

Sedentarism, active lifestyle and sport: impact on health and obesity prevention

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Abstract

The benefits of regular physical activity have been known since ancient Greek. But in the last Century the scientific knowledge around this topic has progressed enormously, starting with the early studies of JN Morris and RS Paffenberger, who demonstrated that physical activity at work reduced incidence of cardiovascular disease and mortality. In the Harvard alumni study, the lowest risk was associated with a weekly output of 1000 to 2000 kcal performing vigorous activities. Further studies in all age groups have supported these findings and have added that even moderate levels of physical activity provide considerable benefits to health, including lower prevalence of overweight and obesity at all ages. Metabolic fat oxidation rate is highest at exercise intensities between 45 and 65% of VO₂max. This means that people must be active regularly and force physiological mechanisms at certain intensities. All this body of evidence has contributed to current WHO physical activity recommendations of 150 min/week of moderate to vigorous physical activity (MVPA) in adults and elderly, and 60 min/day of MVPA in children and adolescents, with additional strength training, apart from adopting an active lifestyle.

In the last 50 years, occupational physical activity has been reduced for about 120 kcal/day, and sedentarism has emerged as an additional risk factor to physical inactivity. Even if less than 60 min of TV time in adults have been related to lower average BMI, there is still a need for research to determine the appropriate dose of exercise in combination with sedentary behaviours and other activities in the context of our modern lifestyle in order to prevent obesity at all ages. As public health measures have failed to stop the obesity epidemic in the last 3 decades, there is clearly a need to change the paradigm. The inclusion of sport scientists, physical education teachers and other professionals in the multidisciplinary team which should be responsible for drawing the road map to prevent the increase of the obesity epidemic effectively is a "must" from our point of view.

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Key words: *Fitness. Health. Physical activity. Obesity. Prevention.*

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SEDENTARISMO, VIDA ACTIVA Y DEPORTE: IMPACTO SOBRE LA SALUD Y PREVENCIÓN DE LA OBESIDAD

Resumen

Los beneficios de la práctica regular de actividad física se conocen desde la antigua Grecia. En el siglo XX, el avance del conocimiento científico fue enorme, empezando con los estudios de JN Morris y RS Paffenberger, que demostraron que la actividad física en el trabajo reducía la incidencia de morbilidad y mortalidad por enfermedad cardiovascular. En el estudio de los ex alumnos de Harvard, el menor riesgo se asoció a gastos semanales de 1000 a 2000 kcal realizando actividades vigorosas. Estudios posteriores en todos los grupos de edad han verificado estos resultados. Además, se ha observado que incluso actividades a intensidades moderadas aportan beneficios importantes para la salud, incluyendo una menor prevalencia de sobrepeso y obesidad a todas las edades. La tasa metabólica de oxidación de las grasas es máxima a intensidades entre el 45 y el 65% del VO₂max, que se alcanzan únicamente con entrenamientos mantenidos en el tiempo, con en fin de forzar los mecanismos fisiológicos a determinadas intensidades. Toda esta evidencia científica llevó a la OMS a formular sus recomendaciones de 150 min/semana de actividad física de moderada a vigorosa (MVPA) en adultos y mayores, y de 60 min/día de MVPA en niños y adolescentes, además de entrenamiento de la fuerza y en el contexto de un estilo de vida activo.

En los últimos 50 años, la actividad física laboral se ha reducido en unas 120 kcal/día, y el sedentarismo surge como un factor de riesgo adicional a la inactividad física. Aunque se han relacionado tiempos de menos 60 min de TV en adultos con menor tasa de IMC, aun es necesario profundizar en la dosis apropiada de ejercicio físico en combinación con comportamientos sedentarios en el contexto de nuestro estilo de vida moderno para prevenir la obesidad a todas las edades. Consideramos necesario un cambio de paradigma, ya que las medidas de Salud Pública no han conseguido frenar el progreso de la epidemia de la obesidad en las últimas 3 décadas. La inclusión de los científicos y profesionales del deporte, de los profesores de educación física en el equipo multidisciplinar que debería ser el responsable de trazar las líneas maestras para prevenir y frenar la epidemia de la obesidad de forma efectiva es algo imprescindible desde nuestro punto de vista.

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Palabras clave: *Condición física. Salud. Actividad física. Obesidad. Prevención.*

Abbreviations

AVENA: Alimentación y valoración del estado nutricional en adolescentes.

EXERNET: Red de investigación en ejercicio físico y salud para poblaciones especiales.

EYHS: European Youth Heart Study.

HBSC Study: Health and behaviour in school-aged children.

HELENA: Healthy Lifestyle in Europe by Nutrition in Adolescence.

MVPA: Moderate to vigorous physical activity.

NHANES: National health and Nutrition Examination Survey.

PRONAF: Programas de nutrición y actividad física para el tratamiento de la obesidad.

Introduction

The human being is meant to move. Our ancestors had to move to hunt animals, gather fruit or cultivate their fields. Since the industrial revolution, human movement has been reduced constantly and sedentarism has increased progressively. It has been estimated that in the 1960's, around half of the jobs in private industry in the U.S. required at least moderate intensity physical activity, in contrast to less than 20% of the jobs currently.¹ A worrying trend as inactivity is accompanied by a tendency towards dysfunction, and in some cases increased morbidity as lack of movement produces progressive atrophy and physical weakness in the whole organism. At the end of the 1950s and beginning of the 1960s, Kraus and Raab² had already introduced the term hypokinetic to refer to a series of changes associated with physical activity and those diseases which could be provoked or worsened as a consequence of physical inactivity.

Modern technology and the development of motor-based transport systems, of machines which take over former high-energy demanding activities both at home and at the workplace, as well as in commuting, have reduced the intensity of, and time spent in, physical activity in our daily living,¹ turning us into a "*Homo sedentarius*". In fact, sedentary behaviour has begun to be used to describe prolonged sitting (*sedēre* in Latin = to sit), instead of the absence of physical activity. The word "sedentary" has begun to be applied to people who spend most of the day sitting down.³ There is a rapidly expanding body of evidence suggesting that time spent in sedentary behaviours is associated adversely with health risks and can be a factor which is independent of the protective action of physical activity.³

Energy balance, which has been considered fundamental for avoiding overweight and obesity, has puzzled scientists for a long time. In the 16th century, Sanctorio in Padua built a scale for himself in order to understand weight maintenance in adulthood.⁴ It was in the late 18th Century with the studies of Lavoisier and his collea-

gues that science started to understand heat production, oxygen consumption and energy output; and at the end of the 19th and beginning of the 20th Century interest grew regarding the physiological and biochemical adaptations to training⁴. In the last five decades, daily energy output due to the reduction in occupational physical activity has been estimated to have decreased among US men and women by 140 and 124 kcal, respectively¹, probably affecting energy balance.

Physical activity and cardiovascular health

The belief that people who are physically active in their daily life both because of their occupation and through their recreation, exercise and sports activities have a lower level of morbidity and mortality are not new ideas, and can be traced back to the writings of different authors in ancient Greece or Rome.⁴ However, for a long time these ideas have come up against the scepticism of health professionals. A change in mentality was brought about as a result of a series of important epidemiological studies.

The famous articles by J.N. Morris and colleagues published in 1953 examined the incidence of coronary heart disease among the bus drivers who spent more than 90% of their working hours sitting down, and bus conductors, who spent their working days going up and down the stairs on the famous London double-decker buses. They found a lower incidence of coronary heart disease among the conductors and postulated that "physically active" work provided a certain amount of protection against sudden death due to cardiac problems as a first manifestation of disease. Further data obtained from post office employees, comparing those who had to deliver the post by walking or by riding a bicycle with those working at the post office that carried out more sedentary work like sorting letters, confirmed the protective effect of physical activity.⁵

In this line of epidemiological research, R.S. Paffenbarger and colleagues⁶ published the results of their research studying the stevedores at the San Francisco port. The researchers found out that in the group of the most active stevedores, who expended an additional 4,200 kJ/week (1,000 kcal/week) cardiovascular mortality was clearly lower than in the less active workers.

Other epidemiological studies from the same research group which have been critical for confirming the relationship of exercise and cardiovascular health and mortality were the college alumni of the University of Harvard studies, initiated by Paffenberger. After a follow-up of 6 to 10 years, it was concluded that there was an inverse relationship between the levels of physical activity and the risk of suffering coronary heart disease. After 12 to 16 years, the researchers showed that an extra energy expenditure of 8,400 kJ/week (2,000 kcal/week), was associated with a decrease of 28% in all cause mortality, and that the decrease was even more with regard to cardio-respiratory problems.

Specifically in the cohort of alumni from Harvard^{6,7} it was demonstrated that those subjects who performed regular physical activity of certain intensity reduced to half the risk of suffering from coronary heart disease compared to sedentary ones. The lowest risk was associated with a weekly energy output of between 4,200 and 8,400 kJ/week (1000 to 2000 kcal) despite the fact that 8,400 kJ/week seems to be a critical point for men. There were benefits with 4,200kJ for women and a dose-response for the levels of exercise training showing a lower risk with a higher energy output and additional benefits with vigorous activities.⁶ Older men should expend at least 4200 kJ/week in total physical activity to potentially reduce their risk for CHD in a statistically significant way (about 20%); however, when expending 2,100 to 4,100 kJ/week, a value slightly lower than the one recommended by the Surgeon General, a 10% reduction was observed. This reduction was not statistically significant but can have an important practical value.⁷ Interesting findings of the above-mentioned studies were that the benefits of regular and vigorous physical activity seemed to be irrespective of body composition; in other words, they also applied to obese subjects. Some exercise is better than none, while more is better than some⁶, and cardiovascular adaptations to training have a positive influence on the many pathophysiological conditions associated with obesity, and better fitness facilitates the tasks of daily living.⁷

More recently, the work of S.N. Blair and others has confirmed these findings in relation to a lower all cause mortality underlining the fact that even moderate levels of physical activity, and an improved fitness level used as a more objective marker of physical activity, provide considerable benefits for health in general⁸. And while the benefits may be more dramatic in a sedentary 45 year-old like Dr Paffenberger himself, benefits can be derived regardless of age as shown in 80-year-olds who can improve the quality of their life significantly,⁶ something possible in even older people.⁹

Physical activity, obesity and health

Obesity (BMI > 30, high body fat) as a risk factor for health has recently been the focus of research, due to the increase in its prevalence in all age groups in developed, and currently also, in developing countries. Age-adjusted prevalence of obesity in the U.S. has shifted from 10%-15% in the 1960s up to 35% in 2008. Over the last 50 years in the U.S. there have been progressive decreases in the percentage of individuals employed in occupations that require moderate intensity physical activity. It has been estimated that daily occupation-related energy expenditure has decreased by more than 100 kcal per day, and that this reduction in energy expenditure could account for a significant portion of the increase in mean U.S. body weight for women and men in the U.S.¹ The estimation of this reduction of 100 kcal/day or even more would have been adequately

compensated for by meeting the 2008 U.S. Department of Health and Human Services Federal Physical Activities Recommendation of 150 minutes per week of moderate intensity or 75 minutes per week of vigorous intensity activity or the 2010 WHO Global recommendations on physical activity for health¹⁰ (table I).

If data on children and adolescents are taken separately, prevalence of overweight has shifted from around 4% in the 1960s up to 20% in 2008.¹¹ As age-adjusted prevalence of overweight has been quite stable since the 1970s (around 28% for women and 40% for men), prevalence of overweight and obesity together is currently around 64% for women and 72% for men in the U.S.¹¹ Currently, data seem to indicate that prevalence is starting to plateau in both children and adults¹¹.

Trends in Europe have been less consistent. In Spain, prevalence of overweight and obesity has increased steadily.¹² Median total body fat of 14-y old boys was 7.5% in 1985 and 14% in 1995 and mean waist circumference increased significantly from 72.75 ± 6.78 cm in 1995 to 77.90 ± 11.89 cm in 2002. Currently, prevalence data are tending to stabilize.¹³ In Europe, prevalence in children and adolescents varies from less than 10% in some of the Nordic countries up to more than 25% in the Mediterranean countries and the UK.¹² In the analysis performed by Church et al.¹, increases of obesity rates in the US adults over the last 5 decades have been related to the decrease in occupation-related physical activity. Interestingly, estimated increase in body weight (since 1960) by means of the energy balance model closely matches measured body weight of the National Health and Nutrition Examination Surveys (NHANES) data form 2003-2006.

There is quite a huge amount of supporting evidence that trained people have less body fat percentage at all ages than non-trained people.¹¹ In the study by Kohrt et al.,¹¹ healthy older endurance-trained men and women had similar body fat percentages (17% and 25%) to healthy young sedentary subjects (18 and 24%, respectively). For comparison, it is interesting to indicate that older sedentary males and females had 28% and 38% body fat, respectively. In the EXERNET study, a representative study of Spanish elderly performed on non-institutionalized subjects of both sexes, those who walked regularly had a lower prevalence of overweight and obesity than the sedentary ones.¹⁴

European adolescents from the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study who performed more than 60 minutes of moderate to vigorous physical activity (MVPA) had less total and abdominal fat (%) than their less active counterparts.¹⁵ In the Spanish cohort of the European Youth Health Study (EYHS) the risk of developing overweight/obesity was nearly 4-fold in children who practiced less than 60 minutes of MVPA per day than their more active counterparts.¹⁶

Exercise intensity has also been proposed as a main factor influencing stem cell differentiation.¹⁷ Based on animal studies it has been hypothesised that vigorous

Table I
Physical activity recommendations by age group. Adapted from WHO 2010¹⁰

<i>Age Group</i>	<i>Physical activity recommendation</i>	<i>Additional comments</i>
5-17 years	<ul style="list-style-type: none"> • Children and youth aged 5–17 should accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity daily. • Amounts of physical activity greater than 60 minutes provide additional health benefits. • Most of the daily physical activity should be aerobic. Vigorous-intensity activities should be incorporated, including those that strengthen muscle and bone*, at least 3 times per week. 	<p>For this age group, bone-loading activities can be performed as part of playing games, running, turning or jumping.</p> <p>In order to improve cardiorespiratory and muscular fitness, bone health, and cardiovascular and metabolic health biomarkers.</p>
18-74 years	<ul style="list-style-type: none"> • Adults aged 18–64 should do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity. • Aerobic activity should be performed in bouts of at least 10 minutes duration. • For additional health benefits, adults should increase their moderate-intensity aerobic physical activity to 300 minutes per week, or engage in 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity. • Muscle-strengthening activities should be done involving major muscle groups on 2 or more days a week. 	<p>For this age group, physical activity includes leisure time physical activity (for example: walking, dancing, gardening, hiking, swimming), transportation (e.g. walking or cycling), occupational (i.e. work), household chores, play, games, sports or planned exercise, in the context of daily, family, and community activities.</p> <p>In order to improve cardiorespiratory and muscular fitness, bone health, reduce the risk of NCDs and depression.</p>
> 65 years	<ul style="list-style-type: none"> • Older adults should do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity. • Aerobic activity should be performed in bouts of at least 10 minutes duration. • For additional health benefits, older adults should increase their moderate-intensity aerobic physical activity to 300 minutes per week, or engage in 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity. • Older adults, with poor mobility, should perform physical activity to enhance balance and prevent falls on 3 or more days per week. • Muscle-strengthening activities, involving major muscle groups, should be done on 2 or more days a week. • When older adults cannot do the recommended amounts of physical activity due to health conditions, they should be as physically active as their abilities and conditions allow. 	<p>For this age group, physical activity includes leisure time physical activity (for example: walking, dancing, gardening, hiking, swimming), transportation (e.g. walking or cycling), occupational (if the individual is still engaged in work), household chores, play, games, sports or planned exercise, in the context of daily, family, and community activities.</p> <p>In order to improve cardiorespiratory and muscular fitness, bone and functional health, reduce the risk of NCDs, depression and cognitive decline.</p>

physical activity produces a sufficient mechanical stimulation of the tissues in order that stem cells are turned preferably into fat-free mass cells. In contrast, the absence of moderate-intensity physical activity or an excessive energy intake favours stem cells turning into fat mass cells.¹⁷ There are two periods during growth in which noticeable increases in adipocytes occur: infancy and adolescence which are viewed as “critical” for the enlargement of the adipose tissue and in turn for development or prevention of obesity during growth. The above-mentioned theory could be “crucial” to apply in these periods in which it is also important to provoke a higher accretion of bone mass, one of the aspects considered in the theory that is important for growth. Professor Claude Bouchard had already proposed in

1990 that physical fitness is the main determinant of health in the broad sense as defined by WHO.

Regarding metabolic risk, cardio-respiratory fitness has been defined as a powerful marker of health at all ages.¹⁹ Healthy children aged 9 and 10 years from the EYHS study and adolescents aged 13 to 18 years from the AVENA study with high cardio-respiratory fitness (classified in quartiles) had a significantly and progressively better metabolic profile (index based on fasting triglycerides, LDL-cholesterol, HDL-cholesterol and glucose concentrations) than those with lower cardio-respiratory fitness.²⁰ But even in overweight subjects, cardio-respiratory fitness can make the difference. Separating the adolescents from the AVENA study according to their body composition, those overweight adolescents with high

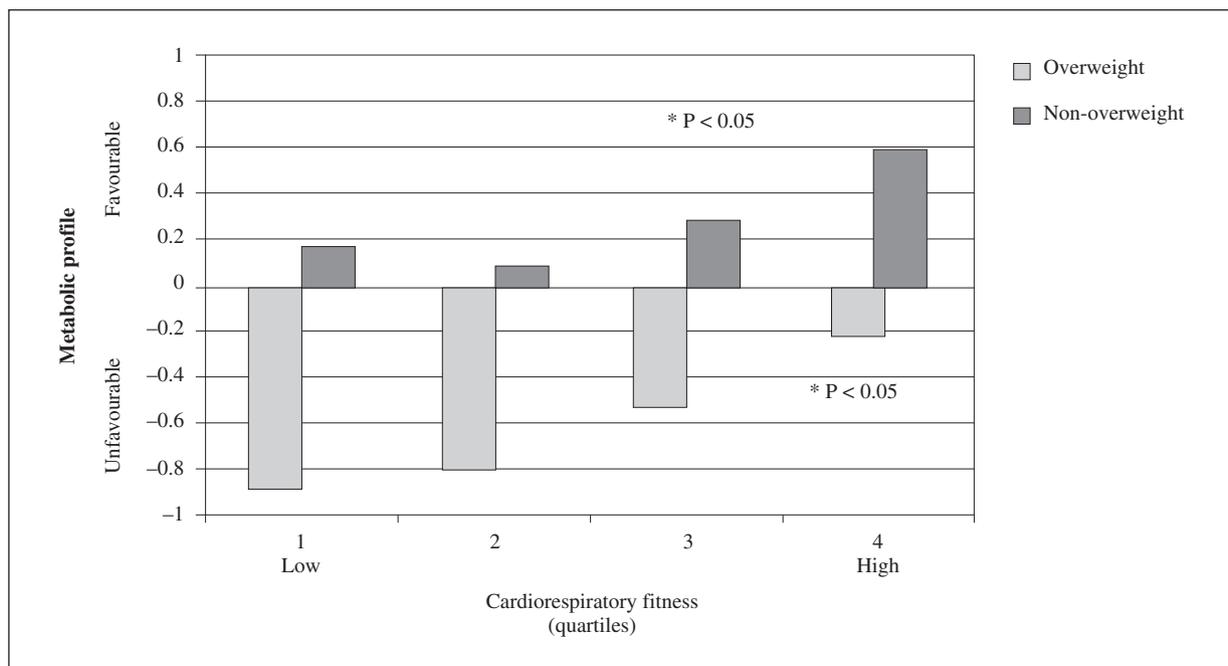


Fig. 1.—Relationship between cardiorespiratory fitness, body composition and metabolic risk in Spanish adolescents from the AVENA study. Modified from¹⁹. Footnote: Association between metabolic profile (computed with age- gender specific standardized values of triglycerides, low density lipoprotein cholesterol, high density lipoprotein cholesterol and fasting glycaemia) and cardiorespiratory fitness quartiles in non-overweight and overweight Spanish adolescents. The higher is the metabolic profile the healthier. Weight categories were constructed following the International Obesity Task Force-proposed gender- and age-adjusted body mass index cutoff points. Data shown as mean and standard error of the mean. *P for trend in both overweight and non-overweight categories.

respiratory fitness had the same metabolic profile as the normal weighted adolescents with low cardio-respiratory fitness¹⁹ (fig. 1). The cardio-metabolic effects of exercise in overweight and obese children (boys and girls) aged 9.4 years have been confirmed in the randomized control trial mentioned below,²¹ and appear to be able to be generalized regardless of race (black and white), of pre-diabetes or a family history of diabetes.

Trying to get a deeper understanding of the dose-response of exercise in overweight and obese children, a randomized control trial over 13 weeks was performed in sedentary children in Georgia (U.S.).²¹ Children had to perform 20 or 40 minutes of aerobic training daily after school and were compared to a control group. General and visceral body fat, among other variables, was reduced significantly in a dose-response gradient. The increment of benefit between the control and low-dose exercise conditions was larger than the additional benefits observed between the low- and the high-dose exercise and both groups showed similar effects on insulin resistance. As has been observed in several studies, the lower the baseline physical activity status, the greater will be the health benefit associated with a given increase in physical activity (fig. 2).

Several studies have proposed that muscular strength influences cardio-metabolic health independently and reduces the risk of metabolic syndrome in addition to cardio-respiratory fitness.²² As we get older, both $\text{VO}_{2\text{max}}$ and strength diminish. Regular exercise can at least

slow down this process. Both the percentage of body fat and total body fat are more similar among trained young and old people than among the un-trained. Studies indicate that trained older people have a similar fat mass to young un-trained people, and one that is much lower than older un-trained people.

Regular daily physical activity contributes to energy balance in several ways. There is no doubt about that every activity the human body performs is linked to energy output. The higher the intensity and duration, the more energy is spent. Additionally, adaptations to training, i.e. increases in muscle mass, in capillaries, etc, also contribute to raising the basal metabolic rate; and after exercise, oxygen consumption (and consequently energy output) remains high for a while until the body has again reached homeostasis.²³

Adipose tissue increases with age and obesity itself has been proposed as a barrier for being physically active. In a recent prospective study performed on middle-aged women, both mean weekly physical activity and MVPA measured by accelerometry decreased significantly more in obese women over a 20-month period than in non-obese women.²⁴ Low levels of growth hormone have been linked to obesity.²³ Growth hormone is one of the hormones involved in FFA metabolism during exercise.

Several studies have shown that at all ages, boys are more active than girls,¹⁸ which tracks also into adulthood, adult men being more active than adult women in

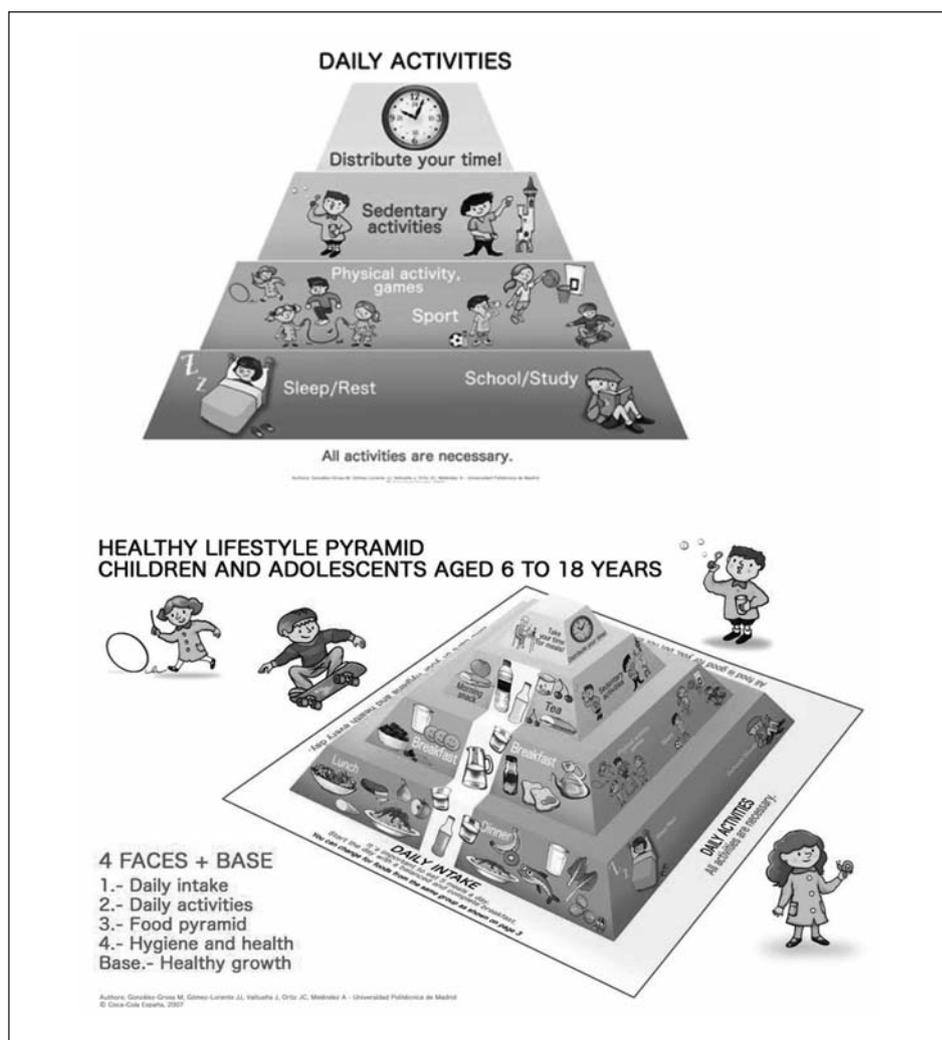


Fig. 2.—The importance of the daily Schedule including physical activity within a healthy lifestyle for children and adolescents.¹⁸

all WHO Regions.¹⁰ In accordance, cardiorespiratory fitness and strength values are higher in boys than in girls, with more homogenous fitness levels among girls than boys.²² In Europe, data from the HELENA study have revealed that 61% of the adolescent boys and 57% of the girls presented a healthy cardio-respiratory fitness (CRF) level,²² a similar prevalence as found for U.S. adolescents. There is consistency among the studies that with increasing age there is a tendency in both sexes to abandon physical activities and sports (i.e. HBSC Study, AVENA study, HELENA Study). According to the “Study of sport habits among school-age children in Spain”,²⁵ the main cause of not practicing physical activity is lack of time, a cause which increases with increasing age (10% at ages 6-7 up to 32% at ages 16-18). It is essential to educate children in learning how to distribute their time in order that MVPA is included in their daily schedule,¹⁸ as it is specifically indicated in the Healthy Lifestyle Pyramid for children and adolescents (fig. 3). Additionally, some other factors have been identified in relationship to physical activity in youth. A physically active mother

(i.e. AVENA study) positively influences both boys and girls. Lower physical activity among female friends and perceived lack of safety in the neighbourhood represents a negative influence among the girls.²⁶

In relationship to relative risk reduction of coronary heart disease, currently the evidence suggests that any type of physical activity contributes to reducing the risk, but that a high level of physical fitness reduces the relative risk even more.²³

In relation to body fat reduction, both strength and aerobic exercise have been demonstrated to be effective, though aerobic exercise has a much higher impact on body fat and body fat distribution.²⁷

In relation to the improvement of blood lipid profiles and glucose metabolism, both types of exercise have demonstrated similar efficacy²⁷ (table II).

Substrate utilization during exercise

The human body functions in accordance with the laws of thermodynamics. If total food calories consu-

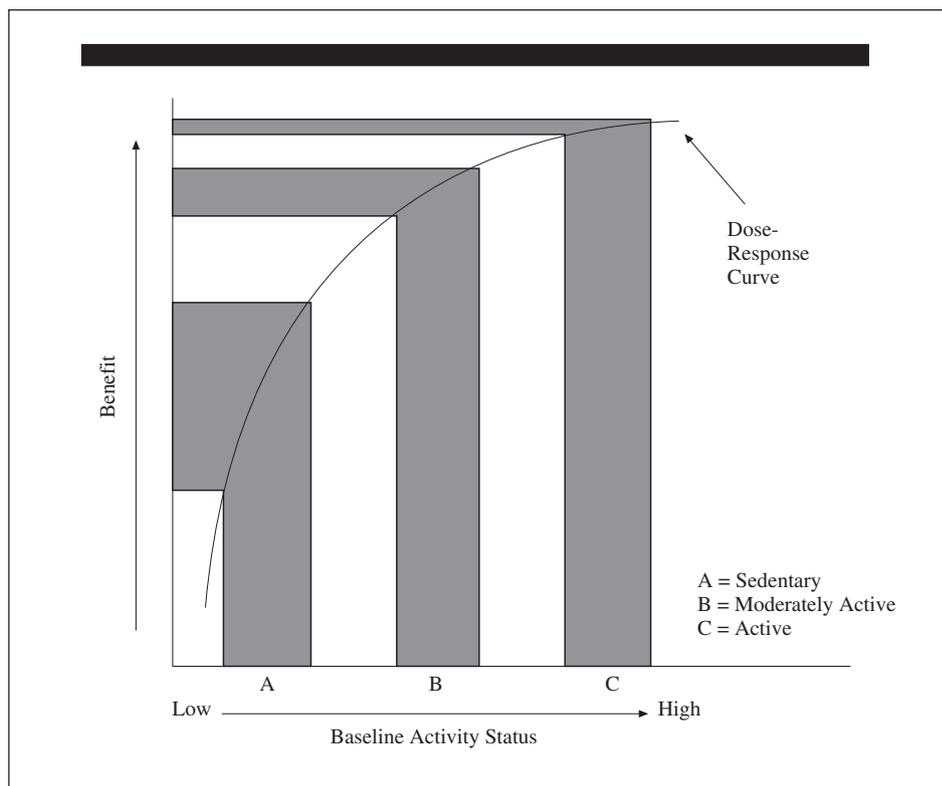


Fig. 3.—The dose-response curve represents the best estimate of the relationship between physical activity (dose) and health benefit (response). The lower the baseline physical activity status, the greater will be the health benefit associated with a given increase in physical activity (arrows A, B, and C).

med exceed daily energy expenditure, excess calories accumulate and are stored as fat in the adipose tissue.²³ In this situation, there are three ways to recover the energy balance: increasing physical activity, decreasing food intake or a combination of the two.

The energy expenditure for an activity depends on its intensity and duration. Greater intensity will demand greater energy expenditure per unit of time, and longer duration greater total energy expenditure. These aspects should be taken into account when a certain amount of energy expenditure is required. Brooks and Mercier²⁸ pointed out that the crossover point is the power output at which energy from carbohydrate derived fuels predominates over energy from lipids, with further increases in power eliciting a relative increment in carbohydrate utilization and a decrement in lipid oxidation. During rest and mild- to moderate intensity exercise, lipids predominate as energy sources, especially in an endurance-trained state. Exercise at low intensities (about 45% of VO₂ max) is accomplished with lipids as the main substrate. In contrast, in hard intensity exercise (about 75% of VO₂ max) carbohydrates become the predominant substrate. Lipids also become the predominant substrate during recovery from exercise that results in glycogen depletion.²⁸

There is a consensus that in endurance trained athletes fat oxidation rate is the highest in those activities performed at intensities around 65% of VO₂ max.¹¹ This intensity corresponds to a value of approximately 70-75% of maximal heart rate, a value commonly recommended in exercise prescriptions for programmes

to improve cardiovascular fitness, but this intensity is difficult to reach or to maintain for overweight or obese untrained people. This was recently confirmed in the PRONAF study, in which untrained overweight and obese adult subjects followed a supervised training protocol of 22 weeks. At the end of the study, even after losing weight and body fat and improving their fitness status, they were not able to perform at the target intensity of 65% VO₂ max.²⁷

There is a belief that to increase the use of fats as the energy source, exercise intensity should be moderate or low because the higher the exercise intensity the greater the body's reliance on carbohydrates as an energy source,¹¹ but to reach a determined energy expenditure for maintaining or losing body weight, untrained, overweight or obese people, should emphasize exercise duration and progress to higher intensity exercise increasing the energy expenditure which will also bring them additional cardiovascular benefits.

Sedentary or Sitting time as a risk factor for health

The relationship between physical activity and sedentary behaviour is still not clear in adults according to the systematic review by Rhodes et al.²⁹ There seems to be some evidence for a negative association between TV viewing and general screen viewing with physical activity, but no relationship is apparent for computer use or general screen behaviour. Few studies

Table II
Effects of aerobic training and strength training on selected health parameter

Variable	Aerobic exercise	Resistance exercise
Bone mineral density	↑↑	↑↑
Body composition		
% body fat	↓↓	↓
Fat free mass	↔	↑↑
Strength	↔	↑↑↑
Glucose metabolism		
Insulin response to glucose challenge	↓↓	↓↓
Basal insulin levels	↓	↓
Insulin sensitivity	↑↑	↑↑
Blood lipid levels		
HDL-cholesterol	↑	↑↔
LDL-cholesterol	↓	↓↔
Heart rate at rest	↓↓	↔
Stroke volume	↑↑	↔
Blood pressure at rest		
Systolic	↓↔	↔
Diastolic	↓↔	↓↔
VO2 max	↑↑↑	↑↑
Endurance performance	↑↑↑	↑↑
Basal Metabolic rate	↑	↑↑

Footnote: The Arrows indicate the change produced by training. ↑ = increase; ↓ = decrease; ↔ = little or no change. The more arrows, the greater the effect. Modified from 11.

have analysed the combined influence of sedentary behaviour and physical activity on obesity. In a recent study on adults from the NHANES, low MVPA was consistently associated with a higher risk of obesity, regardless of TV time or total sedentary behaviour.³⁰ Interestingly, small differences in daily MVPA (5-10 minutes) were associated with relatively large differences in the risk of obesity. Another study found that the strength of the association between certain types of sedentary behaviour and BMI was influenced by the time spent performing physical activity. More than 60 minutes of MVPA and less than 60 minutes of TV time per day resulted in lower average BMI than the same TV time but less than 60 minutes of MVPA.³¹ As data are still scarce and even contradictory when analysing the same subjects,^{30,32} the combined effect of sedentary behaviour (and here differentiating between several ones like TV time, reading, learning, etc) and physical activity (here also differentiating between MVPA, active transportation, etc.) deserves further study.

Currently, many common forms of behaviour in our daily life involve sitting, for example, driving a car, working at a desk, eating a meal at a table, playing video games, watching TV, listening to music, etc, and they can occupy a large part of our day, a tendency which is predicted to increase further in the near future.²⁹ Sedentary has begun to be studied as an independent risk factor in the last decade. A recent study performed on 222,497 adults in Australia, concluded that prolonged sitting is a risk factor for all-cause mortality even for people who engage in the recommended 150 min/week of physical activity, suggesting that what happens in the remaining 6500 minutes of the week one is awake is important for health.³³ Shorter sitting time and physical activity are independently protective against all-cause mortality not just for healthy individuals but also for those with cardiovascular disease, diabetes, overweight and obesity. In contrast, sitting periods of 4 to less than 8 hours/day, 8 to less than 11 hours/day, and 11 or more hours/day, increased the mortality hazard ratios (1.02, 1.15, 1.4, respectively) after an average follow-up period of 2.8 years. The association between sitting time and all-cause mortality appeared consistent across the sexes, age groups, body mass index categories, and physical activity levels and across healthy participants compared with subjects with pre-existing cardiovascular disease or diabetes mellitus.³³

General practitioners participating in the health care system should be involved in a population-based intervention to increase physical activity in the population.³⁴ But the percentage of primary care physicians who include physical activity together with nutrition in a combined lifestyle guidance to their patients is low, and therefore we are possibly missing additional opportunities for obesity prevention.³⁵ Other settings such as schools, workplaces and sports clubs have been proposed for increasing physical activity in all age groups by providing optimal conditions for each subpopulation.³⁴ These authors also express the urgent need of a coordinated population-based intervention program for improved health and reduced health expenses through increased physical activity in the entire population, which should be implemented at the national and international level.

Conclusions and future prospects

There is scientific evidence that regular physical activity reduces total mortality risk, mortality risk from cardiovascular disease and other causes (independently of weight loss). Physically active people have a lower body fat percentage than inactive people, at all ages and in both sexes. Overweight people who have a good fitness level have better cardio-metabolic health than non-fit overweight people and similar to lean but unfit people. Physical activity and physical fitness seem to exert synergic but independent effects on health-related parameters. Sedentary and hours of physical inactivity

seem to act as independent risk factors for health. Aerobic exercise should be complemented with strength training in both sexes and all age groups. An active life is fun and helps in socialization. Several studies have shown that it is never too late to start doing physical activity; this means that intervention programmes should focus on people of all ages, including the elderly. Gender aspects should also be taken into account.

There is still a need for research to determine the appropriate dose of exercise (time, duration and intensity) in combination with sedentary behaviours and other physical activities (i.e. transport) in the context of our modern lifestyle in order to prevent obesity at all ages. As has been mentioned above, obesity prevention has not been a target issue of sport sciences until quite recently. As public health measures have failed to stop the obesity epidemic in both developed and developing countries in the last 3 decades, there is clearly a need to change the paradigm. The inclusion of sport scientists, physical education teachers and other professionals in the multidisciplinary team which should be responsible for drawing the road map to prevent the increase of the obesity epidemic effectively is a “must” from our point of view.

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