee IM, Buring JE, Ridker PM (2006) Association of physical activity and body mass index with novel and traditional cardiovascular biomarkers in women. JAMA 295:1412–1419

Morris JN, Clayton DG, Everitt MG, Semmence AM, Burgess EH (1990) Exercise in leisure time: coronary attack and death rates. British Heart Journal, 63:325-334

Morris JN, Heady JA, Raffle PAB, Roberts CG, Parks JN (1953a) Coronary heart disease and physical activity of work. Lancet 2:1053–1057

Morris JN, Heady JA, Raffle PAB, Roberts CG, Parks JN (1953b) Coronary heart disease and physical activity of work. Lancet 2:1111–1120

Onat A, Sansoy V, Yildirim B, Keles I, Uysal O, Hergenc G (2001) C-reactive protein and coronary heart disease in western Turkey. American Journal of Cardiology 88:601-607

Paffenbarger RS, Wing AL & Hyde RT (1978) Physical activity as an index of heart attack risk in college alumni. American Journal of Epidemiology 108:161-175

Paffenbarger RS Jr, Hyde RT, Wing AL & Hsieh C-c (1986a) Chronic disease in former college students: XXX. Physical activity, all-cause mortality, and longevity of college alumni. New England Journal of Medicine 314:605–613

Paffenbarger RS Jr, Hyde RT, Wing AL, Hsieh C-c (1986b) Chronic disease in former college students: XXX. Physical activity, all-cause mortality, and longevity of college alumni. New England Journal of Medicine 315:399–401

Paffenbarger RS Jr, Hyde RT, Wing AL, Lee I-M, Jung DL, Kampert JB (1993) Chronic disease in former college students: XXXVII. The association of changes in physical activity level and other lifestyle characteristics with mortality among men. New England Journal of Medicine 328:538–545

Paffenbarger RS Jr, Kampert JB, Lee I-M, Hyde RT, Leung RW, Wing AL (1994) Chronic disease in former college students: LII. Changes in physical activity and other lifeway patterns influencing longevity. Medicine and Science in Sports and Exercise 26:857–865

Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, Buchner D, Ettinger W, Heath GW, King AC, Kriska A, Leon AS, Marcus BH, Morris J, Paffenbarger RS, Patrick K, Pollock ML, Rippe JM, Sallis J, Wilmore JH (1995) Physical activity and public health. A recommendation from the CDC and the American College of Sports Medicine. JAMA 273:402–407

Pedersen M, Bruunsgaard H, Weis N, Hendel HW, Andreassen BU, Eldrup E, Dela F, Pedersen BK (2003) Circulating levels of TNF-alpha and IL-6-relation to truncal fat

mass and muscle mass in healthy elderly individuals and in patients with type-2 diabetes. Mechanisms of Ageing and Development 124:495-502

Piestrzeniewicz K, Łuczak K, Komorowski J, Maciejewski M, Jankiewicz-Wika J, Goch JH (2008) Resistin increases with obesity and atherosclerotic risk factors in patients with myocardial infarction. Metabolism: Clinical and Experimental 57:488-493

Porrini E, Gomez MD, Alvarez A, Cobo M, Gonzalez-Posada JM, Perez L, Hortal L, García JJ, Dolores-Checa M, Morales A, Hernández D, Torres A (2007) Glycated haemoglobin levels are related to chronic subclinical inflammation in renal transplant recipients without pre-existing or new onset diabetes. Nephrology and Dialysis Transplantation 22:1994-1999

Pradhan AD, Manson JE, Rifai N, Buring JE, Ridker PM (2001) C-reactive protein, interleukin-6 and risk of developing type 2 diabetes mellitus. JAMA 286:327-334

Reid KF, Naumova EN, Carabello RJ, Phillips EM, Fielding RA (2008) Lower extremity muscle mass predicts functional performance in mobility-limited elders. Journal of Nutrition, Health and Aging 12:493-498

Reuben DB, Judd-Hamilton L, Harris TB, Seeman TE (2003) The associations between physical activity and inflammatory markers in high-functioning older persons: MacArthur Studies of Successful Aging. Journal of the American Geriatrics Society 51:1125-1130

Ridker PM, Buring JE, Cook NR, Rifai N (2003) C-reactive protein, the metabolic syndrome, and risk of incident cardiovascular events: an 8-year follow-up of 14719 initially healthy American women. Circulation 107:391-397

Ridker PM, Buring JE, Shih J, Matias M, Hennekens CH (1998a) Prospective study of C-reactive protein and the risk of future cardiovascular events among apparently healthy women. Circulation 25:731-733

Ridker PM, Glynn RJ, Hennekens CH (1998b) C-reactive protein adds to the predictive value of total and HDL cholesterol in determining risk of first myocardial infarction. Circulation 97:2007-2011

Ridker PM, Rifai N, Rose L, Buring JE, Cook NR (2002) Comparison of C-reactive protein and low-density lipoprotein cholesterol levels in the prediction of first cardiovascular events. New England Journal of Medicine 347:1557-1565

Ridker PM, Stampfer MJ, Rifai N (2001) Novel risk factors for systemic atherosclerosis: a comparison of C-reactive protein, fibrinogen, homocysteine, lipoprotein(a), and standard cholesterol screening as predictors of peripheral arterial disease. Journal of the American Medical Association 285:2481-2485

Rifai N, Ridker PM (2001) High-sensitivity C-reactive protein: a novel and promising marker of coronary heart disease. Clinical Chemistry 47:403-411

Schoenborn CA, Stommel M (2011) Adherence to the 2008 adult physical activity guidelines and mortality risk. American Journal of Preventive Medicine 40:514-521

Steensberg A, Keller C, Starkie RL, Osada T, Febbraio MA, Pedersen BK (2002) IL-6 and TNF-alpha expression in, and release from, contracting human skeletal muscle. American Journal of Physiology, Endocrinology and Metabolism 283:E1272-E1278

Steensberg A, Fischer CP, Keller C, Moller K, Pedersen BK (2003) IL-6 enhances plasma IL-1ra, IL-10, and cortisol in humans. American Journal of Physiology, Endocrinology and Metabolism 285:E433-E437

Stewart LK, Flynn MG, Campbell WW, Craig BA, Robinson JP, Timmerman KL, McFarlin BK, Coen PM, Talbert E, (2007) The influence of exercise training on inflammatory cytokines and C-reactive protein. Medicine and Science in Sports and Exercise 39:1714-1719

Torre-Amione G (2005) Immune activation in chronic heart failure. American Journal of Cardiology 95:3C-8C

Torres JL, Ridker PM (2003) Clinical use of high sensitivity C-reactive protein for the prediction of adverse cardiovascular events. Current Opinion in Cardiology 18:471-478

Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M (2008) Physical activity in the United States measured by accelerometer. Medicine and Science in Sports Exercise 40:181-188

USDHHS (1996) Physical Activity and Health. A Report of the Surgeon General. USDHHS, CDC, National Center for Chronic Disease Prevention and Health Promotion, Atlanta GA

USDHHS (2000) Healthy People 2010: Understanding and Improving Health. 2nd ed. US Government Printing Office, Washington, DC

USDHHS (2010) Healthy People 2020. US Government Printing Office, Washington, DC

USDHHS (2011) Physical activity guidelines for Americans. USDHHS. Washington DC. www.health.gov/paguidelines/, accessed on October 19th

Virani SS, Polsani VR, Nambi V (2008) Novel markers of inflammation in atherosclerosis. Current Atherosclerosis Reports 10:164-170

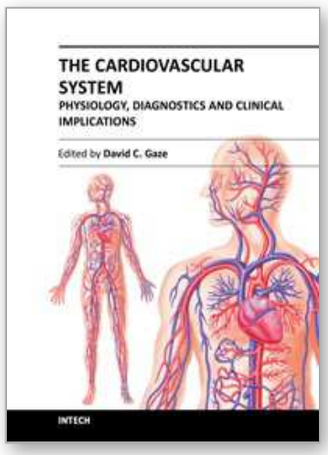
Visser M, Pahor M, Taaffe DR, Goodpaster BH, Simonsick EM, Newman AB, Nevitt M, Harris TB (2002) Relationship of interleukin-6 and tumor necrosis factor-alpha with muscle mass and muscle strength in elderly men and women: the Health ABC Study. The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences 57:M326-M332

Wannamethee SG, Lowe GD, Whincup PH, Rumley A, Walker M, Lennon L (2002) Physical activity and haemostatic and inflammatory variables in elderly men. Circulation 105:1785-1790

Welk GJ (2002) Physical Activity Assessments for Health-Related Research. Human Kinetics, Champaign, IL

Widmaier EP, Raff H, Strang KT, Vander AJ (2011) Vander's human physiology: the mechanisms of body function, 12th edn. McGraw-Hill Higher Education, New York

Zurlo F, Nemeth PM, Choksi RM, Sesodia S, Ravussin E (1994) Whole-body energy metabolism and skeletal muscle biochemical characteristics. Metabolism 43:481-486



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The cardiovascular system includes the heart located centrally in the thorax and the vessels of the body which carry blood. The cardiovascular (or circulatory) system supplies oxygen from inspired air, via the lungs to the tissues around the body. It is also responsible for the removal of the waste product, carbon dioxide via air expired from the lungs. The cardiovascular system also transports nutrients such as electrolytes, amino acids, enzymes, hormones which are integral to cellular respiration, metabolism and immunity. This book is not meant to be an all encompassing text on cardiovascular physiology and pathology rather a selection of chapters from experts in the field who describe recent advances in basic and clinical sciences. As such, the text is divided into three main sections: Cardiovascular Physiology, Cardiovascular Diagnostics and lastly, Clinical Impact of Cardiovascular Physiology and Pathophysiology.

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