Instituts thématiques

Inserm

Institut national
de la santé et de la recherche médicale

Physical activity

Contexts and effects on health

Synthesis and recommendations

This document summarises the work of the group of experts assembled by Inserm as part of the collective expert report procedure (appendix) carried out at the request of the French Ministry of Youth, Sports and Community Development *(Ministère de la Jeunesse, des Sports et de la Vie Associative)* with regard to physical activity, its contexts and its effects on health. The work reflects the scientific data available in the second half of 2007. The documentary base consists of some 2,000 articles.

The Inserm Collective Expert Report Center was responsible for the coordination of this collective expert report.

Group of experts and authors

Sylvain AQUATIAS, Université de Limoges, Institut universitaire de formation des maîtres, PPF Interactions didactiques et langages / GRESCO (groupe de recherche en sociologie du Centre Ouest)

Jean-François ARNAL, Inserm U 858, Institut de médecine moléculaire de Rangueil (I2MR), Toulouse ; Fabien PILLARD, Service d'exploration de la fonction respiratoire et de médecine du sport, Hôpital Larrey, Toulouse ; Daniel RIVIERE, Service d'exploration de la fonction respiratoire et de médecine du sport, Clinique des voies respiratoires, Hôpital Larrey, Toulouse

Jean BILARD, EA 4206, Conduites addictives de performance et santé, Université Montpellier I, Montpellier

Jean-Paul CALLEDE, CNRS UMR 8598, Groupe d'étude des méthodes de l'analyse sociologique, Maison des sciences de l'homme, Paris

Jean-Marie CASILLAS, Inserm U 887, Motricité et plasticité, Pôle de rééducation et réadaptation, CHU, Dijon

Marie CHOQUET, Inserm U 669, Troubles du comportement alimentaire et santé mentale des adolescents, Maison des adolescents, Hôpital Cochin, Paris

Charles COHEN-SALMON, Inserm U 676, Physiopathologie, conséquences fonctionnelles et neuroprotection des atteintes du cerveau en développement, Hôpital Robert Debré, Paris

Daniel COURTEIX, Laboratoire de biologie de l'activité physique et sportive, EA 3533, Université Blaise Pascal, UFR STAPS – Clermont-Ferrand II

Martine DUCLOS, Service de médecine du sport et des explorations fonctionnelles, CHU Gabriel Montpied, Centre de recherche en nutrition humaine (CRNH-Auvergne), INRA UMR 1019, Université Clermont I, Clermont-Ferrand

Pascale DUCHE, Laboratoire de biologie de l'activité physique et sportive, EA 3533, Université Blaise Pascal, UFR STAPS – Clermont-Ferrand II

Charles-Yannick GUEZENNEC, Pôle départemental de médecine du sport de l'Essonne, Centre national du rugby, Marcoussis

Patrick MIGNON, Laboratoire de sociologie du sport, Institut national du sport et de l'éducation physique (INSEP), Paris

Jean-Michel OPPERT, Inserm U 557, Épidémiologie nutritionnelle, Centre de recherche en nutrition humaine Île-de-France ; Service de nutrition, Hôpital Pitié-Salpêtrière (AP-HP), Paris ; Université Pierre et Marie Curie, Paris

Christian PREFAUT, Inserm ERI 25, Muscle et pathologies, Service central de physiologie clinique, Hôpital Arnaud de Villeneuve, Montpellier

Pierre ROCHCONGAR, Unité de biologie et médecine du sport, CHU de Rennes, Rennes

Anne VUILLEMIN, École de santé publique, Faculté de médecine, Université Henri Poincaré, Nancy I, Vandoeuvre lès Nancy

The following presented papers

François DUFOREZ, Damien LEGER, Centre du sommeil et de la vigilance, Hôtel-Dieu, Paris

Brian MARTIN, Office fédéral du sport, Haute école fédérale, Macolin, Switzerland

Francesca RACIOPPI, World Health Organization (WHO), Rome, Italy

Angélo TREMBLAY, Service de médecine sociale et préventive, Université de Laval, Québec

Wanda WENDEL-VOS, Centre de prévention santé, Institut national santé et environnement, Bilthoven, The Netherlands

Critical rereading

Martine BUNGENER, Cermes (Centre de recherche médecine, science, santé et société), CNRS UMR 8169 – Inserm U 750, EHESS, Université Paris-XI, Villejuif

Didier MAINARD, Physiopathologie et pharmacologie articulaires, UMR CNRS 7561, Service de chirurgie orthopédique, Hôpital central, Nancy

Scientific, editorial, bibliographical and logistic coordination

Fabienne BONNIN, scientific associate, Inserm Collective Expert Report Center, Xavier-Bichat Faculty of Medicine, Paris

Catherine CHENU, scientific associate, Inserm Collective Expert Report Center, Xavier-Bichat Faculty of Medicine, Paris

Véronique DUPREZ, expert report manager, Inserm Collective Expert Report Center, Xavier-Bichat Faculty of Medicine, Paris

Jeanne ÉTIEMBLE, director, Inserm Collective Expert Report Center, Xavier-Bichat Faculty of Medicine, Paris

Cécile GOMIS, secretary, Inserm Collective Expert Report Center, Xavier-Bichat Faculty of Medicine, Paris

Anne-Laure PELLIER, scientific associate, Inserm Collective Expert Report Center, Xavier-Bichat Faculty of Medicine, Paris

Chantal RONDET-GRELLIER, documentalist, Inserm Collective Expert Report Center, Xavier-Bichat Faculty of Medicine, Paris

Contents

Foreword

In industrialised countries, changing lifestyles are accompanied by a gradual decline of physical effort in professional and everyday life activities. While in the past excessive physical toil led to a premature ageing of the population, the growth of sedentary work today is tending to deprive a majority of people of the physical stimulation necessary for a balanced life and good health. Mention is often made of the epidemic of obesity and the increasing prevalence of chronic conditions such as cardiovascular diseases in relation with this phenomenon.

This reality constitutes a challenge to the public authorities and professionals working in the health and sports spheres, worried about their ability to influence the habits, well-being and health of the population via various strategies for promoting physical activity. "Physical movement" has thus become a new public health challenge.

While it is commonly agreed that regular physical activity is good for the health, in particular for preventing certain chronic diseases or contributing to their treatment, the relationship between physical or sports activities and health is far more complex than it seems. It depends in fact not only on a wealth of individual parameters such as age, sex, state of health and psychosociological determinants but also on the characteristics of the activity itself, its volume and frequency throughout life.

The Ministry of Youth and Sports has asked Inserm to conduct a collective expert report, on the basis of scientific and medical knowledge, concerning the effects of physical and sports activity on health in terms of benefits and risks. The abuse of drugs in sports is an area of investigation in its own right and is outside the scope of the expertise.

To this end, Inserm has brought together a multidisciplinary group of experts competent in the fields of sociology, epidemiology, physiology, clinical medicine, biology, psychology and public health. In the course of 13 working sessions, the group analysed and summarised the international scientific and medical literature in order to address the following questions:

- What has been the result of changes in lifestyle on physical activity in everyday life?
- What are the recent figures concerning physical and sports activity in France according to sex, age and socio-economic level? How does France compare to other countries?
- What is the socio-historical background to the practice of sports in France and what are the foundations of the "sports" policies?
- What are the psychosociological and environmental determinants conditioning adherence to physical and sports activity? What are the resulting strategies in terms of promoting physical activity?
- What are the instruments and methods for measuring physical activity, particularly in an everyday life setting?
- What is the epidemiological evidence concerning the link between physical activity and reduced mortality?
- What are the effects of physical activity on well-being, quality of life and sleep?
- What is known of the effects of physical activity on the major bodily functions: muscle function, osseous capital, the osteoarticular system, cardiovascular system,

cerebral functions, immune system, weight control, etc.? What are the effects in terms of preventing illnesses?

- What do the data say about the benefits and risks of physical activity in patients suffering from cardiovascular diseases, cancer, broncho-pulmonary diseases, musculoskeletal disorders and obesity? What types of physical activity – and at what frequency and intensity – are required in order to provide protection against these diseases or their risk factors and to contribute to their treatment?
- What are the traumatisms and their consequences linked to sport and physical activity? Are there contexts fostering dependency on sport (social context, type of personality, sex, age)?
- What is known of the genetic determinants associated with performance?
- What are the benefits and risks of physical activity in certain sectors of the population (children, women, athletes, the elderly, handicapped persons) as far as physical and mental health are concerned? What shape should physical activity take at different ages for it to be beneficial to health?
- What are the recommendations (based on knowledge) for the general adult population, children, the elderly, and for those suffering from diseases?

In order to complete its analysis, the group of experts listened to what several key players in the research world had to say about the strategies for promoting physical activity and the environmental approaches, the effects of physical activity on sleep and studies in health economics.

Synthesis

Physical activity can take place in different contexts. It may be linked to a professional activity, form part of leisure activities or even involve housework or travelling and commuting.

For much of the population, physical activity is no longer associated with professional activities and getting about in everyday life. The growth of sedentary work and of physically passive recreational activities (television, video games, etc.) has led to an imbalance resulting from the expenditure of less energy. Thus, with adults, physical activity depends mostly on their motivation to engage in it in the course of their leisure time, whether spontaneously or as members of a club or sports association. The number of such adults practising outside the structure of a club is much greater than in the past (75% compared to 50% in 1985).

In France, there are numerous local initiatives successfully seeking to promote "sport for all". But how is the health factor incorporated with the other objectives of a sports activity? Little consideration has as yet been given to physical activity as an essential component of health.

How can the impetus given at State level and the initiatives taken locally help to curb the generalisation of an excessively sedentary lifestyle?

Generally speaking, the models used here are "socio-ecological" models of behaviour referring back to the dynamic interactions between individuals and their physical and socio-cultural environment.

Moreover, the promotional and exhortatory messages issued by the authorities must be grounded in a critical review of the scientific work studying the effects of physical and sports activity on the quality of life and morbidity/mortality. It is important to know by which mechanisms physical activity acts on the major bodily functions, and it is on the strength of this knowledge that recommendations can be drawn up concerning physical activity and how it should be practised among the general population.

Studies on the effect of physical activity among persons suffering from chronic pathologies and among the elderly have developed considerably in recent years, and have resulted in the definition of specific and consensual recommendations at international level.

Understanding the French situation regarding sport and physical activity: historical background

There are many origins of "sport" in France (military instruction, gym classes at school, athletic sports, etc.) and they can be traced back a long way. In the early 1920s, public policy with regard to sport crossed the path of another tradition dating back to the 1880s – that of practising sport in clubs (particularly inspired by British athletics clubs). These sports associations were important components in civil society. Fiercely attached to their autonomy, and even their independence, they continued to flourish. Working alongside the public authorities, they helped build up a new cultural and educational arena centred on sport and characterised by social participation, initiative, cooperation and contractualisation.

The socio-historical context of the practice of sport in France may be roughly divided into two principal phases of development:

- An initial phase featuring civilian clubs and predating the direct involvement of the public authorities in the sports field (1880-1920)
- A long period during which the public authorities supported and successively accompanied the civilian clubs, starting in the 1920s and continuing up to the present day. The early 21st century witnessed a phenomenon of social differentiation as regards the various forms of sports activity, while subsidies and public funding (from the State, municipalities and other local authorities) reached unprecedented levels.

In the course of the initial phase when the practice of sport began to take shape in France, various activities such as gymnastics, recreational shooting, fencing, cycling, boating and rowing became well established and preceded the introduction of athletic sports. The Army, for its part, had long set great store by physical exercise: walking, swimming, fencing, horseback riding, gymnastics, and so on. Gymnastics was also practised and taught in schools (particularly from the age of 12); and starting in the 1890s outdoor games started to become a feature of school life. Thus, the Annuaire de la jeunesse[1], a sort of study guide and directory of educational establishments, referred to the tensions and contradictions implicit in the concept of sports activity: "Physical education may be approached from three angles; from the point of view of athletics, military life or hygiene".

The second period is marked by a few key stages during which we may distinguish three successive models for the organisation of sports activities. Up to the mid 1920s, the most common model was the sports club (often a multi-sports club). These clubs endeavoured as far as possible to own their own facilities (office, sports ground, changing rooms with showers and bathrooms, and so on). They owned the sports facilities as associations. It was the "modèle associatif patrimonial". Following the municipal elections of 1926, certain town councils, newly in the hands of the Left, started to develop public facilities (stadiums, gymnasiums, swimming pools, rooms set aside for physical education and medical gymnastics, school outdoor centres, and so on). This was the municipal model of public facilities. The Popular Front (Front Populaire) government of the mid 1930s helped to extend these initiatives throughout the country (urban communities for the most part). In the interwar years, a few large companies introduced physical education, sports and medical examinations into their programme of services for employees. This paternalistic model often formed part of a global – and controlled – management of company employees[2].

To sum up these different phases and events, we may say that, on the eve of the advent of the Fifth Republic in 1958, sports were for the most part reserved for young people, in particular in school establishments, and much more for boys than for girls. The 1960s were to usher in several changes:

- The modernisation of the "sports system" set in motion by Maurice Herzog, Minister of Sport at the time
- The crisis of the "modèle associatif patrimonial" (state-run organisational model) whose sports facilities were no longer in a position to meet social demand
- The introduction of a municipal policy of public sports facilities (especially in the suburbs where public housing projects abounded).

[1] *Annuaire de la Jeunesse* (by MH Vuibert, rue des Écoles, Paris). Chapter «*Éducation physique*» (Physical education). Paris, Librairie Nony et Cie, 1894 (5th year) (VII-1111 p.), p 3-11

[2] Michelin (Industriels). *Une expérience d'éducation physique* (An experiment in physical education). *Prospérité, revue trimestrielle d'organisation scientifique*, Clermont-Ferrand, Éditions Michelin, n°12, 1932. The results – positive – of this experiment in the application of the Hebertist method are set out in the review for the year 1936.

Thus, a third model for organising the practice of sport began to emerge. In this model of standardised cooperation, the municipal authorities provided the sports facilities, paid the staff responsible for maintaining them and handed out subsidies to the clubs. The sports clubs, for their part, favoured a volunteer set-up and the inculcation of models of sports culture through the teaching of sporting disciplines. Thus there grew up side by side a "communal" or public model, reflecting the preponderant role played by municipalities in local sports, and a "liberal" model emphasising its own network but without being hostile to the pluralistic approach embodied in the associations.

In the course of the 1980s, the model prevailing over the previous 20 years ran into difficulties. There was first of all an identity crisis (prompted by the rise of professionalism and strong financial pressure). To this were added the growing pains resulting from an upsurge in the numbers of those engaged in physical and sports activities plus a certain crisis of ideological legitimacy. An emerging "new generation", interested in voluntary gym classes, leisure sports activities, etc., was now clamouring for improvements in sports facilities (changing rooms, swimming pools, gymnasiums, and so on), and their associations were anxious to secure a decent annual subsidy. On top of this, the popularisation of sport, particularly as a leisure activity, was giving rise to an increasing number of accidents and injuries. This became a cause for concern for the medical profession and a financial burden for the social security and insurance bodies (as well as the complementary insurance companies). Successive programmes designed to use sport as a means of preventing juvenile delinquency were introduced in the so-called "problem" districts, adding a hitherto unknown dimension to the practice of sport.

Another structure for promoting physical and sports activities consisted of company sports clubs and the employee benefit component of works committees. The rise of these entities helped to democratise leisure activities and to act as a spur to teaching innovation and even research[3]. By the end of the 1980s, these clubs were beginning to feel the effects of changes in economic life and a diminished involvement on the part of unions, discernible at national level.

The practice of sports today encompasses sports at a popular level as organised by the clubs, high-level sport, which nowadays depends on more or less professional clubs, and physical activities practised by sportsmen and women who are not members of an association. To this should be added school sports practised on a voluntary basis in secondary schools (in other words, outside the compulsory time reserved for physical and sports education). Mention should also be made of the emergence of outdoor sports not requiring membership of a club or federation (mountaineering, paragliding, windsurfing, etc.) but which have all the characteristics of a sports activity, particularly in terms of technical accomplishment. These practices correspond to specific age groups and socio-cultural backgrounds and are sometimes the expression of a local or regional tradition (e.g. rugby in the south-west of France).

At municipal level, outside the realm of professional sport, several kinds of "public" services tying in with the models presented above may be identified:

- A simple associative movement: this is the oldest model but it could also mark an emerging trend related to an initiative taken by a group of persons

[3] Mention should be made of the "Cahiers de l'IFOREP", a training and research institute linked to the Welfare Unit of the French Electricity and Gas Boards (EDF-GDF). Some of the papers published are of interest to us here: "Les activités physiques et sportives" (Physical and sporting activities), No.7, 1979; "Quel sport pour quelle santé?" (What sport for what health?), 1983; "Pour le sport" (In favour of sport), No.60, 1990.

- A contractual associative movement organised on the basis of an agreement on objectives binding the club(s) and the municipal authority
- A municipal model of direct service to persons. This is a complement to the above model and includes such services as the installation of a municipal swimming school, a multisports school supervised by municipal staff, etc.

Another organisational model is exemplified by the gymnasium clubs, fitness clubs, and so on launched by private commercial interests. This is a lucrative business, well adapted to changes in social demand: diversification of services, conviviality, and proximity to the place of work.

A new model referred to as "mass sports individualism"[4] is beginning to take shape and could lead to significant changes in the improvement of living conditions. Sports enthusiasts in urban areas (individuals, families, groups of friends) have been demanding the creation of a coordinated network of bicycle paths, and the development of itineraries (for running, roller-blading and walking) in parks and public gardens, along the banks of rivers, or of reserved and protected itineraries leading on to peri-urban areas.

Thanks to physical and sports education (now an educational discipline) and school sports (practised in sports associations and based on the voluntary membership of junior and senior secondary school students), the youth of today are able to become acquainted with various physical and sports activities in greater numbers. At the same time, there is a fall in the number of adolescents (of both sexes) taking out "sports licences" enabling them to participate in competitions. Perhaps they feel they can express their desire for cultural sociability outside the realm of sport?

As for the population as a whole, significant differences are observed in the way that physical and sports activities are conceived, in the way that these activities are expressed on a daily and weekly level and within the framework of leisure activities. However, the different social space-time singularities (work, family, leisure, transport and travel), and the control exercised over them, are difficult to characterise and cannot be reduced to a few typical tendencies. That said, it is known that the living environment (the place of residence) remains a highly relevant "synthetic" variable, partly related to the efforts accomplished by the municipalities (towns and villages), the départements and the régions.

The situation observed locally in France is linked to other dimensions: contract between the State (the Ministry[5]) and the CNOSF[6] (and the national federations), relayed and completed by a tripartite relationship at regional level (DRJS[7], CREPS[8], Regional Council and CROS[9]) or at the level of the départements (DDJS[10], General Council and CDOS[11]).

---

[4] Haumont A. *La pratique sportive.* In: *Sociologie du sport.* Haumont A, Levet Jl, Thomas R (eds). PUF, Paris, 1987: 63-148; See p. 86 et seq.

[5] *Ministère de la jeunesse, des sports et de la vie associative* (Ministry of Youth, Sports and Community Life) (name in force until June 2007)

[6] CNOSF: *Comité national olympique et sportif français* (French National Olympic and Sports Committee)

[7] Direction régionale de la jeunesse et des sports (Regional Directorate of Youth and Sports)

[8] Centre régional d'éducation populaire et sportive (Regional Centre of Popular and Sports Education)

[9] Comité régional olympique et sportif (Regional Olympic and Sports Committee)

[10] Direction départementale de la jeunesse et des sports (Departmental Directorate of Youth and Sports)

[11] Comité départemental olympique et sportif (Departmental Olympic and Sports Committee)

Where do the other countries stand compared to France?

In France, the Ministry of Youth and Sport created a “Sport for all” department in 1978. This was no more than official recognition of a general aspiration on the part of the population, already perceptible in changes of behaviour, for recreational physical activities. Article 1 of the Law of 1984 emphasised that sports culture should be accessible to all. And yet a firm, original, specific and long-term line of action seemed to be lacking in the Ministry’s position. Today, an awareness of the importance of physical activity for health is beginning to emerge. With the Ministry’s backing, the CNOSF, the sports federations and the local authorities are becoming involved in the various “Sport for all” programmes. France has a wealth of local initiatives which, by virtue of their goals and impacts, correspond to the “Sport for all” objectives. Even so, only limited headway has been made in the consideration of physical activity as an essential component of health.

Spain and Portugal, countries in which a non-democratic state long exercised a strong influence on the sports movement, have since those days developed, mainly in big cities, policies designed to facilitate sports facilities, to support sports associations and to directly promote "Sport for all" programmes. These policies have not in any way hindered private business initiatives.

Italy is something of a special case since, under Mussolini, the Italian National Olympic Committee played a preponderant role in competitive and high-level sport. But this did not stop the federalisation of the idea of sport for all (with the Unione Italiana Sport Popolare). The country has succeeded in attracting new sectors of the population to sport and leisure physical activities through a wide range of initiatives.

In several countries of northern Europe, the State has opted to attribute the status of contractual agent to the entire association sector and not just to the national sports federations (who might have laid claim to an exclusivity contract). This is what is usually understood by the term “Scandinavian Model”. It concerns Denmark, Finland, Norway and Sweden.

In Germany, the regional governments, the Länder, are in charge of the development of sport for all through their support for local initiatives against a backdrop of crisis in the welfare state.

Great Britain is something of a special case, with a non-interventionist State leaving the way clear for initiatives by civil society and the private sector. Britain is also referred to as the “sports country par excellence”. However, there is no confusion between the different models of physical activity, including at ministerial level.

Are there similarities between the American and Canadian experience and the situation in Great Britain? In both these countries, sport and leisure physical activities were taken seriously much earlier than in Europe.

In the United States, sport features prominently as a major element in leisure activity. However, starting in the 1960s, and leaving aside periods when sport is traditionally practised less often (when people leave the educational system or when they are in their forties), there has been a general fall in the practice of sport. This loss of interest may partially be due to a reaction against the model of competitive sport, deemed too demanding. In order to understand this phenomenon, the government agencies commissioned a series of surveys, and in the 1970s and 1980s leading research institutes conducted studies to better understand the new trends. Among these trends, hiking, cycling and outdoor activities close to home were top activities.

In 1943, the Canadian government enacted the first National Physical Fitness Act, accompanied by the creation of the National Physical Fitness Council. Since then, the commitment shown by the public authorities has had its ups and downs, with a high in the 1960s and early 1970s, but a low point ten years later. However, the statistics supplied by the Canadian government at the beginning of the 1980s highlighted the growing importance of physical activities (walking, cycling, swimming, jogging, running, gardening, physical fitness at home, etc.). Local conditions are highly contrasted in countries as large as the United States and Canada. Differences are also the result of historical factors, the living environment (urban or rural setting), industrial development, climate conditions and financial resources.

The socio-historical context in which a country's sports activities are practised corresponds to a singular reality. The way in which recreational physical activity is conceived depends on how the "sports" population reacts to the initiatives of the associations and the measures taken by the public authorities.

In France, are policies geared towards the promotion of sport for health reasons?

Sports policies in France are grounded in the principle of making physical and sports activities accessible to as many people as possible. Such policies must reflect not only the pursuit of excellence embodied by the elite – those who will represent France in international competitions – but also the disadvantages and possible harmful effects to health of not having access to physical and sports culture.

The public authorities define the general interest in the sphere of sports policy. This interest is expressed by the building of sports facilities, the training of supervisory staff and the allocation of financial means. The objective is to encourage as many citizens as possible to engage in physical and sports activities. On the one hand, the champions contributing to the country's reputation are accommodated in specialised institutions complete with trainers, doctors, physiotherapists and even psychologists, and have substantial financial means at their disposal. In marked contrast, however, there are special situations such as the lack of sports activities for young people in disadvantaged neighbourhoods and the virtual exclusion of handicapped persons. The public authorities are anxious to deal with these situations by setting up "sport and social reintegration" programmes for young people, or "adapted sport" plans for the handicapped. Such programmes call for human resources (socio-sports educators) and financial means.

Sports policies in France thus embody two realities: values (the "sport for all" ideal together with a concern for special situations) and organisation (administration, material and human resources).

Historically speaking, the Sports Ministry first concentrated on the so-called "captive" sectors of the population: schoolchildren and students, national servicemen and licensed members of clubs. It was not until the mid 1930s that the imbalance in the treatment of boys and girls in terms of physical and sports education was redressed. At that time, the enthusiasm for nature and outdoor life led to the promotion of physical exercise over and above its purely competitive aspects. The advent of the "leisure age" in the 1960s prompted the rise in independent sports activities at different levels of the population: the "second age" (people already too old, for example, to take part in competitive sports in a club), and the "third age" or "senior" category of society.

The degree of commitment behind sports policies tended to vary in function of the times and the economic circumstances. The status of the "Sports Ministry", its rank within the government, the precise definition of its spheres of competence and, where appropriate, its attachment to a parent ministry, can give us a good idea of the importance attached to the relationship between the practice of sport and health. How has this relationship been perceived, and how has it changed, with the passage of time?

At the end of the First World War, Henry Paté (1919), in his capacity as Chairman of the "Comité national de l'éducation physique et sportive et d'hygiène sociale", solemnly declared that "France demands the building of swimming pools, playgrounds and stadiums in all municipalities, and the transformation of all school establishments into places for the propagation of hygiene and the dissemination of the healthy joy of physical exercise."

However, in these immediate post-war years, there was a fierce struggle for influence between various institutions: the Ministry of War (in charge of the Ecole de Joinville), the Ministry of Public Health and Social Hygiene, and the Ministry of Public Education. The medical profession was responsible for physical rehabilitation and so-called "corrective", "respiratory" and "orthopaedic" gymnastics.

The year 1925 was to prove a turning point in the shaping of the first sports policies put into practice by the town councils, particularly those that were supposedly "progressive". The rooms (or gymnasiums) destined for physical education or physical rehabilitation formed part of a programme of public facilities. The issues at local level were not always the exact reflection of national concerns. Generally speaking, the promotion of a culture of sport tended to overshadow the vague patriotic desire for a utilitarian and "military" approach to physical education.

In the early years of the 1930s, the question of a fully-fledged Sports Ministry rose to the surface. During the short-lived Popular Front government (1936-1938), the physical and sports education of the young was actively encouraged. In the first Popular Front government, Léo Lagrange became Under-Secretary of State for the Organisation of Sports and Leisure, under the authority of the Ministry of Public Health. He insisted that all young people should have access to sports education, with the Popular Sports Licence (Brevet sportif populaire) constituting relevant "proof" of this access. "The purpose is to encourage French people to take care of their health and their physical development by getting them to undergo tests indicating a good level of health". It was at this time that an effective connection between State policy and application at local level was established, particularly in the towns.

Starting in 1946, the establishment of a National Open Air Committee (for the promotion of outdoor activities) and the development of outdoor institutions (holiday villages for children, summer camps, health camps, outdoor schools, sanatoriums, etc.) marked a return to the spirit of the Popular Front. These decisions helped to popularise the idea of physical activity, particularly in youth movement and popular education circles.

At ministerial level, the status of physical and sports education was to meet with mixed fortunes, apart from a frequent attachment to the Ministry of National Education: in late 1947, its sphere of competence was entrusted to a director-general and it was absorbed by the Ministry of Youth, Arts and Letters. On the other hand, in 1950 this field was included in a State Secretariat for Technical Education, Youth and Sport.

In the 1950s, Dr Encausse, a scientist in charge of the Medical Bureau of the High Commission for Youth and Sports (headed by Maurice Herzog), set out his ideas in a work entitled Sport et santé (Sport and Health) (1952, 1962). This work studied, firstly, the

influence of physical and sports activities on the body and, secondly, the administrative, technical and practical organisation of the medical supervision of these activities.

The emphasis on the "sports" aspect of physical culture and exercise increased throughout the 1960s and the following decade. Competitive sport was imbued with an ideological legitimacy which tended to overshadow the other practices. At the time, the peer and multi-sports federations, club officials, and youth and popular education associations stood aside in favour of the sports model proclaimed by the single-sport federations. However, in addition to the "declared" sportsmen and women (licensed club members), there were also self-proclaimed "sportspersons" who are not registered with a club. There was also a category of "non-sportspersons" who, in most cases, did not pursue any physical activity. This disparity harks back to a social question of the time: in 1968 the Fédération Française des offices municipaux des sports chose to address the question of "Sport for all" at its annual conference.

The law on "the development of physical education and sport" of 29 October 1975, the so-called "Mazeaud Law", constitutes an important milestone. This law was designed primarily to accompany, from the organisational point of view, the transformation of sport in France. It stresses that "companies would appear to be one of the best structures for the development of sport for all" (Part II). However, the law had relatively little to say about the role of physical activities and their importance for the maintenance of health. The "National Day" operations, jointly run by the Ministry's departments, the clubs and the local authorities (for example the Parcours du Cœur initiative), did not seem to have a significant and lasting impact on individual behaviour. Wasn't France in danger of losing ground compared to certain neighbouring countries?

In the early 1980s, the Avice Law, concerning the organisation and promotion of physical and sports activities, was enacted on 16 July 1984. Cultural changes were added to a crisis of the welfare state and tangible signs of economic recession. Physical and sports activities, together with sports holidays continued to progress, although social inequalities persisted or changed shape. These inequalities were in part related to the increasing complexity of migration flows. The actions carried out by powerful works councils were then at their zenith, contributing to the democratisation of physical and sports activities and holiday camps.

In the following years, economic difficulties and the rise of unemployment served to put a brake on these innovative tendencies. Priority was given to sports activities for young people living in the so-called "disadvantaged" districts (the "Vacances et loisirs pour tous" (Holidays and Leisure for All) and "Loisirs quotidiens des jeunes" (Daily Leisure Activities for the Youth) interministerial programmes).

The "ministerial" status of the Ministry of Sports varied over the years: sometimes there was a ministry in its own right, sometimes a State Secretariat with responsibility for sport headed by a personality acting as a delegate attached to the Prime Minister.

Decentralisation, which became effective with the laws of 1982 and 1983, resulted in the redistribution of roles between the State, the départements and the régions. Some départements had already started to implement actions to foster the development of sports among young people. Decentralisation conferred new powers on the regions, complementary to the crucial role played by the municipalities.

In 1996, Roger Bambuck noted that the "State's role had been radically transformed from that of tutor to a partner" (Junior Minister for Youth and Sports). Sports policies at local (departmental and regional) level took on a new shape, reconciling town and country planning, sustainable development and tourist promotion of nature areas, and the practice of

sports. Did the question of health form part of their thinking process? A handful of isolated initiatives were observed, such as the operations (symposiums, training days, on-site actions) organised by the Office départemental des sports de l'Hérault in southern France. The role of injury treatment and fitness centres for athletes was once again emphasised during this period.

There was an increasing number of ministerial initiatives in favour of physical activity and sports for the greatest number, but the issue of health did not loom large within the Ministry. More specifically, the objectives of social cohesion and solidarity took precedence over healthcare issues. In this connection, it is particularly instructive to analyse the Ministry's activity reports which, since 1994, have been recording the actions carried out over the previous year. The first explicit reference to health is found in the Annual Report of September 1996. We learn that the "Mission de médecine du sport et de la lutte anti-dopage made a commitment in 1995 in an effort to promote sports activity for health purposes." Over the following years, most efforts were concentrated on the anti-doping campaign. A first anti-doping law was promulgated on 1 June 1965, with the aim of preserving the health of athletes and defending the ethics of sports and the principle of fair competition among sportsmen. It was followed by two other laws in 1975 and 1989.

The activity report for the year 2004 (Ministry of Youth, Sports and Community Life, 2004) gives a detailed description of two lines of action of the Ministry's policy. First, the document notes "the promotion of health through sport" with the continuation of the programme engaged the previous year. The CREPS (Centre for Popular Education and Sport) of Houlgate was awarded the status of national pilot site for "sport-health" initiatives. Second, it dwelt at length on the "prevention of high-risk behaviour" among young people. This preventive action was relayed by the DRJS[12] and the DDJS[13] in partnership with the community life sector.

The public authorities have been instrumental in giving impetus to the interest aroused by "health" questions in connection with physical and sports activity. This interest now seems well entrenched in the public consciousness, as reflected in the title of the new "Ministry of Health, Youth and Sports", constituted in the wake of the Presidential Elections of May 2007.

An inventory of physical and sports activity in the population will obviously depend on the definition given to physical activity

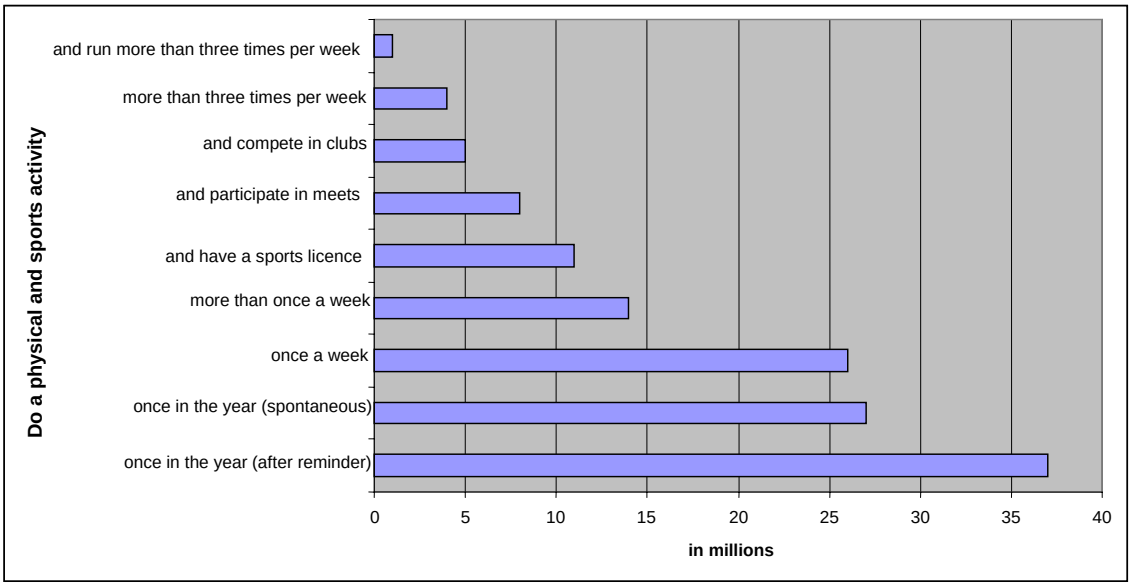
The assessment of the level of physical and sports practice in France has only recently become a subject of enquiry in France, dating back no further than the 1980s. The available evaluations come from a variety of sources that base their estimates on variable definitions and criteria: the reality observed (sports or physical activity), the phenomenon to be measured (level of activity or penetration rate of disciplines), the time unit considered (week or year). These differences quite clearly lead to highly variable estimations.

A first leisure survey conducted by Insee (National Institute for Statistics and Economic Studies) in 1967 questioned French people on their sports activity. The study showed that 39% of the population aged 14 years and over practised a sport. Another study, conducted on the same basis twenty years later, put the figure at 48%. This increase corresponds to a sharp increase in the number of licensed members of sports associations, the development of non-sports physical practices and a policy aiming to encourage sport.

[12] Direction régionale de la jeunesse et des sports (Regional Directorate of Youth and Sports)

[13] Direction départementale de la jeunesse et des sports (Departmental Directorate of Youth and Sports)

The surveys carried out in 1987 and 2000 by Insep (National Institute of Sport and Physical Education) and the Ministry of Youth and Sports, plus the investigation jointly conducted in 2003 by Insee, the Ministry of Youth and Sports and the Ministry of Culture, took the diversification of physical practices into account. This time, people were asked if they had engaged in a physical or sports activity at least once in the course of the previous year. The rate rose from 73% in 1987 to 84% in 2000 for all people aged between 15 and 75 years. The Insep surveys measure the weight of the different physical or sports activities and evaluate the intensity of the activity (frequency in time). While 36 million French people stated that they had engaged in at least one physical or sports activity in the year, only 14 million of them practised said activity more than once a week. Some 10 to 12,000 people are high-level amateur and professional sportsmen/women who devote most of their time to sport.



Levels of participation in physical and sports activities in France according to the survey conducted by Insep and the Ministry of Youth and Sports in 2000

For its part, Inpes in its Baromètre santé (Health Barometer)[14] evaluates the level of physical activity using the International Physical Activity Questionnaire (IPAQ) which compares the physical activity of the population under study with that of other countries according to standards put forward by the various public health bodies. The survey carried out by the Baromètre Santé in 2005 revealed that during the week leading up to the survey, 45.7% of the French persons surveyed (aged 15 to 74 years old) performed a physical activity at a level leading to health benefits.

It is instructive to compare these two kinds of data: in 2005, a little over 80% of French people aged over 15 engaged (at least once) in the year in a physical or sports activity, while over half the population showed insufficient physical activity according to the public health recommendations published by various national and international organisations.

According to the surveys conducted by the Ministry of Youth and Sports, the most popular activities practised by more than 10 million people are (in order of popularity): walking (all forms), swimming (all forms) and cycling. These are followed by running, boules, gymnastic activities and winter sports. In this classification, football ranks top among organised sports, with five million practitioners, followed by tennis (four million).

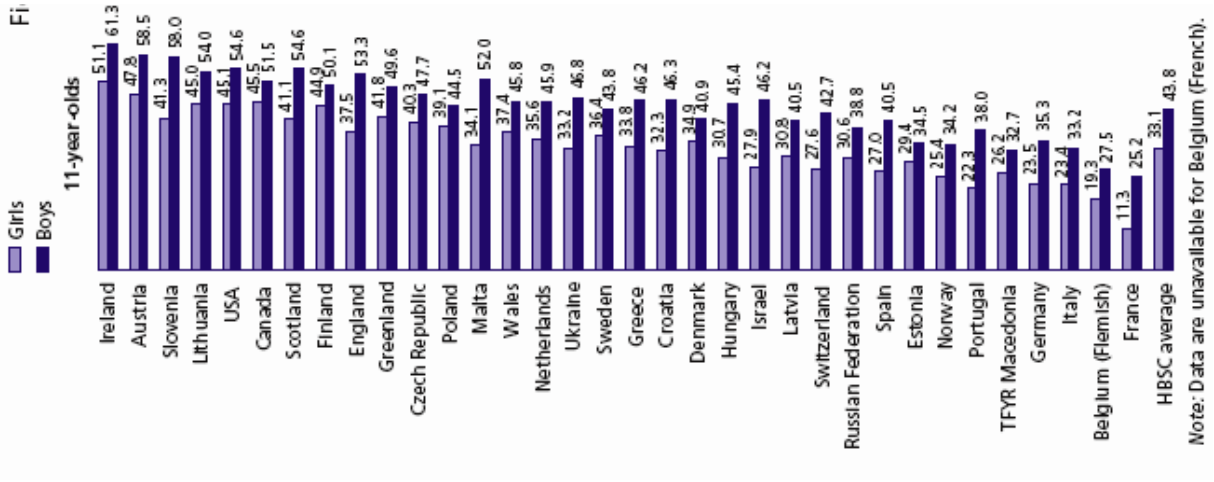
[14] ESCALON H, VUILLEMIN A, ERPELDING M-L, OPPERT JM. Activité physique, sédentarité et surpoids. Inpes, 2007

The remarkable transformation of sports activities has meant that the sports federations have lost the monopoly they once enjoyed on the development of new activities. Although the number of licences issued by the federations increased between 1950 and 2006 (from two to fourteen million), the number of practitioners increased even faster than the number of licensed members. In 1985, one person in two practised a sports activity in the context of an association; today this ratio has dropped to one in four.

There would appear to be two overriding objectives behind the decision to take up a sports activity: firstly, the quest for well-being and personal equilibrium, linked to health concerns or the need for exercise; secondly, the statement of a form of sociability (family and friends) which is far more important than the search for performance or competition, not to mention the taking of risks.

Although there are too few accidentology studies, sports accidents (just after household accidents) rank high among accidents of daily life compiled by the Caisse nationale d'assurance maladie (National Sickness Insurance Fund)[15] (22% of everyday life accidents specifically involve young persons aged from 14 to 24 years during the practice of collective sports). Several explanations may be advanced for these findings. A greater number of practitioners obviously leads to a greater number of accidents; physical activity involves the taking of risks for which practitioners are sometimes ill-prepared, even with activities such as hiking; outdoor sports such as boardsports (skiing for example), practised mainly by young boys outside the embrace of sports associations, are high-risk activities due to the inherent increase in risk-taking. High-risk behaviour such as dietary disorders or the consumption of medicinal drugs is not insignificant in relation to the intensive practice of a sport.

How does France stand in relation to other countries with regard to physical activity among young people? The international "Health Behaviour in School-aged Children" study (HBSC), conducted in 2001-2002, compared the performance of sports activity in pre-adolescents in several European and American countries.



Proportion of 11-year-old schoolchildren whose practice of sports (moderate to intensive) complies with the recommendations (after Currie et coll., 2004 HBSC Study 2001-2002; WHO, 2004)

Physical activity is determined from two questions put to children: the first question concerns the number of days when physical activity lasting at least 60 minutes took place during the 7 days preceding the survey. The second refers to the number of days when they

[15] CAISSE NATIONALE D'ASSURANCE MALADIE (CNAM). Les accidents de la vie courante en 2002. Point Stat 2005, 41 : 1-6

have a physical activity lasting at least 60 minutes in the course of a typical week. This physical activity varies widely from one country to another. In France, 11% of 11-year-old girls and 25% of 11-year-old boys have a physical activity consistent with the recommendations. In Ireland, the figures are 51% and 61% respectively.

The practice of a physical or sports activity is strongly influenced by social integration factors that influence individual motivations

Not many studies make the distinction between sports activities and physical activity in general, and few of them take into account the expenditure of energy due to work, travelling or domestic activities (housework, DIY, gardening, etc.).

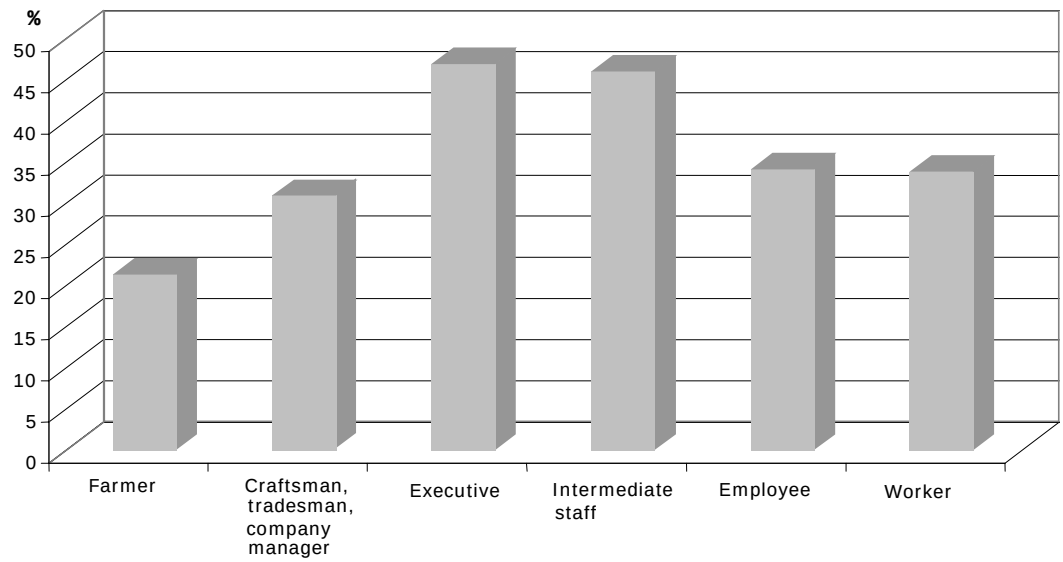
The practice of leisure sports activities varies first of all according to age and sex. Children, teenagers and young adults are more involved than older persons, as are boys compared to girls. Socio-economic variables also come into play.

The first variable is related to the level of education. Those with at least one or two years of higher-education have a greater tendency to practise sports activities (88% of practitioners in 2003), followed by those with diplomas lower than the baccalauréat or school-leaving certificate (vocational training certificate, technical school certificate, junior secondary education certificate), and finally by those without any diploma (45% of practitioners). The diploma is also instrumental in the differences of practice between men and women. Women with higher education attainments have virtually the same level of sports activity as men. But the diploma is not a factor in sports practices among men.

The second variable is the level of personal income. Cost is a determining factor in the most vulnerable sectors of the population. Income level also has an influence on the type of practice: the physical activities of wealthier persons tend to take place in institutional structures (clubs, exercise rooms, etc.), and thus occur more regularly.

The third variable is the place of residence and access to a favourable environment (facilities, parks, bicycle paths, etc.). What counts here is not so much the divide between urban and rural environments as the level of facilities or access to premises where leisure physical activities can be practised. People living in less privileged areas tend to see their environment in a less positive light, both in terms of attractiveness and safety. This perception has a negative impact and tends to limit leisure physical activities in the area. This is especially true for women and children.

A fourth variable is established when socio-professional category is matched with family life cycles defining the amount of time available for leisure activities. The likelihood of taking regular physical exercise is less for people who have young children, work in small companies or are self-employed. However, having time at one's disposal is not in itself enough to prompt the practice of a physical and sports activity. It is recognised that people with a higher educational level and socio-professional category are more likely to organise their time better for this kind of activity.



Percentage of persons practising a sports activity per socio-professional category (after Guilbert et coll., 2001, Baromètre santé 2000)

These four major variables are less clearly established when all areas of activity are taken into account (including the expenditure of energy associated with work, travelling or household activities). Thus, the two socio-professional categories most likely to have a physical activity conducive to health (i.e. the equivalent of 10,000 steps per day) are workmen and in particular farmers and agricultural workers – the very people who are least likely to have a normal sports activity. At the other end of the scale, employees, intermediate staff, managers and intellectual professions, who have fewer obstacles to practising a sports activity, are precisely those who show a decline in daily physical activity. Persons with incomes in excess of 1,500 euros per month and possessing a higher educational level are less likely to have a daily health-enhancing physical activity. In rural areas, the chances of practising a sports activity are less than in urban zones (towns with at least 100,000 inhabitants), but there is a greater likelihood of having a health-enhancing physical activity in towns of over 200,000 inhabitants. Lastly, the presence of a child under the age of 14 in the household has no impact on whether or not adults have a health-enhancing physical activity, but it reduces the chances of having a regular sports activity.

The best explanations for the differences between the practice of a sport and the level of physical activity would seem to lie in the social contexts responsible for different lifestyles. The different studies examined clearly show that it is not enough to consider the different kinds of work (despite their importance for the physical effort expended at the place of work). Attention should also be paid to professional commitments and to individual culture.

Women more often indulge in sport for reasons of health or appearance whereas for men it is more a question of pleasure and competition. Age plays a part for as people get older, the health factor becomes more important in the practice of sport. Social context plays an important role in the adult population: the greater the number of practitioners among one's friends and acquaintances, the more likely one is to practise a sport oneself. In the case of senior citizens, reduced sports activity is most often explained by health problems and by the feeling that they are too old to engage in physical and sports activities. This is particularly true with women.

Adolescents are first of all drawn to a sport by a desire to let off steam, to relax and to have fun. This is followed by a wish to learn, to master a technique, to get out of the house and to find something to do. The three reasons most often mentioned for giving up a sports activity

are poor mastery of the technique, the feeling of not being very proficient (especially for boys) and the constraints related to training (more for girls). A high educational level and a regular physical and sports activity on the part of parents increase the likelihood of their children engaging in such activities. Low incomes reduce the rate of physical and sports activities among girls much more than with boys.

Whether considered from the point of view of motivation or the underlying socio-economic determining factors, the practice of physical or sports activities is linked to the degree of social integration. Thus housewives, single persons with children and job seekers more often declare that they do not practise any physical or sports activity.

Environmental changes are liable to modulate the level of physical activity for all

Environmental determinants are liable to play a role in facilitating or hindering "ordinary" physical activity (to distinguish it from recreational and/or sports-based physical activity). This area is covered by a relatively large number of recent surveys. It is a new sector of investigation explored by various disciplines such as sociological surveys and town and country planning studies. On the whole, the works concentrate on English and American contexts and focus on travel on foot, brisk walking and cycling. This is what is meant by "daily routines" or "routine activities". The idea is to replace passive liaison space-time continuums by active sequences of travelling, or by introducing a true physical activity component into these continuums. This idea, which is probably the product of cultural innovation, is still in its infancy in France.

The environments - mostly urban - can be classified according to different criteria. The socio-geographical situation within the urban framework is one such criterion for distinguishing town centres, urban suburbs, small outlying towns, etc. Other criteria are more morphological in nature: urban density, networks of pedestrian walkways or bicycle paths, distribution of public parks, public transport systems, aesthetic dimension of buildings, "human" quality of areas, location of shops, amenities, etc.

Yet other criteria are linked to social representations and to the perceptions held by individuals or groups (for example, the elderly or parents looking at things from the point of view of their children) of the urban environment. This environment is a "space" which includes the home, the place of work, shopping or service areas, schools, etc. This space may or may not be seen as "secure". The "positive" image of a neighbourhood or district – one which inspires confidence – and the impression of a quality environment may be the product of such things as the presence of pavements outside pleasant buildings (shop windows deemed attractive and illuminated at night, parks and gardens, etc.), and bicycle paths banned to motor traffic.

Some studies stress, from the outset, the decline in ordinary physical activity due to the use of the automobile, television, video games, the Internet, etc. in everyday life. Others (Canada, USA, Australia, etc.) have highlighted the positive impact of adjustments to the urban environment (pavements, public benches, pedestrian walkways, protected bicycle paths, and so on) on the decision to walk or ride a bicycle.

Models of the environment are somewhat complex and there is no general agreement as to methodologies. However, specialists are at one in recognising that environmental factors are crucial in health promotion operations. Some studies show that the quality of the environment gives us a better understanding of why, within a particular locality, a physical activity is, or is not, practised. An environment defined objectively (by the investigator) and

perceived subjectively (by the respondents) as a context conducive to travelling on foot or to using a bicycle, is indeed stimulating and encouraging for the development of physical activity. American authors have distinguished between types of towns suitable for walking and those ill-suited for such a purpose. In the Netherlands, where short journeys are concerned (a radius of 300 metres, 500 metres, etc.), the use of public parks and gardens and recreational facilities is associated with the use of bicycles.

On the strength of most of the surveys examined, we may consider that the quality of the environment is a key incentive for ordinary physical activity. The instruments for characterising those environments most conducive to an ordinary physical activity are now in place but there is still a dearth of investigations. However, some analyses show that sociological variables (such as educational or cultural level) would seem to play a more important role than the contextual factor (the environment).

There are fewer studies focusing on rural areas or those comparing several environments (cities, suburbs, the country). Some of them show that adults under 65 and over 65 living in rural areas (even those of modest means) engage in physical activity if there are appropriate conditions (notably pavements in a good state of repair and footpaths) close to their homes. Thus, we find that people living near facilities for physical activities will willingly use them.

There is still a lack of in-depth and detailed studies on the range of motivations for physical activity (walking, cycling, etc.) which could take place in the course of people's daily and routine travelling/commuting. Several surveys evoke the "units" of time or distance in which people could walk or cycle rather than use their car.

These aspects tally with the trends and/or observations noted in the brochure "Physical activity and health on Europe. Evidence for action" (HEPA, 2006)[16] with respect to environmental factors. Urban density, the geographical distribution of services, traffic lanes reserved for pedestrians or cyclists, and the social representations associated with these aspects – these are factors which should be taken into account if mentalities are to be improved.

Such an environment is objectively an incentive to physical activity but it will not be used by individuals or groups unless it is accompanied by awareness campaigns proposed by public health institutions. The most successful programmes comprise a national dimension, publicised by the media, together with an appropriation at local, and even very local, level. In France, according to the published and consulted experience feedback, this voluntary appropriation is often made through community-life initiatives. Questions of "health through physical exercise", as relayed by sport, multi-sport and school federations, are doubtless still inseparable from the idea of conviviality and recreational sociability.

The promotion of health through physical activity forms part of a policy of behaviour change and town planning

Initiatives with regard to the promotion of physical activity fall into two categories. On the one hand, they are connected with the desire of individuals to improve their health or physical appearance and on the other hand, they are related with the environmental factors which can facilitate physical and sports activities by means of certain incentive measures or adjustments.

In terms of individual motivations, these initiatives are generally based on the "trans-theoretical" model of behaviour change, a model originally devised for curbing tobacco

[16] HEPA. Physical activity and health on Europe. Evidence for action. CAVILL N, KAHLMEIER S, RACIOPPI F (eds). 2006, 34p

consumption. The model describes the elements that would better reflect the progress towards health-enhancing physical activity. These are the stages of change (indifference, ambivalence, decision, action and maintenance), psychosocial variables (awareness, self-confidence, social openness, etc.) and barriers to change (pain, discomfort, loneliness, etc.). While the theoretical strengths of this model have been acknowledged, its practical applications are more limited. They have proved effective in the short term or during the specific passage from one stage to another, but the effects of actions following on from this model are less apparent over the long term or when the stages are taken as a whole.

The effectiveness of the general campaigns to promote physical activity is related to the individualised advice and consideration given to the lifestyle of the populations in question.

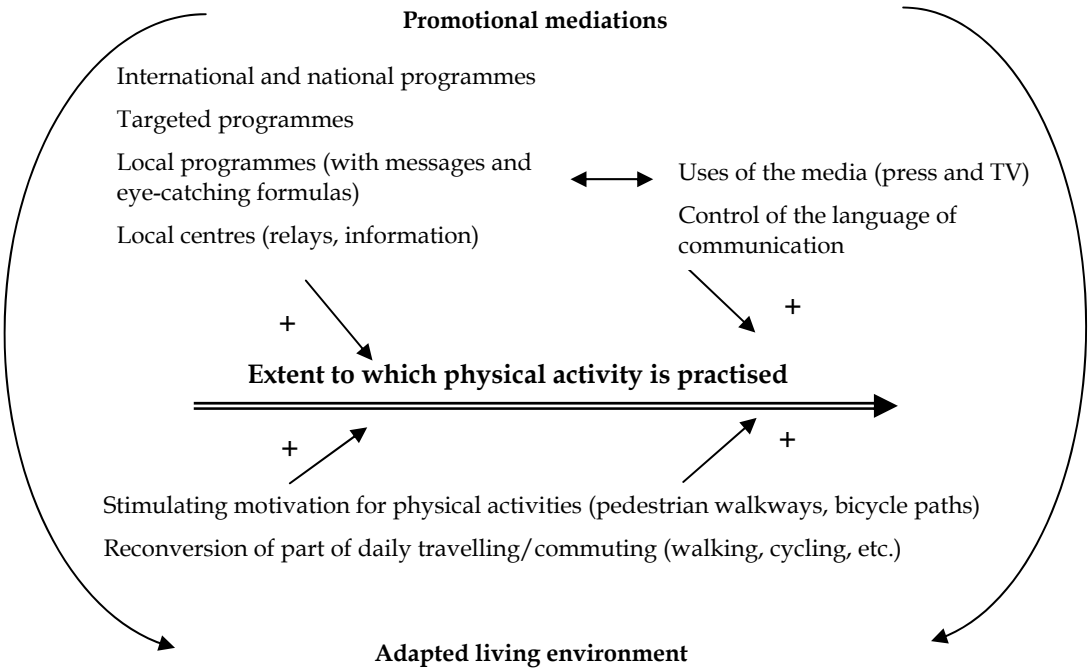
The obstacles to physical activity include lack of time and interest (motivations) but also the aforementioned socio-economic determining factors: status in the workplace, environmental considerations (safety and availability of facilities) and the time available. In some ways, it appears that the practice of physical and sports activities has not escaped the major mechanisms of social domination: access to diplomas and employment, income, gender and age.

Environmental considerations concern first and foremost aspects of the living environment, particularly the characteristics of the distance travelled on the usual routes taken to get to work or to school, to get to the shops and to meet other obligations. The other factor relates to affirmative action (messages, signposts, recommendations, etc.) drawing attention to and promoting the incentive character of the environment.

Strategies for promoting physical activity include the launch of awareness campaigns on health issues. Such campaigns are liable to have an impact on public perceptions of health policy issues and to strengthen organisational links. But of course the campaigns in question must be effective and adapted to the target population. For example, there is a need for easy-to-remember reference points, clear instructions as to the amount of effort to devote to physical activity (30 minutes per day, to be taken from daily travel time; 40 metres corresponds to 5 minutes of walking).

The effectiveness of the communication (messages, slogans, eye-catching formulas, etc) is measured by the degree to which the message is accompanied by initiatives at a practical, local level, if possible presented in an entertaining and "fun" way.

Environmental elements serving to facilitate physical activity may be set out in diagram form. Characteristics falling into the category of the living environment and its appropriation are found in the lower part of the diagram, while the various messages and recommendations representing the mediations and vectors of increased mobilisation are included in the upper part.



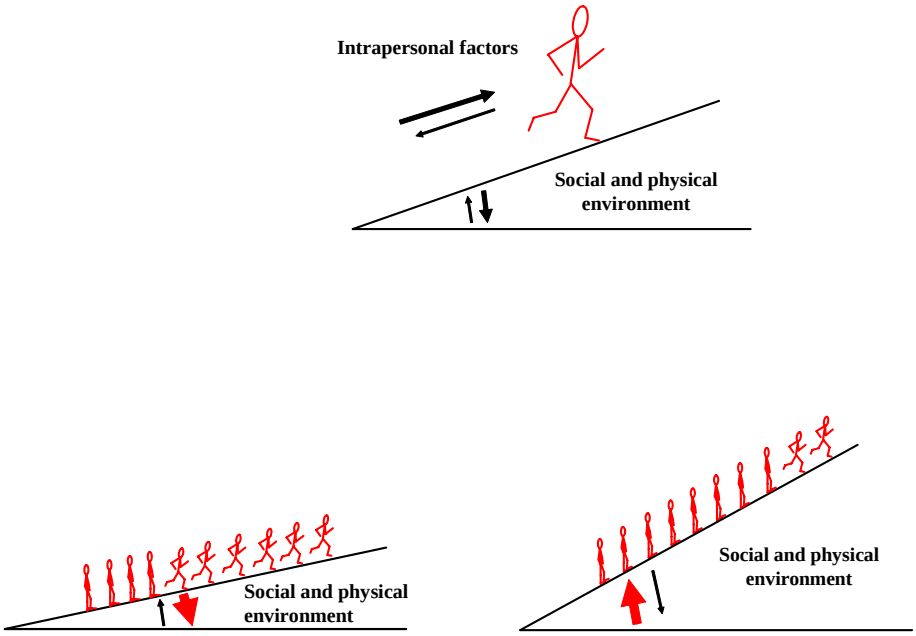
Environmental factors and their impact on the practice of physical activity

In France today, urban planning policies allow for the possibility of people travelling daily on foot or bicycle. The multiplication of pedestrian walkways in the city centres, the development of bicycle paths and the desire to make them part of inter-communal or peri-urban systems, not to mention the creation of special itineraries for joggers – these are all tangible signs of this new approach. Certain policies to restrict motor traffic in cities like Paris, Lyon and Bordeaux are accompanied by schemes designed to make bicycles easily available for hire at a nominal fee.

Intervention studies show that it is possible to increase the level of physical activity of the general population

In general, the models used in the interventions are "socio-ecological" models of behaviour, referring to the dynamic interactions between individuals and their physical and socio-cultural environment. While intrapersonal factors such as attitudes, values, positive expectations, capabilities and skills can be important at individual level, factors that affect the social and physical environment seem more appropriate at the general population level.

An integrated approach to promoting physical activity, focusing on changes, seems more appropriate for populations as a whole rather than at individual level.



Effects of changes in the social and physical environment on physical activity profiles at population level

Looked at from the point of view of behaviour, physical activity is notable for the fact that it takes place in well defined places or circumstances. The notions of micro- and macro-environment are important if we are to clearly identify the possibilities of intervention.

Priority should be given to interventions that have already shown some effectiveness or signs of promise: physical education/activity at school, integrated approaches at the workplace, "active" transport in town and country planning strategies seeking to promote physical activity on a daily basis. Preliminary studies aiming to pinpoint the relationships between "constructed" environment and individual habits of physical activity are a recent phenomenon and as yet little developed, especially in France.

Initiatives may focus on "sectors" (for example, the transport system, the educational system in the broadest sense, the health sector, etc.) or on "sites" (for example, schools, companies, all sports facilities, etc.).

In this field, there is wide recognition of the need for an integrated, multi-sector approach, with strong commitment at local level. Health professionals can play a leading role in this integrated process by fostering dialogue between the sectors and partners involved and developing appropriate means of evaluation. Evaluation is a priority and must be implemented at several levels with a view to measuring such elements as the impact of interventions, the implementation of actions and cost-benefit analysis. It is not easy to strike the right balance between strategies focused on changing individual behaviour and those relating to environmental change (broadly defined). However, certain educational measures will not bear fruit in the absence of prior action on people's living environment. Thus, actions designed to encourage walking will not make sense unless personal safety can be ensured.

Promotion of physical activity in the adult. Interventions of proven efficacy (after Kahn et coll., 2002; Hilldson et coll., 2006)

Information actions
Campaigns at community level
Signs encouraging people to use the stairs
Actions on individual or group behaviour
Changes of health-behaviour adapted to the individual
Support from family circle, etc., social environment at community level
Actions on the environment in the broadest sense
Creating or facilitating access to physical activity sites and facilities, combined with information on this access

A number of countries have considerable experience in promoting physical activity. An analysis of the strategies adopted shows the limits of an approach based solely on information campaigns (isolated communication) and the need for an integrated approach. Finland was the first European country to develop such an integrated approach to promoting health through physical activity. A general model used by the Finnish Institute of Public Health to illustrate the role of the individual and society in different kinds of health behaviour can be adapted to behaviour in the context of physical activity.

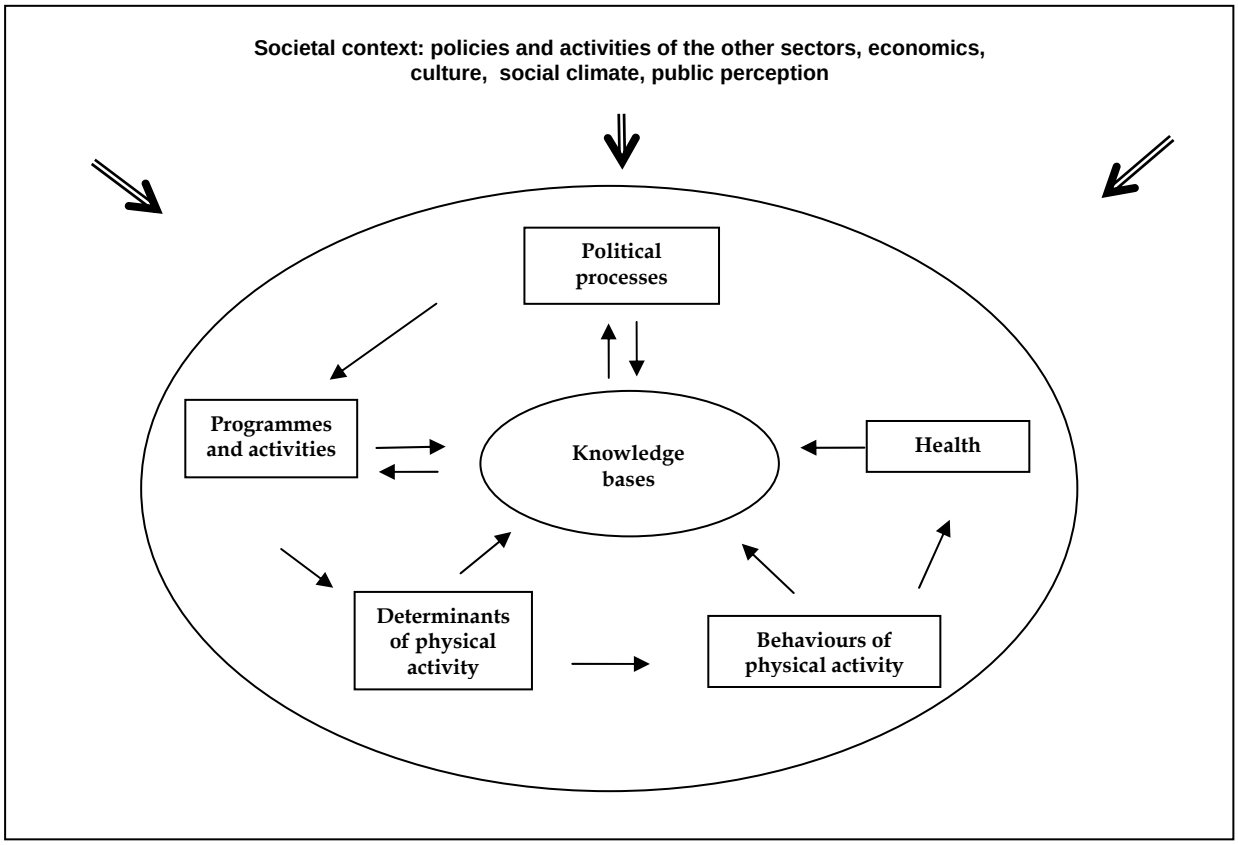
In a systematic approach based on established scientific arguments, the key issue is not only to reach a better understanding of the many determinants governing physical activity behaviour, but also to define the role of communication in the principles and mechanisms for the advancement of health through physical activity. To help in the review and development of new initiatives in this area, the European Network for the promotion of health-enhancing physical activity (HEPA Europe) has drawn up a general model for promoting physical activity. The two basic elements of the proposed framework are firstly a series of different levels of health promotion through sport beginning with a political process and ending with health, and secondly an overall cyclical structure with evaluation as a key link.

With a view to classifying the interventions designed to promote physical activity, the European HEPA network suggests the following four groups: structured activities such as physical education classes, activities in attractive environments, counselling and coaching, information and event-based campaigns. The introduction of these measures requires good coordination, training of mediators or instigators and financial or technical support. The interventions can be described by sector involved (such as health, sport or the transport sector) and depending on the geographic level, from local to international. In order to provide a return on the mechanisms of initiatives and to prevent situations in which activism gains the upper hand, it is essential to have these interventions evaluated.

The role of sports is often discussed in promoting health through physical activity. In the few countries where an increase in physical activity has been observed, this result is attributed more to sports and leisure activities than to a real increase in everyday physical activities.

While most measures to promote physical activity become operational at local level, the national approach remains of paramount importance not only for political support, but also for the coordination of campaigns and programmes. Finland, followed by the United Kingdom and the Netherlands, were the first European countries to develop national strategies to promote physical activity for health purposes. Others have since followed suit and their reports are listed in the HEPA Europe inventory of documents concerning promotional policies[17].

[17] www.euro.who.int/hepa



Overview of the HEPA Europe framework for the promotion of physical activity

International organizations are also essential for promoting the concept of regular health-enhancing physical activity. The World Health Organisation (WHO) has played an important role in the shape of the WHO global initiative on active living, the "Move for Health" day and the Global Strategy on Diet, Physical Activity and Health in 2004, not forgetting the 2006 Ministerial Conference on Counteracting Obesity. The HEPA Europe network works closely with WHO's European Regional Office (located in Rome) and contributes to the dissemination of knowledge on the effects of physical activity on health and the effectiveness of approaches to promoting physical activity in order to contribute to the development and implementation of national policies.

Demand at the population level is important and experiments conducted in Finland and Canada show in particular that an integrated long-term approach can prove successful at national level.

Evaluating the impact of physical activity on health means possessing the relevant tools for measuring the levels of this activity

Physical activity takes place mainly in four contexts: occupational activity (paid or otherwise), leisure, home, travelling/commuting. It is also characterised by its type, duration, frequency and intensity. The social conditions in which it is practised, together with seasonal variations, are also important in measuring this activity. Physical activity has an energy cost that can be translated into energy expenditure, itself dependent on factors such as body mass, and the output and efficacy of the movement. Unlike the methods for measuring energy expenditure, the methods used for measuring physical activity collect the

different characteristics of this physical activity, and even extrapolate the energy expenditure associated with physical activity. The indicators obtained through these different methods may take the form of a score, "membership" of a pre-defined group, time or energy expenditure.

Several methods may be used for measuring physical activity: observation, daily log or diary, recall of activity and actimeter. Observation makes it possible to characterise the practice and to quantify the different parameters of physical activity using observation grids filled in by trained observers. The log is a declarative method consisting of the subject's regular recording of his/her physical activity. The recall of activity is also a declarative method in the form of a questionnaire completed by the subject himself/herself, in the course of an interview or by a third person (teacher, child-minder, spouse, etc.). Questionnaires are often used in epidemiological studies as a way of classifying subjects according to their usual level of physical activity. They may be paper form, computer-assisted, and filled in on the web. The period covered may even encompass the subject's entire life. The actimeter is a device used for quantifying movement. We now possess portable devices that can record changes in limb speed or body mass in order to report on physical activity and even the energy expended in the course of varied activities. There are two principles involved in measuring physical activity by means of movement detectors. The first is based on the principle of counting steps using a pedometer. The second includes the acceleration of movement quantified by using an accelerometer.

The methods for measuring energy expenditure essentially involve indirect calorimetry and heart rate. Indirect calorimetry includes the doubly-labelled water method, recognised as a benchmark for assessing energy expenditure in real-life situations, and oxygen consumption. The heart rate is directly related to oxygen consumption and makes it possible to calculate energy expenditure, determined individually from regression equations. The use of this parameter combined with an accelerometer yields interesting and promising results. The methods for measuring energy expenditure provide data over a limited period of time; they are useful as a criterion for evaluating alternative methods when energy expenditure is considered as the reference criterion. Other physiological parameters such as body temperature, blood pressure, respiratory rate and the degree of sweating are also linked to energy expenditure and may be recorded by instruments worn by the subject. However, these parameters are of limited accuracy and/or feasibility in estimating energy expenditure and are not tailored to measuring physical activity. Nevertheless, they are potentially interesting and useful as part of a monitoring system.

Principal methods of measuring routine physical activity and parameters measured

Measuring methods/instruments	Parameters measured
Indirect calorimetry:	
Doubly-labelled water	Total energy expenditure
Gaseous exchanges	VO_2
Observation, log, recall:	
Log books/Diaries	Physical activity (type, intensity, duration, frequency)
Questionnaires	Energy expenditure linked to the activity (calculated)
Actimetrics:	
Pedometer	Number of paces, distance travelled (estimated)
Accelerometer	Activity and intensity in the form of acceleration expressed in "beats per min" according to time Energy expenditure linked to the activity (calculated)
Heart rate:	
Cardio frequency meter	Activity and intensity in form of beats/min VO_2 or energy expenditure linked to the activity (calculated)

The multiplicity and diversity of methods and instruments is a measure of the interest but also the complexity of measuring physical activity. Measurement is made difficult by the variety of activities and conditions of practice. The various methods of measurement generally use different components of physical activity and are therefore not always comparable. By combining different methods, it is possible to collect a greater quantity of information and increase the accuracy of this information. The applicability of a measuring instrument can be assessed through 5 criteria: the financial cost or the cost in time for the investigator and the subject, acceptability, the intrusive nature or the ability to modify the subject's activity, reliability and validity. However, the choice of method depends above all on the context and purpose of the measure.

We are also witnessing the emergence of methods for measuring sedentary behaviour and indirect measurements of physical activity based on environments conducive to physical activity and their use (sports facilities and amenities, parks, walking or cycling trails), and the subject's perception of these environments.

Epidemiological studies show that regular physical activity reduces mortality

Physical or sports activity is in theory considered to be a factor conducive to health. The health benefits of physical and sports activities have been known since ancient times. In the nineteenth century, the first scientific work, carried out in 1843 in London, showed that the mortality rates of sedentary people were higher than those of physically active workers. At the beginning of the 1950s, a study comparing 30,000 bus drivers (supposedly not very active physically) with 20,000 bus conductors (supposedly active) revealed that the latter were less exposed to the occurrence of a myocardial infarction. Since the end of the 1980s, a substantial body of work has seemed to confirm the existence of a link between physical activity and a reduction of premature mortality, taking all causes into account.

The general population studies published in recent years, focusing on at least 5,000 persons monitored for at least 5 years in different countries (USA, Canada, Great Britain, Denmark, Finland, Japan, Hong Kong, etc.) consistently show a lesser relative risk of death among the physically active compared to inactive persons. The same result is found irrespective of age and of the cause of death. It appears more conclusive for men than for women. A reduction in overall mortality lying between 2% and 58% is observed according to the type and level of activity considered and depending on the studies. It must be stressed how difficult it is to isolate the specific effect of physical activity as this activity is associated with a more comprehensive healthy lifestyle. Besides, mortality is an indicator that goes beyond mere physical activity, incorporating as it does socio-economic and mental health factors among many others.

The work assessing levels of physical activity showed an inverse dose-response relationship between physical activity and mortality. These studies have often distinguished three groups of people depending on the intensity of their activity: not very active; moderately active; very active. Since physical activity was not quantified in a precise manner with regard to the level of its intensity, its frequency and duration, it was difficult to define a useful threshold to be reached in order to curb mortality. However, it was noted that an energy expenditure of 1,000 to 1,700 kcal per week would seem to be associated with a significant reduction in mortality.

A prospective study published in late 2007 and concerning 250,000 persons took into account a very large number of adjustment factors. It shows that a performance close to that of the

recommendations for activity of moderate intensity (at least 3 hours per week), or for activity of high intensity (at least 20 minutes 3 times a week), leads to a reduction of mortality risk of the order of 30%.

Some authors have set out to analyse the effects of changes in practice on mortality from all causes. Their studies show that the mortality rate of subjects who have become active or who have increased the intensity of their practice is lower than with those who have remained inactive or have not changed the intensity of their practice. Finally, one of the studies suggests that past activities do not in themselves provide protection and that the protective benefit is lost when physical activity is discontinued.

Many studies have focused on the relationship between cardiovascular risk and physical activity in view of the high mortality rate involved. Most of the studies suggest an inverse relation between physical activity and the rate of premature mortality by cardiovascular disease, in particular coronary disease. In subjects who are at risk of developing cardiovascular disease and who are physically active, cardiovascular mortality is lower than among those who are not active. This also holds true for people suffering from diabetes. The risk of death by cancer is also decreased in people who are active (moderate to intense activity) compared to non-active subjects.

However, for healthy people as for those with risk factors, the level and type of physical activity required to obtain optimum benefit in terms of reducing mortality and longer life expectancy has yet to be determined.

The regular practice of physical activities of moderate intensity contributes to well-being and quality of life

WHO defines health as "full enjoyment of social, mental and physical well-being". Well-being is a complex, multi-factorial and poorly defined notion which cannot be reduced to the mere fact of feeling well. This psychological state is constantly changing and developing throughout our lives, and is the result of four dimensions:

- emotional well-being (state-trait anxiety, stress, tension, state-trait depression, anguish, confusion, energy, vigour, fatigue, emotions, optimism, etc.)
- self-perception (competences, global self-esteem, image of the body, perception of one's physical condition, perception of self-control, causal attribution of successes and failures)
- Physical well-being (pain, perception of somatic disorders, state of health, etc.)
- Perceived well-being (quality of life, subjective well-being, purpose of life, etc.)

Well-being is measured on scales that reflect these four dimensions as a whole or that concentrate on certain factors: anxiety, self-esteem, depression, sense of control, etc.

With persons aged between 55 and 75 and not suffering from any pathology, regular physical activity of moderate intensity has a beneficial effect on well-being (feeling of competence, good self-image, low degree of anxiety). In particular, the studies show that physical or sports exercise slightly but significantly increases the level of self-esteem. This increase is revealed more clearly with persons who initially have a poor opinion of themselves.

There is a broad consensus as to the beneficial role of physical activity among adolescents in the throes of bodily and psychic puberty. The positive effects are to be found particularly in the level of stress, well-being, self-image, social functioning, etc. Here, too, the effects of

physical activity on self-esteem are greater among adolescents who suffer from a low opinion of themselves.

In people with mental disabilities, research shows that participation in physical activity is a factor working in favour of the development of well-being. However, longitudinal studies stretching over several years of male and female adolescents with behavioural problems or slight intellectual disabilities practising collective sports tend to put the extent of the repercussions into perspective. The effects on self-esteem seem to be more conclusive on subjects with moderate intellectual disabilities placed in institutions and presenting low self-esteem at the outset. Involvement in "appropriate" sports activities would appear to have a positive effect in terms of motivation, socialisation, shared pleasure and positive perception on the part of peers and parents. However, pedagogical methods must be adapted and participation in competitions should be accompanied by psychological support.

Controlled research work on other specific populations (the chronically ill) are still too few in number and too diverse to tell us much more than that potential benefits are expected and that rehabilitation programmes through physical activity must be developed.

Recent work considers that physical activity acts primarily and most significantly on the perceived physical value and its components (athletic prowess, strength, physical condition, physical appearance). Global self-esteem (which depends on many other social, family and professional factors) will be influenced by the physical self depending on the importance of "corporeality" in the subject's life and environmental factors (peers, parents, teachers), whence its extreme variability in time.

The notion of quality of life is nowadays defined by WHO as "an individual's perception of their position in life, in the context of the culture and value systems in which their live and in relation with their goals, expectations, standards and concerns". Today, the Health-Related Quality of Life rating is the most often used in the field of physical activity and health. It corresponds to the subject's satisfaction in relation to his daily life (autonomy, physical symptoms, psychological status, sexuality, self-image, social relations, material problems, leisure). Health-related quality of life is evaluated by means of an interview, a questionnaire (self-administered or completed by another person) or scales of subjective sensations. Generic questionnaires are used to compare levels between populations or the benefits of intervention (physical activity, medicine, surgery, etc.). Special questionnaires are drawn up for populations with medical conditions.

In the case of the chronically ill, people with disabilities and the elderly, the benefits of exercise (or of a phase of rehabilitation/readjustment, including effort retraining) on the overall quality of life have been well demonstrated.

In the population aged 18 to 64 not suffering from health disorders, those participating in leisure activities have significantly higher quality of life scores than non-active persons. There is a significant correlation between participation in leisure physical activities and satisfaction with life, particularly in the case of the female population and adolescents. The practice of leisure physical activities as a family increases the sense of well-being and good quality of life among parents and children.

The regular practice of physical activities of moderate intensity contributes to subjective well-being and the overall quality of life by acting on the factors involved in the different dimensions integrated (positive emotional experiences resulting from integration in a group or the positive perception of others, decline in the level of stress, satisfaction in relation to the body, satisfaction through active participation in social life). The psychological effects are found in both pathological and non-pathological populations.

Studies show that physical activity conditions muscular function

The skeletal muscle is the only organ ensuring the biomechanical work of locomotion. It is capable of transforming the biochemical energy contained in the energy substrates into mechanical energy. In humans, the level of physical activity influences the total muscle mass, its metabolic and contractile properties and its evolution according to the different stages of life. The maintenance of a normal muscle function is essential to interpersonal relationships and functional autonomy. In addition, the muscle is the "hub" of the metabolism, insofar as muscle volume and activity play a role in the prevention of metabolic diseases. It adapts as a result of physical training through changes in the muscle typology, muscle volume, the number and compartmentalisation of the mitochondria as well as the properties of key enzymes of the energy metabolism. The determining factor of muscle mass results from a balance between the processes of synthesis and degradation which act along separate pathways.

The mediators of muscle growth in response to exercise are:

- Mechanical stress
- Metabolic factors
- Nervous factors
- Hormones
- Type of nutrition

Mechanical strain is exercised at the level of the membrane structures. They can be passive in response to muscle stretching, or active linked to shortening during contraction. They are relayed to the membrane by integrins, a group of molecules that promote cell adhesion. These proteins act on transduction factors, Mitogen Activated Protein Kinases (MAPK), which trigger transcription factors regulating the expression of the genome. Other tension sensors, such as titin (a protein of the cytoskeleton), are located inside the contractile machine. Their purpose is to integrate the mechanical strain sustained by the contractile proteins. On a practical level, a knowledge of the mechanical factors allows us to adapt the prescription of physical activity aimed at promoting muscle development. To this end, it is necessary to propose activities requiring a level of mechanical strain which is both adequate and acceptable to the subject.

Muscle growth can also be stimulated by metabolic factors. The energy flow of muscle contraction leads to a decrease of the intramuscular energy charge. The result is an increase in the AMP:ATP ratio. The activation of an enzyme system, Adenosine Monophosphate Kinase (AMPK), is regarded as the sensor of the cell's energy status. The system works by increasing the muscle protein syntheses. The other metabolic factor affecting muscle development is influenced by the level of muscle oxygenation; this is the Hypoxic Inductible Factor (HIF), which promotes mitochondrial biogenesis. A knowledge of the precise role of these metabolic factors shows that the muscle's adaptation to physical training is achieved at the cost of a major metabolic stress.

The nervous control of motivity acts initially on the entry of calcium into the muscle cell. The modulation of the calcium flows activates the phosphatases (calcineurins) which, at the end of the chain, activate the NFAT nuclear transcription factor (Nuclear Factor of Activated T cells). An important element of the transmission of the nervous message via the calcineurin is represented by the myogenins, the proteins that regulate the gene expression of the muscle proteins. This cascade of events acts on the metabolic and structural differentiation of the muscles. The increase in the synthesis of the chains of slow-type myosin and the

mitochondrial biogenesis in response to physical training are to a large extent dependent on the activation of the calcium signalling pathways.

Many hormones play a role in muscle development. For the sake of simplification, we may distinguish the hormonal axes involved in the development of muscle mass and the hormones acting on the differentiation of the muscle tissue. The increase in muscle mass results from the coordinated action of steroid hormones (mainly testosterone), growth hormone (GH) and insulin. The role of steroids on muscle development occurs at all stages of life. The influence of these hormones is particularly marked during puberty in boys. The physiological decline of all steroids during ageing in both sexes is also associated with a reduction of muscle mass and a concomitant increase in fat mass. The response of the somatotropic axis is important under the effect of muscle exercise and training. The production of Insulin Growth Factor I (IGF-1) is stimulated during physical exercise and plays a role in the response of the muscle anabolism. IGF-1 plays a special part in the proliferation of the muscle cells of old persons subjected to physical training. The hormonal response for the same level of physical training is influenced by age, nutritional status and level of recovery compared to previous exercises. All these elements must be taken into account if the goal of training is to improve muscle function.

It has now been clearly demonstrated that the muscle growth of an organism depends on both protein intake and total caloric intake. The existence of a threshold below which muscle growth stops and then becomes negative has made it possible to define minimum intakes. This minimum protein intake is currently estimated at 0.80 $g.kg^{-1}$ of body weight per day for an adult male. This need is increased by physical training and is greater for endurance training compared to strength training, but it should not exceed 2 $g.kg^{-1}$ per day.

It has been suggested that the increase in the level of physical activity could increase oxidative stress in the muscles. This hypothesis is based on the relationship between the increase in oxidative metabolism and the generation of free radicals. These are likely to foster muscle or vascular injuries. Their action has been evoked in the mechanism of muscle pains resulting from intense and prolonged physical activity. The exact role of oxidative stress is the subject of a debate compounded by the methodological difficulties surrounding its measurement. However, it seems well established that physical training considerably increases the antioxidant defences. Recent work shows that endurance training increases antioxidant capacity so that nutritional supplementation in antioxidant compounds is unnecessary and even dangerous in these subjects. All in all, well-conducted physical training is an effective way to combat oxidative stress.

Numerous studies in humans and animals have shown that muscle contraction stimulates insulin-independent muscle glucose transport. These effects may be explained by the existence of two types of muscle glucose carriers (GLUT-4 transporters): one of them is stimulated by insulin and the other by muscle contraction. Under the action of insulin, these glucose carriers stored in the form of intracellular vesicles will be activated, and the GLUT-4 vesicles will migrate to the cell membrane. Exercise stimulates the transport of glucose by an insulin-independent path involving an AMP-dependent kinase protein (AMPK). In the course of exercise, the consumption of ATP activates the AMPK, which induces the translocation of a specific batch of insulin-independent GLUT-4 transporters to the plasma membrane. This translocation facilitates the entry of glucose in the muscle cell.

Moreover, the post-exercise period is characterised by an increase in muscle sensitivity to insulin. This leads to increased uptake of glucose lasting several hours after discontinuation of a single exercise session in healthy subjects as well as type 2 diabetes subjects. This phenomenon is located solely in the muscles mobilised during exercise and depends in part on the degree of glycogen depletion. The increase in muscle sensitivity to insulin lasts an

average of 48 hours in subjects with a normal diet. It is associated with an increased number of GLUT-4 vesicles present at the cell membrane surface. The intake of a diet rich in carbohydrates after exercise, which leads to an overcompensation in glycogen, prevents an increased response to insulin. On the other hand, this increase persists for several days if the excess glycogen is prevented by a diet low in carbohydrates.

It is well established that endurance training increases sensitivity to insulin in healthy, insulin-resistant, normoglycemic or type 2 diabetes subjects. These data were obtained by comparing sedentary subjects to endurance-trained subjects, or during intervention studies in which sedentary subjects have been subjected to training. Thus, the uptake of glucose in the same subjects before and after 6 weeks of endurance training is increased by 30% to 40%. This effect is observed 48 to 72 hours after discontinuing the exercise, thus eliminating any lingering effect from the last exercise performed.

Training has many effects. It causes an increase in the post receptor signalling of insulin, GLUT-4 and the transport of glucose, in the activity of glycogen synthetase and hexokinase (glycolysis), which increases the muscle's oxidative capacity. It also causes an increase in the amount of glucose and insulin delivered to the muscle (increase in capillary density); it reduces the release and increases the clearance of free fatty acids (FFA). It alters the muscle composition (increase in the proportion of type I oxidative fibres).

A knowledge of the different mechanisms at work makes it possible to adapt physical training with a view to optimising muscle volume and function. Muscular training imposes strong mechanical stress and efficiently increases muscle mass. It is particularly useful in preventing the physiological loss of muscle mass due to ageing. Endurance training imposes metabolic constraints and is useful in the context of the prevention of cardiovascular and metabolic diseases because muscular adaptation acts on mechanisms favouring the emergence of such diseases. An adapted physical training may be proposed in the treatment of certain myopathies. The prescription of physical activity should be adapted to each type of muscular dystrophy in the light of its pathophysiology and its level of evolutivity. It may combine a part of endurance activity or muscular training. With regard to those mitochondrial myopathies where the disorder essentially concerns the muscle's metabolic function, an improvement in functional capacity has been shown as a result of training plans combining endurance and strength. In the general context of muscle dystrophies focusing essentially on structures of the muscle, strength training seems to be effective in preventing the loss of muscle strength. In this particular case, a beneficial effect of physical training on the capacity of the respiratory muscles has been clearly brought out. The physical training of subjects with myopathies must be very carefully monitored for the evolution of the biological markers of muscle damage.

Physical activity contributes to the acquisition and maintenance of the osseous capital but only in certain conditions

The skeleton is made up of articulated osseous parts which, at the impetus of the muscles, allow human beings to move. This function subjects the skeleton to a mechanical stress which intensifies with growth owing to the increase in body size and muscle mass. During development, the size and morphology of the osseous parts evolve in order to adapt to the mechanical stress.

Early childhood is characterised by rapid bone accretion as a result of substantial statural growth. The second bone accretion peak takes place during puberty. Roughly one quarter of the adult bone mass is acquired during the two years surrounding the second bone accretion

peak when the rate of bone mineralisation is at its highest. The bone mineralisation peak occurs 6 to 18 months after the statural growth peak. This time difference explains why there is a period of relative fragility in the skeleton, occurring at 12-14 years for boys and 10.5-11.5 years for girls. At these times, there is indeed a higher incidence of fractures.

During the fusion of the epiphyseal cartilages, bone mineral density reaches 90 to 95% of its maximum value. The age of peak bone mass occurs between 20 and 30 years and varies according to sex and the site being considered. The increase in bone mineral content during growth is more the result of an increase in the size of the bone parts than in the volumetric bone mineral density.

The formation of bone tissue is regulated by mechanical, hormonal and energy factors. Before puberty, growth is mainly regulated by the growth hormone and IGF-I (Insulin-like Growth Factor-I), whereas during and after puberty, it is the sex steroids that exert a dominant influence. Estrogen (both sexes), associated with the growth hormone and IGF-I, introduce the three or four years of rapid bone growth during which the skeleton doubles its mass. Other hormones (parathyroid hormone, calcitriol or 1,25-dihydroxyvitamin D, vitamin D, calcitonin, thyroid hormones) are involved in regulating bone metabolism.

The total energy intake plus the protein and calcium intakes are key regulators of musculo-skeletal development, particularly in the case of deficiencies. Children and adolescents with insufficient calcium intakes run the risk of attaining a lower peak bone mass. In France, the recommended calcium intakes for young persons aged from 10 to 18 years amounts to 1,200 mg/day. Beyond a value of between 800 and 1,200 mg/day, any further increase of calcium consumption does not appear to affect bone tissue.

Physical activity through the mechanical stress exercised on the skeleton induces the formation of osseous tissue. This phenomenon has well been well established since the 1970s. During the period of growth, physical activity plays an important role in the acquisition of osseous capital. The optimum intervention period corresponds to the occurrence of the peak velocity of bone calcium accretion, i.e. between 11 and 14 years for girls, and 13 and 17 years for boys (this period in fact corresponds to the hormonal activation of puberty).

The earlier physical activity is initiated, the greater the influence on the osseous capital. The osteogenic effect exerted by physical activity is all the stronger when the mechanical stress is varied and removed from the usual stress of walking or running. This effect is particularly noticeable in the pre-pubescent child, and more so at the beginning than at the end of puberty. In other words, the prevention of bone loss crucially takes place during the period of growth.

Physical activity acts on the osseous mass, its density and texture (macro- and micro-architectures). Benefits are also observed on the mechanical properties of the bone (increased resistance to fracture). The practice of multi-activity sports seems to correspond to the best expected benefit during this growth period.

Physical and sports activities characterised by impacts or stress (Peak Strain score) are more effective than the so-called "fleet" practices (20 to 33% increase of bone mineral density, depending on the osseous site, in gymnasts compared to swimmers and controls). Swimming, which takes place in a hypogravitational environment, does not appear to have any effect, and this is consistent with the results observed with astronauts. "Soft" practices (as practised at school or for recreational purposes), although less effective, can still yield significant results.

In the case of physical practice, beginning after the peak bone mass has been reached (between the ages of 20 and 25 years), while it does not lead to an osseous gain it nevertheless contributes to a slowing down of the process of bone loss. In the opinion of

some authors, the osseous capital acquired during childhood continues into adulthood only in the case of continuous training. For others, the situation for adults remains linked to the characteristics of the physical activity pursued during childhood (type, age of onset of practice, frequency, intensity, etc.). Some studies show that among high-level sports practitioners, bone mineral density remains high even after training has been discontinued entirely (gymnasts followed up over a period of 12 years).

However, intensive practice can lead to risks of osteoarticular injury and even hormone disorders, especially when combined with a deficit of the energy balance of young girls (usually in activities of a predominantly aesthetic nature). A relationship has been shown between bone mineral density and fracture risk. For example, in a prepubescent child, bone mineral density in the lower tercile increases the risk of fracture. Physical practice, by improving bone mineral density, helps to prevent fractures.

Physical activity acts in association with other factors in the formation of bone capital. A potentiation is observed with adequate nutrient intakes, particularly a calcium and/or protein supplementation.

Physical activity helps to prevent cardiovascular conditions by protecting the blood vessels

Many cardiovascular diseases originate in the impairment of the functions of the blood vessel wall.

The endothelium is the single layer of cells lining the inner surface (intima) of all the vessels. Long regarded as a mere "envelope" involved in the processes of haemostasis, the endothelium turns out to be an endocrine gland as well as an integrator of the subjacent tissular processes. Thus, nitric oxide (NO) is a radical messenger produced continuously by the endothelium and which locally fulfils many functions, the best known of which being the relaxation of the subjacent smooth muscle cells and the inhibition of platelet aggregation. The endothelium produces other substances with a vasodilator action (such as prostacyclin) or vasoconstrictor action (such as endothelin, but whose expression is suppressed under physiological conditions). The endothelium is continuously influenced by the flow of blood (flow-dependence) and by the presence of neurohormonal mediators. Thus, the increased blood flow causes a greater friction of the blood on the endothelium (endothelial shear) and very quickly an increased production of NO, resulting in flow- and endothelium-dependent vasodilatation (as a result of the relaxation by NO of the subjacent vascular smooth muscle cells).

The endothelium can express so-called adhesion molecules which, as their name suggests, facilitate the recruitment and passage of white blood cells circulating in the intima. It plays a crucial role in the inflammatory processes. Furthermore, it to a large extent controls the inter- and transcellular passage of the many circulating nutrients and hormones.

Lastly, the endothelium is involved in blood clotting by preventing exposure of the sub-endothelium, thrombogen, to the circulating factors of coagulation and by synthesising a number of anti- or procoagulant factors.

It has been agreed for several years that physical training is associated with an increase of vascular calibre. For example, data from autopsies and angiographic studies indicate the presence of coronary arteries with a wider diameter among athletes. These structural vascular changes (increase in luminal diameter) could be an adaptive response designed to limit the endothelial shear during repeated muscle exercises. However, the positive effects of

an endurance physical activity on endothelial function may be limited in some cases. Thus, a recent study suggests that the too regular and over-intensive practice of physical activity is likely to diminish vascular response to NO due to a remodelling of the vascular wall and/or a desensitisation of the smooth vascular muscle to NO, or again to an increased production of oxygen free radicals.

With advancing age, irrespective of the presence or absence of high blood pressure, there is an impairment of endothelial function via an altered NO pathway and production of free radicals that compromise, secondarily, availability of NO, and a low-grade chronic inflammatory condition which also modifies the bioavailability of NO. This anomaly predominates in the arteries rather than the arterioles, and helps to promote the development of atheroma. Endurance training attenuates the loss of muscle vasodilator response that develops with age. It is now known that it is possible to limit these changes through the practice of a physical activity.

The majority of studies involving subjects suffering from conditions characterised by impaired NO-dependent vasodilatation (high blood pressure, hypercholesterolemia, diabetes, etc.) have shown an improvement of this function in the large vessels and resistance vessels thanks to physical exercise, whereas such an improvement is less often observed in healthy subjects.

In view of the clear pathophysiological and prognostic links between functional and structural vascular anomalies and the occurrence of cardiovascular events, it would seem that the practice of regular physical activity is essential for the care of patients with these diseases. However, there are still areas of uncertainty, concerning not only the mechanisms (for example NO) brought into play through physical activity but also the definition of intensity and the optimum conditions of exercise.

Physical activity has variable effects on the immune system

Numerous studies have focused on trying to understand the relationship between infection, immune parameters and intensity of exercise. The practice of a moderate physical exercise can be a way of preventing certain diseases in which the immune system is involved. The phenomena of leukocytosis occurring in exercise and then lymphopenia post-exercise are widely described in the literature and constitute the biphasic response to intense exercise. The immunocompetent cells return to base values; this is obtained several hours after the end of a very intense exercise. There is evidence that cortisol and the catecholamines are important mediators of these responses. Thus, the injection of norepinephrine is able to mimic exercise, with a rapid decrease in the number of lymphocytes and a continuous increase in the number of neutrophils 2 hours after injection. Intense exercise causes changes in the number and relative distribution of the lymphocyte subtypes. These changes are usually transient.

Longitudinal and cross approaches have been used in studying the immune response during physical training in the athlete. In the crossover studies, the immune parameters (incidence of diseases, numeration and T lymphocyte function) are compared between athletes and sedentary subjects, or in relation to reference values. No differences were found between groups of different levels of training. The longitudinal studies have tracked immune parameters over time, for example for the duration of training, and the values are compared between different types of training (moderate versus intensive training versus competition). The convergent results show that the relationships between physical training and immune parameters follow an inverted U-shaped curve. The immune status improves as a result of a

moderate training and then deteriorates for intense training. Intense training, even over short periods, may be responsible for an increased incidence of respiratory infections. Thus, the incidence of respiratory infections is more than 40% among competition-level swimmers monitored over 4 weeks of intense training. The frequency rather than the severity of respiratory infections appears greater among athletes compared to sedentary subjects. However, moderate training does not increase, and may even reduce, the risk of respiratory infections. These data drive home the fact that moderate training stimulates the immune function, while intense training inhibits it.

The ageing of the immune system is characterised by a progressive decline of the response against exogenous antigens. It has been shown that the increase of physical activity levels among the elderly prevents the decline of the immune functions. The vaccine response to the influenza vaccination is higher among older physically active subjects. The delayed-type hypersensitivity response after sensitisation to a new antigen, which reflects the functions of memory T cells, is more pronounced among the most physically trained of active subjects. All these data point to the interest of maintaining a high level of activity in order to prevent the adverse effects of ageing on the immune functions.

Physical activity helps the brain to function properly

Regular physical activity provides excellent protection against brain damage in different anatomical locations (hippocampus, motor cortex, brain stems, cerebellum). This observation has been made for different aetiologies (use of toxins, focal ischemia or lesions secondary to an innate neurodegenerative disease). Exercise reduces, or even blocks, neuronal impairment or loss irrespective of the type of injuries caused in animals, and promotes the recovery of behavioural and/or motor performance. These effects are accompanied by an increase in BDNF (Brain-Derived Neurotrophic Factor) and IGF-I (Insulin-like Growth Factor-I) in the brain areas concerned.

Neurotrophines and more particularly the BDNF and NGF (Nerve Growth Factor) play a critical role in the modulation of synaptic plasticity in the adult brain. They are expressed in many regions of the central and peripheral nervous system and ensure the survival of the neurons in the nervous system. The synthesis and release of NGF and BDNF by the neurons are controlled by neuronal activity.

The ability of BDNF to modulate synaptic plasticity in the adult brain has been identified in numerous studies: BDNF regulates the branching and remodelling of axons and dendrites, synaptogenesis in tree axonal endings, the effectiveness of the synaptic transmission and functional maturation of inhibitory and excitatory synapses. The deletion or inhibition of the gene coding BDNF leads to a deficit in LTP (Long Term Potentiation), the electrophysiological correlate of learning and memory. This deficit in synaptic function may be amended by the exogenous application or overexpression of BDNF.

Neurogenesis exists throughout life in adult animals (mice, rats, birds, primates) and in humans. Exposing adult rats to an enriched environment or giving them voluntary access to a hamster wheel increases neurogenesis in the hippocampus (dentate gyrus), as can be seen from increased performance in specific tasks related to spatial memory. The changes in neurogenesis are accompanied by the induction/expression of LTP and by a concomitant increase in the expression of BDNF. As these observations are confined to the dentate gyrus, there is a strong suggestion that these changes play a part in regulating structural and functional plasticity. Proof is provided by the counterexperiment: blocking the action of

BDNF serves to prevent the gain in learning and memory induced by exercise. The functional outcome is a decline in cognitive performance.

Muscle exercise increases the production of BDNF in regions other than the hippocampus, and in particular in areas of the brain directly involved in motor activity (motor cortex and striatum), in the anterior horn of the spinal cord and in the skeletal muscles. BDNF plays a role in the development of the functional connections between the skeletal muscle and the spinal cord. Thus, BDNF and other neurotrophines produced in the skeletal muscle could amplify the innervation potential of the motoneurons and play a critical role in the plasticity of the neuromuscular synapse.

After spinal cord injury in rats, the mRNA of BDNF and GNDF (Glial Cell Line-Derived Neurotrophic Factor) is increased by 11 and 14 times respectively, in the soleus muscle of animals subjected to a training programme, suggesting that the BDNF and GNDF produced and released by the muscle could be involved in spinal plasticity.

Regular physical activity also strengthens the neurovascular unit through at least two mechanisms: growth of angiogenesis and astroglia.

The action of physical activity on the brain also concerns the degenerative diseases: physiological ageing and Alzheimer's disease.

Ageing is accompanied by morphological changes in the hippocampus, the brain structure involved in learning and memory in humans. Moreover, hippocampal neurogenesis is reduced with age.

In animal experiments, it has been clearly shown that the ability to acquire new tasks in the rat declines with age. In the human, imaging has revealed hippocampal atrophy in the elderly.

These harmful consequences of ageing can be prevented and even reversed. Elderly people who have engaged in regular physical activity throughout their life suffer from less loss of brain tissue than sedentary subjects and have better cognitive performance.

In old mice subjected to a training protocol, a 50% reversal in the loss of neurons in the hippocampus has been shown compared to sedentary mice controls of the same age. These active mice also show increased hippocampal neurogenesis and learning capacities compared to sedentary mice. It is particularly interesting to note that the old trained mice learn faster (spatial learning) than the young sedentary mice.

In a model of Alzheimer's disease (TgCRND8 mice), it has been shown that voluntary physical activity significantly reduces the load in slabs of amyloid β. Physical activity could represent a simple behavioural strategy in the resistance to the development of Alzheimer's disease. Indeed, recent studies suggest that regular physical activity might delay the onset and/or slow the progression of Alzheimer's disease.

The principal neuroprotection mediator associated with exercise is IGF-I, a hormone that has a very powerful neurotrophic effect and plays a mediating role for most of the effects of muscle exercise on the brain (stimulating the input of calcium, glucose, etc.). Muscle exercise increases the amount of mRNA of the IGF-I in the brain and the quantity of IGF-I. This effect is mediated by the IGF-I receptor. Inhibiting the activation of the IGF-I receptor with exercise abolishes the effects of exercise on the synthesis of BDNF and cancels the increase in cognitive performance of rats. Muscle exercise also protects the brain from injury by increasing the uptake of IGF-I circulating in the brain.

The action mechanisms of intra-cerebral IGF-I are clearly established and could potentially be brought into play under the influence of physical activity. These mechanisms include apoptosis and proteins involved in neurogenesis, calcium homeostasis and increased glucose

metabolism by neurons. IGF-I could act on angiogenesis and the uptake of oxygen by neurons and also intervene in the modulation of neuronal excitability via the ion channels, glutamate receptors or the size of synapses.

Genetic factors could condition the effect of physical activity

There are considerable differences between individuals in the response to exercise, both in terms of cardiorespiratory endurance and the improvement of the risk profile. The identification of the genes and their mutations involved in the response to training is fundamental to an understanding of the role played by exercise in the health of different populations and the development of the physical performance potential of athletes.

The level of heterogeneity in the aerobic capacity response to physical training under the influence of genetic factors in the general population was highlighted by a major study started in 1992 the USA. This HERITAGE study (Health Risk Factors Exercise Training and Genetics) seeks to establish links between genetic heritage and performance. Another major aspect in terms of health is to verify to what extent genetic heritage may influence the positive response to training.

As a result of the genomic screening carried out on maximum oxygen consumption and the response to training, 4 loci related to VO_2 max in the sedentary state have been identified - loci situated on chromosomes 4, 8, 11 and 14 – together with 5 loci connected to the maximum consumption of oxygen in training and located on chromosomes 1, 2, 4, 6 and 11. A total of 56 polymorphisms within 34 candidate genes have been identified. Studies of association and genetic linkage with a number of these candidate genes have been carried out. They have helped to clarify the contribution of the ACE gene (angiotensin I-converting enzyme) to aerobic performance. The ACE gene is responsible for the conversion of angiotensin I to angiotensin II, an important vasoconstrictor involved in regulating blood pressure and also in tissue growth. The variability of the expression of the ACE gene has been advanced as the major factor in aerobic capacity. The ACE gene is expressed in several tissues, including the skeletal muscle, and may therefore be considered, in view of its action on tissue growth, as a candidate gene of performance. Allele I carriers of ACE I/D polymorphism would seem to be at an advantage in terms of respiratory cardiorespiratory endurance.

Other genes present a polymorphism linked to performance: muscle creatine kinase (MCK) gene; muscle alpha actinin-3 (ACTN3) gene; adenosine monophosphate deaminase (AMPD) gene; interleukin 6 (IL-6) gene.

The 37 genes encoding proteins involved in the production of ATP may be considered as candidate genes of performance. The carriers of mutations within the sub-unit 5 of NADH dehydrogenase (MTND5) have a VO_2 max that is higher than in subjects not carrying these mutations. Muscle-specific creatine kinase (CKMM) is an important enzyme for the production of ATP in the muscle cell. The results of the HERITAGE study show that the polymorphism of the creatine kinase muscle reflects 9% of the variance seen in the changes of VO_2 max as a result of training.

A key determinant of health is the level of spontaneous physical activity. It has been shown that there are wide individual variations of this parameter. The comparison of pairs of twins has revealed a strong heritability in the level of spontaneous physical activity. However, the confusion arising from the role of family, cultural and environmental factors justifies a call for further studies. One study showed that genetic heritage explained both participation in leisure physical activities and sports physical activities, the association seeming more

pronounced among men. Another important factor relates to body composition. Several genes are involved in the change in body composition with physical training. In agreement with the metabolic function of the sympathetic system, it has been shown that mutations in the β-adrenergic receptor (ADRB3) could influence the response of body fat to exercise. The polymorphism of the gene coding the coupling protein UCP3 is also associated with the level of response of body composition to muscle exercise. The results of the HERITAGE study have shown that the polymorphism of the IGF-1 gene was associated with the gain of lean body mass as a result of training.

As far as hormonal factors are concerned, the effects of physical activity on the action of insulin have been linked to the polymorphism of the β-adrenergic receptor ADRB3, and the polymorphism of the ACE gene. It has recently been shown that the polymorphism of the interleukin-6 gene could influence the glucose tolerance index.

In terms of cardiovascular risk, several studies have highlighted the association between changes in the genome, the response to the physical activity of blood lipids and factors affecting coagulation. There is an interaction between the level of physical activity, the level of expression of the gene coding apolipoprotein E and lipoproteic profile.

With regard to the regulation of blood pressure, it was initially suggested that the polymorphism of the ACE gene might explain the individual variability of the response of blood pressure to training. However, this relationship has not been confirmed by the results of recent publications.

On the strength of the results accumulated on the genetic bases of performance up to the present time, we may conclude by stating the presence of family resemblances for most performance indicators measured without prior training and in response to physical training. The heritability estimates range from 25 to 50% for oxygen consumption (measured for a maximum or sub-maximum effort) and from 40 to 70% for the metabolic properties of the skeletal muscle.

The few studies conducted on the molecular foundations of aerobic performance have shown positive associations with certain candidate genes. The interaction between the variability of certain genes and response to the level of physical activity is clearly demonstrated for body composition, lipoproteic metabolism and sensitivity to insulin.

Physical activity appears to represent the best means of preventing cardiovascular diseases and constitutes an important element in their treatment

Cardiovascular diseases of atheromatous origin are a major medical-economic problem in France. Indeed, they remain the primary cause of mortality and their incidence is constantly on the increase.

Several longitudinal surveys have studied the link between physical activity and cardiovascular diseases of atheromatous origin. Most of these studies focus on the "medium term" relation (between 5 and 10 years). They are mostly non-European and take into account many confounding factors (sex, age, BMI, consumption of psychoactive substances, blood pressure, cholesterol, diabetes, cancer, lifestyle including level of education, eating habits, family history, stress and well-being). It transpires that the "physical activity" factor is less significant in the occurrence of cardiovascular disease of atheromatous origin than other factors such as tobacco consumption, obesity, hypertension, diabetes, etc. However, the

accumulation of risk factors is itself a cardiovascular risk factor, especially among young men.

Physical activity is henceforth recommended in the field of cardiovascular diseases, both as a means of preventing their occurrence and of limiting their consequences once they have occurred. The principal affections concerned are coronaropathy, chronic heart failure and arteriopathy of the lower limbs. On the other hand, there is still a shortage of experimental proof concerning the impact of physical activity on cerebrovascular diseases.

Although the mechanisms – in particular the molecular mechanisms - underlying the impact of physical activity on the evolution of the atheromatous disease have yet to be elucidated, there is experimental proof of the effectiveness of physical activity on various factors closely correlated with these diseases.

Type 2 diabetes is a particularly explicit example inasmuch as physical activity on its own is capable of preventing its occurrence in almost 60% of cases presenting an intolerance to glucose. Once diabetes is installed, physical activity facilitates glycemic homeostasis on both the hyper- and hypo-glycemic side. Physical activity can thus lighten the medicinal treatment. It delays the apparition of those degenerative complications which make diabetes such a serious disease. These effects are explained, at least in part by the reduction of insulin resistance, the improvement of transport and the use of muscle glucose, and reduced hepatic production of glucose. It is for this reason that physical activity is currently deemed a priority objective of health policy in the fight against the type 2 diabetes pandemic.

Physical activity reduces blood pressure in hypertensive patients, on average by 11 mmHg for systolic blood pressure and by 8 mmHg for diastolic blood pressure. It reduces high blood pressure due to exertion in the same proportions. It postpones, and even eradicates, the need for treatment by medicinal drugs of a recently diagnosed high blood pressure. The mechanisms underlying this effect are still not fully known. Nevertheless, the following results have been shown: diminished peripheral arterial resistance, a reduction of endothelial dysfunction and neuro-hormonal abnormalities linked to high blood pressure, as well as increased sensitivity to insulin (implicated in the pathogenesis of high blood pressure).

In addition, physical activity helps to improve the serous lipid profile with an average reduction of 3.7% in the triglyceride level and of 5% in the LDL-cholesterol level, and a 4.6% increase of the HDL-cholesterol level. Together with diet, physical activity helps to control excess weight, with an increase of lean body mass and reduction of abdominal adiposity. Physical activity makes it easier for people to give up smoking and reduces the depressive syndrome which has been identified as a high and frequent risk factor in the course of major cardiovascular events and a pejorative prognostic factor. Finally, physical activity improves hypercoagulability and inflammation implicated in the pathophysiology of the atheroma.

Once the cardiovascular disease is installed, physical activity has a significant impact on the disease. It acts on the improvement of insulin resistance, endothelial dysfunction and neuro-hormonal abnormalities.

One of the most spectacular effects is a 25 to 35% reduction of mortality in patients suffering from coronary heart disease. A reduction in clinical signs (such as angina, dyspnea or arterial claudication) and an increase in physical abilities are associated. Physical activity can therefore extend life expectancy in better conditions.

Components of the physical activity recommended during cardiovascular diseases associate global exercises (covering extensive muscle areas) and more analytical exercises (limited number of muscles) developed against a resistance to movement. The question arises as to the most appropriate level of intensity for these exercises. A minimum level is, however, required in order to obtain an impact on morbidity/mortality. It is close to 50% of the

maximum capacity measurable by an effort test of each subject. It is then possible to remain at this level of training if no more than an improvement in aerobic performances is sought. If, however, a partial recruitment of the anaerobic metabolism with a greater gain in muscle strength is sought, the level of exercise will be higher without however attaining the maximum capacities for which the risk of complication is at its strongest. The minimum duration of an exercise session should be 30 minutes. For the global training, a daily frequency is usually recommended, or at least 5 days a week; the recommendation for muscle training against resistance is a minimum of two sessions per week. The types of exercises available are very diverse, adaptable to the tastes, age and abilities of a large number of subjects: walking, running, cycling, swimming, gymnastics, various sports activities, use of different ergometers or muscular training systems, etc. The procedure will take the context into account: physical activity as part of primary or secondary prevention. In the latter case, a preliminary medical evaluation will be required in order to stratify the risk and adapt the exercises, particularly during heart failure for which greater progressivity and regular monitoring will be required.

The risks involved in physical activity during cardiovascular diseases are primarily represented by cardiac complications and occur mainly when efforts are intense and ill-adapted to the subject's true capacities. Thus, these risks are very small when the training is carried out in the context of supervised programmes (rehabilitation). They concern above all coronary thrombosis complications occurring on an "unstable" atheromatous plaque (unprotected by fibrosis and which will therefore crack) and which are the cause of possibly dramatic myocardial ischemic accidents. The volatile character of the atheromatous plaque does not in most cases attain the most stenosing coronary lesions (usually detected in current practice by coronarography, the reference imaging method). Similarly, an effort test will seek an effort myocardial ischemia in relation with a tight coronary stenosis but will not contribute to the discovery of such a vulnerable plaque. Caution must therefore remain the rule: violent effort should be avoided and contraindications to physical training respected. These contraindications are essentially unstable angina, decompensated heart failure, severe hypertension, complex cardiac arrhythmias, narrowing of the tight aortic valve, and any evolving inflammatory or infectious disease. Musculo-skeletal complications related to exercise in the course of cardiovascular diseases are rare provided that physical activity is individualised, i.e. adapted to each subject's age and abilities.

Physical activity is a treatment in its own right of chronic obstructive pulmonary disease (COPD)

There is a very close relationship between physical activity and respiratory disease. Physical activity is the most effective therapeutic tool in the treatment of dyspnea and chronic obstructive pulmonary disease (COPD), the fast-proliferating smokers' respiratory disease (to be ranked third in the world for fatal diseases in 2020). It would seem that physical activity can also play a role in preventing this disease or its complications. In the case of athletes, on the other hand, high-level sport induces hypoxemia and may lead to severe asthma in non-allergic subjects.

There are few studies on the effectiveness of physical activity in preventing respiratory diseases, and those that exist tend to concentrate almost exclusively on COPD. Two recent studies on a large number of subjects provide convincing evidence. The first study, following up 6,790 subjects over 11 years, has shown that active smokers engaged in a physical activity equal to or greater than 2 hours per week have a reduced risk of developing COPD compared to smokers whose amount of physical activity is below this threshold. The same

team, following up 2,386 patients suffering from COPD for 20 years, had previously shown, for the same amount of physical activity, a 40% reduction in hospitalisations and mortality of respiratory origin.

The recourse to physical activity as a therapeutic tool comes from the initial model, defined in the 1980s, of a vicious cycle of the deconditioning or spiral of dyspnea. The person suffering from respiratory disease, short of breath because of his/her illness (the respiratory part of dyspnea) calls a halt to all activity, leading to a "deconditioning", i.e. to a loss of fibres and enzymes of the oxidative muscle metabolic pathway. Any exercise is then essentially carried out through the lactic fibres. Directly or indirectly, the lactic acid thus formed then stimulates the respiratory centres thereby aggravating the existing dyspnea (the muscle part of dyspnea).The purpose of re-training is thus to restore the oxidative path in order to break this vicious circle. Re-training reduces patients' dyspnea by improving the muscle part without changing the overall respiratory function. This model is today proved and completed. COPD is an inflammatory disease at all levels: respiratory, blood, muscle, etc... Physical activity has an anti-inflammatory and anti-oxidant effect which necessarily contributes, alongside other phenomena, to the improvement of these patients' condition.

Dozens of controlled studies have been devoted to the effects of effort retraining in patients suffering from COPD. Since 1996 these studies have been brought together in the form of a meta-analysis or have been analysed in terms of "evidence-based medicine". The results are particularly striking: dyspnea, tolerance to exercise, quality of life and the number of exacerbations are improved at the highest level (A) in terms of "evidence-based medicine".

The latest recommendations on effort retraining for patients suffering from COPD all agree on the notion of 2 hours of physical activity per week, to be practised regularly and permanently. There is disagreement as to the level of intensity. The protagonists of high intensity point to better results in the short term, while those in favour of moderate intensity emphasise the importance of attracting and maintaining patient cooperation, leading to clinically positive results.

There is a shortage of studies on the other respiratory diseases on which to build meta-analyses. They nevertheless show results equivalent to those obtained for COPD. A special word on asthma: the era when doctors signed certificates forbidding the practice of sports for asthma cases is now in the past. Today, such behaviour would be considered a professional fault. Asthma patients are as a result much less "deconditioned" than in the past. While physical activity cannot, strictly speaking, be prescribed for asthma, it should just the same be strongly recommended.

High-level sport may be the cause of exercise-induced hypoxemia which appears in two-thirds of endurance-trained, young, high-level athletes. As from the age of 40, this is virtually constant and by the age of 60 it is systematic with cyclists. This totally asymptomatic hypoxemia is probably the result, at least in part, of lung parenchyma subedema-type impairments. There do not seem to be any long-term repercussions from hypoxemia induced by exercise. But this is not the case with asthma appearing with mature (about 25 years old), high-level and non-allergic sports practitioners. This disrupts their performance and is difficult to eradicate. The abrasion of the airways by extreme and repeated hyper-ventilations would appear to be the cause of this particular clinical form of asthma.

The regular practice of a physical and sports activity limits and helps to control weight gain

Moderate physical activity is an important factor in the maintenance of body weight. It is essential to distinguish between, on the one hand, the effects of physical activity in terms of preventing weight gain, and on the other hand, its role in the treatment of overweight subjects. There are numerous intricate factors involved in weight increase and the development of obesity (biological, behavioural and societal factors), and physical activity is one of the elements that can influence the energy balance and the state of health, together with eating habits. Similarly, where the treatment of obesity is concerned, physical activity recommendations are of major importance in the general context of an overall management combining diet advice and psychological support.

The results of the currently available observation studies show that physical activity can play a role in attenuating weight gain over time in adults, adolescents and children, although it cannot completely prevent the phenomenon or facilitate weight loss at population level. Interestingly enough, it has been shown, in the adult, that everyday activities of moderate intensity, such as walking or cycling to work, are inversely associated with weight gain after several years of follow-up. Moreover, some studies suggest an inverse relation between the usual level of physical activity and the abdominal location of the fat. It is established that the abdominal accumulation of fat is associated with the development of metabolic (type 2 diabetes) and cardiovascular (coronary disease) pathologies.

Sedentary behaviour is another important aspect in connection with obesity. This corresponds to such passive behaviours as looking at a screen, working on a computer, reading, telephoning, etc. Physical inactivity, for its part, refers to a state in which body movements are reduced to a minimum. After allowing for physical activity and dietary habits, certain sedentary behaviours in adults, adolescents and children, such as the time spent sitting down in front of the television, seated at work or driving a car, are each linked to the risk of obesity. Further more, on the question of preventing weight gain in children, the fight against sedentary behaviour – the reduction but not necessarily the suppression of the time spent watching TV and playing video games – has proved to be an effective strategy and a complement to initiatives focused on promoting physical activity.

The current recommendation for the general adult population is to practise a regular physical activity at least equivalent to 30 minutes of walking at a good pace (fast walking) per day. Children are advised to practise a moderate to high intensity physical activity for at least 60 minutes per day. The general aim of these recommendations is to promote harmonious growth (in children) and to prevent the principal chronic diseases (in adults). They also apply to the prevention of weight increase. However, a greater volume of physical activity (in terms of duration and intensity) could prove necessary for this specific objective. Consequently, it is suggested that adults should increase the duration (e.g. at least 45 to 60 minutes of moderate-intensity activity per day) and/or the intensity of the physical activity, or reduce their energy intake, in order to avoid putting on weight.

There are many beneficial effects of physical activity for overweight persons. In the context of the treatment of obese adults and children, it is essential to differentiate the impact of physical activity on weight loss, of moderate amplitude, from the effects on maintaining weight after an initial loss of weight, of major amplitude, as well as the beneficial effects of improvements in the comorbidities of obesity.

The maintenance of a reduced weight after an initial loss of weight, or a smaller recovery of weight, represents one of the major advantages of physical activity in the case of excess weight. There is much debate as to where the activity threshold for such an effect is situated.

In this situation, 60 to 90 minutes of activity of moderate intensity per day, or a shorter period of activity of higher intensity, would appear to be necessary with adults. This is by no means a negligible volume of activity. It should above all be noted that the main effect of physical activity in this field is not loss of weight but not putting on weight again. Very generally speaking, the weight loss obtained by combining a diet and a programme of physical activity is greater than that resulting from a diet on its own. But there is only a small difference between the two methods, a question of a few kilos only. In most cases, therefore, physical activity has only a modest effect on weight loss. One explanation is that the additional energy expenditure induced by physical activity remains quantitatively limited. In order to obtain a substantial weight loss through physical activity alone, several hours of intensive training per day would be required! However, even an activity of moderate intensity, in endurance, can boost the contribution made by the lipids to energy expenditure and help to improve body composition.

The aim is to lose fatty body mass by retaining non-fatty or lean body mass (of which the muscles are one of the main components). It is known that the loss of lean mass as a result of diet alone is of the order of 25% of the weight lost. When diet is associated with a programme of endurance-type physical activity, the loss of lean mass is reduced by half. This effect on the composition of the weight lost is important on several counts. First of all, lean mass is the major determinant of energy expenditure at rest, that is to say the basic expenditure necessary for the organism to function. A decrease in lean mass leads to a reduction of energy expenditure and this in turn can lead to the subsequent recovery of weight. Secondly, a substantial reduction of lean mass, in particular the muscle component, can seriously impair functional abilities and thus mobility – the very opposite of the result sought.

Various abnormalities linked to the syndrome of resistance to insulin (hyperglycemia, increased triglycerides and reduction of the protective HDL cholesterol, increased blood pressure) itself associated with obesity are improved by the regular practice of a physical activity of moderate intensity. The important point to grasp in this sphere is that these favourable modifications of sensitivity to insulin, tolerance to glucose and lipid profile under the effect of regular training can be observed independently of modifications in weight or fatty mass, and in the absence of major modifications of cardiorespiratory capacity (VO_2 max). It is also instructive to note that the results of certain prospective epidemiological studies in the adult suggest that corpulent or fat but nevertheless fit subjects have a lower total and cardiovascular mortality risk than subjects of normal build but with a weaker physical capacity.

As a general rule, physical activity of moderate intensity has positive effects from the psychological point of view by improving mood, the feeling of well-being and self-esteem. These psychological benefits could be associated with better compliance with dietary advice, but more extensive documentation is necessary to confirm this possibility.

The difficulty in all these cases is to encourage “inactive and sedentary” persons to (re)discover a liking for movement and to become at least moderately active on a regular and long-term basis in their everyday life. The purpose is to incorporate physical activity as much in the realm of well-being as in the sphere of improved state of health, thanks to the “entertainment” or “fun” aspect of physical activity, especially where children are concerned. Individualised advice with regard to physical activity, together with the importance of “progressivity”, is a crucial notion in this connection. An important measure consists in limiting (but not removing altogether) the time devoted to sedentary occupations. With children, this has repercussions on maintaining (not regaining) weight after an initial weight loss. In the current state of opinion, the global volume of physical activity seems to be

more important than its intensity. The first objective is to attain the physical activity recommendations for the population as a whole, and then to increase the duration and/or intensity of the physical activity in the light of individual possibilities. In the case of children, the parents' cooperation is vital.

Physical activity reduces the risk of developing cancer of the breast and colon

Cancers for which a preventive effect of regular physical activity has been sought are the most frequent cancers precisely because we have studies on large cohorts at our disposal for these cases.

The most substantial body of proof of the preventive effect of physical activity is to be found for cancer of the colon. Of the 51 studies focusing on colon and colorectal cancer, 43 have shown a reduced risk in subjects with the greatest physical activity (average reduction of 40 to 50%). Out of the 29 studies seeking a dose-response effect, 25 have shown that an increase in the level of physical activity is associated with a reduced risk. However, this protective effect is not found for cancer of the rectum.

As far as breast cancer is concerned, of the 44 studies conducted in 2002, 32 showed a reduced risk in the subjects with the most physical activity. In 2006, 45 out of 64 studies showed a reduced risk in the subjects with the most physical activity, with an average reduction of 30 to 40%. Out of the 23 studies seeking a dose-response effect, 20 showed that an increase in the level of physical activity is associated with a reduced risk. It is difficult to give a minimum quantity of exercise for obtaining protection inasmuch as different types of physical activity may be effective: walking, intense physical activity of short duration, household physical activity, etc. Nevertheless, taking solely a walking-type physical activity into consideration, the minimum effective threshold is about 4 hours of walking per week. With women previously treated for breast cancer (stage I, II or III), recent studies show that a walking-type physical activity (3 to 5 hours per week) reduces the risk of death or relapse by 20 to 50%.

In 2003, out of 23 studies on lung cancer, most showed a reduced risk in the subjects with the most physical activity, with a reduction ranging from 20 to 60% depending on exercise intensity but one study reported an increased risk of 40%. In most of the studies, the role played by smoking was controlled. However, sports practitioners are not smokers and therefore have a low incidence of lung cancer. The protective role of physical activity has yet to be shown for women.

As far as cancer of the prostate is concerned, half of the 37 studies published show that physical activity reduced the risk of cancer by 10 to 30%, with a dose-response relation found in 10 out of 19 studies. But there are still too many contradictions in the results of the different studies (some of them report an increased risk of prostate cancer with physical activity) for a definitive conclusion to be drawn.

With regard to cancer of the endometrium, a recent review (2007) indicates that 14 out of 18 studies show an average 30% reduced risk (a dose-response relation is reported in 7 studies out of 13). According to the results of several other recent studies, it seems that physical activity has a probable protective effect with regard to cancer of the endometrium.

There are certain other cancers for which a few other publications highlight a possible protective role of physical activity (cancer of the ovary, the stomach, etc.), but there are not enough data from which to draw conclusions on the causal relationships.

To sum up, according to the definitions developed by the World Cancer Research Fund and the American Cancer Research Institute (level of scientific proof ranging from "convincing" to "probable", "limited" and then "insufficient"), physical activity has a convincing preventive effect on cancer of the colon, and a probable effect on breast cancer (in menopaused women) and cancer of the endometrium. On the other hand, proof is limited for lung and prostate cancer. For the other cancers, the effect has yet to be demonstrated. In most cases, a dose-response effect is observed for an activity of moderate-to-high intensity, as an over-intense physical activity does not generate greater benefits. During and after treatment, an adapted physical activity of low-to-moderate intensity improves the quality of life and reduces the sensation of fatigue.

The mechanisms behind the beneficial effect of physical activity on the prevention of certain cancers are now beginning to be identified. This beneficial effect marshals systemic effects of physical activity or, in the case of cancer of the colon, local effects.

One of the systemic effects of physical activity is the reduction of the biologically active fraction (free fraction) of the sexual hormones. This beneficial effect is exercised on the hormone-dependent cancers (breast, endometrium, prostate). Regular physical activity reduces the risk of occurrence of these cancers by reducing the endogenous production of the estrogens but also by increasing the SHBG (Sex Hormone Binding Globulin). By binding to estradiol or testosterone, the SHBG therefore reduces their biologically active free fraction. The production of SHBG also depends on diet (normal or hypo-calorie intake), high-fibre diet, etc.), and the effects of physical activity are sometimes confused with the effects of diet.

Another systemic effect of regular physical activity is the reduction of insulin and IGF-I. Obesity and a sedentary lifestyle induce an insulin resistance and a compensatory hyperinsulinism. Insulin resistance is associated with a cohort of metabolic impairments defining the metabolic syndrome and leading to a reduction of SHBG and the proteins binding IGF (IGF-BP) and thus to an increase of the biologically active free fraction of the hormones linked to these proteins (IGF-I for IGF-BP, estradiol and androgens for SHBG).

For cancer of the colon, the protective effects of regular physical activity marshal local mechanisms. Two types of mechanisms have been advanced:

- Increased intestinal motility inducing a reduction of gastro-intestinal transit time and therefore a reduced opportunity for the cancerogens to come into contact with the colic mucosa and faecal content
- Modifications of the prostaglandin concentrations: increase of the PGF prostaglandins inhibiting the proliferation of the colic cells and increasing intestinal motility. On the other hand, physical activity does not increase the level of PGE2 prostaglandins which, on the contrary, stimulate the proliferation of the colic cells

Other biological mechanisms have been suggested, such as the reduction of oxidative stress and effects on immunity. It is clear that the beneficial effects of physical activity depend on many inter-connected mechanisms. However, the level of scientific proof in each case is a matter of debate and further research is needed in order to determine the preventive mechanisms for each type of cancer.

Moreover, the mechanisms of the beneficial effects of regular physical activity on survival after cancer treatment, and most importantly on the quality of life (decreased post-treatment fatigue, improved symptoms secondary to treatment) have yet to be determined (not to mention the need to know when to begin physical activity in relation to treatment, and at what dose: duration and intensity).

Physical activity, when practised regularly, plays a major role in the prevention and treatment of osteoarticular and degenerative diseases

The regular practice of a physical activity is now recognised as forming an integral part of the treatment of disability, chronic and degenerative diseases.

The maintenance of a certain level of physical activity is effective against the harmful effects of immobility on the structure of the ligaments and tendons (expressed by a lowering of the rupture threshold, a loss of elasticity aggravated by age).

The positive effects of physical activity have been shown in the treatment of chronic lumbago (but not in the case of acute lumbago).

With regard to rheumatic disease, the benefits of physical activity are now proven for inflammatory syndromes and in particular rheumatoid arthritis. Results giving the same level of proof have recently been reported in the care of fibromyalgia (unlike the chronic fatigue syndrome for which physical activity seems to have no real effect).

Special emphasis should be placed on the major public health problem posed by osteoarthritis. While the moderate and regular practice of sport is not in itself a factor prompting the development of this pathology, this is not the case where intensive practice is concerned. This has now been clearly demonstrated, particularly when subjects have pre-existing morphological abnormalities (knee and hip in particular), and when they have previously been victims of an articular traumatism. This finding underlines the importance of respecting the time required for healing and the need for a gradual resumption of sport after injury. There is a need for further studies in this area.

However, it is important not to draw the wrong conclusions as to the place of physical activities in the treatment of arthrosis (which, to varying degrees, concerns virtually everyone over the age 65 years). Indeed, many studies published in recent years all point, with a very high level of proof, to the benefits of adapted physical activity (that is to say, respecting the periods of attack), in terms of pain, strength and, more generally, quality of life.

Whatever the pathologies, but particularly in the treatment of patients suffering from arthrosis, care should be taken to specify which programmes are most effective (in particular muscular training and even rehabilitation) in terms of duration and frequency. In addition, the relationship between the intensity and the beneficial effect of exercise for these diseases has yet to be elucidated. Another major point – and one for which current data in the literature are far from complete – concerns the degree to which these programmes are respected by (often isolated and elderly) patients in the medium and long term. The dropout rate is in most cases high and the beneficial effects are therefore limited in time, especially for subjects with no past history of sports activity.

Physical activity is gradually becoming one of the preferred means of rehabilitation for persons with disabilities, but few controlled studies have been devoted to this question. For all persons with physical disabilities, physical activity brings a sense of bodily control (real or imagined) which has a very considerable impact on quality of life. Research based on extensive samples has shown the psychosocial repercussions of effort retraining during hospitalisation on the resumption and continuation of sport, on requests for medical assistance, on employability and motor autonomy. The authors show that spinal cord patients, mostly young adults, who have undergone effort retraining during their stay in re-education centres, enjoy a higher quality of life in the five years following injury. The same holds true for the improvement in physiological capacities. In addition, people with a

physical disability are investing increasingly in competitive sports, reaping all the individual and social benefits but sometimes taking the risks inherent in excessive practice.

Several recent publications have highlighted the benefit of physical activity vis-à-vis the care of degenerative neurological diseases (multiple sclerosis, Parkinson's disease and Alzheimer's disease). This is a major new field of investigation for the years ahead, directly connected to the therapeutic progress observed with regard to these neurological diseases and the ageing of the population.

Excessive physical activity increases the risk of injuries

The regular practice of a physical activity may potentially give rise to a risk of injury. The type and seriousness of the injury depends in particular on the sports discipline, age and the conditions in which the sport is practised.

The very notion of trauma must always be specified (whether or not requiring medical care or hospitalisation, whether or not accompanied by a change or discontinuation of physical activity, or even sick leave). It is also necessary to clearly differentiate acute injuries from chronic injuries or overuse.

The vast majority of acute injuries lead to discontinuation of sport, even to hospitalisation (though less often compared to accidents of everyday life). The potential seriousness and the resulting financial impact are expressed today in the fact that numerous publications have been devoted to certain sports, while others have attracted few or no studies. Head injuries, fractures and dislocations of the upper limbs are mainly found in the practice of "winter" sports (ice-skating, skiing, snowboarding), cycling and roller sports (roller-skating, skateboarding). Similarly, several publications have focused on the rugby union (22 injuries per 1,000 hours of sport) and specific recommendations have been made on how to avoid serious injury of the cervical spine, among others. The rupture of the anterior cruciate ligament of the knee (usually leading to surgery) has been particularly described in team sports (football: 0.1 ruptures for 1,000 hours of pratice; handball: 9.7 ruptures for 1,000 hours of practice) and during downhill skiing (irrespective of the level of technical skill). In the last-mentioned case, the annual number of ruptures has been put at 16,000 in France for 55 million skier-days. This risk is on average three times higher among women than men, regardless of the sport studied. Sprained ankles are particularly common in team sports, the relative risk being 2.81 for female basketball players, against 1.15 for football (men or women), compared to a control group.

These acute injuries can be prevented in part by making changes in the rules of games (in rugby for example), and by wearing helmets and protective gear (elbow pads, gloves, knee pads), in particular for cycling and boardsports. These measures have shown themselves to be effective and the same is true for wearing ankle orthesis as protection against the recurrence of sprains. Finally, changes in training programmes may also be considered as a means of preventing these injuries. Thus, it has been shown that the risk of breaking the cruciate ligament rupture of the knee in women may be divided by 3 or 4 by implementing dynamic muscular training and proprioception programmes in volleyball and football. It is recommended that the same studies be conducted on other high-risk sports such as judo and skiing. It is particularly important to detect morphological abnormalities that may facilitate injuries, and to ensure that the time required for healing is respected, especially in the context of intensive sport. As demonstrated by numerous studies, the first occurrence of an accident increases the likelihood of recurrence and possible complications.

Chronic injuries, or injuries due to overuse, are very specific to the practice of sport and to the movement involved. In this respect, they resemble the musculoskeletal disorders described in occupational medicine. These injuries rarely involve heavy medical care, but almost always lead to a cessation of physical and sports activities ranging from a few days to several months. As of today, not all sports have received the same attention. It is noteworthy that swimming gives rise to the frequent occurrence of shoulder tendinitis (up to 21% of all injuries in certain studies). Cycling is responsible for frequent tendinopathies of the knee (13 for 100,000 km cycled). Running has attracted the largest number of studies (over 10 prospective studies referenced at the time of writing). This activity causes first of all patellar syndromes, tendinitis of the knee and ankle and fatigue fractures accounting in athletics for 8 to 20% of injuries according to the studies, compared to an average of 1% for other sports.

With the growing child, particular attention must be paid to the risks of overtaxing the growth cartilages (epiphyseal and apophyseal cartilages), still referred to as osteochondritis. These are much more frequent than the ligament, muscle and tendon injuries found in adults. In other words, this period of life calls for special surveillance which is not forthcoming for all sports at the present time. Indeed, contrary to the case with adults, traumatic risk is proportionally higher during training than in competition. This has been particularly clearly highlighted by studies conducted with young soccer players practising their sport intensively. Particular care should therefore be taken with the medical surveillance of growing boys and girls in order to avoid problems with joints and tendons in adulthood. This surveillance should in particular incorporate the concept of quantity and intensity of training. Similarly, and more broadly, prevention among sports-minded children and adolescents should include the study of the movement or gesture itself, and of the equipment used, depending on the sport in question, e.g. floor, shoes, rackets.

This leads to the need to appraise the notion of benefit/risk as precisely as possible. This has not as yet been exhaustively evaluated, particularly with respect to the type of sport practised, its intensity and frequency, and the age of the person in question.

Physical activity is a factor of equilibrium in mental health

Anxiety and stress are the consequences of a society whose values are based on performance and competition. Indeed, we note that competitive sport itself is a stress factor, an observation confirmed by experiments revealing an increase in anxiety as a result of highly-intensive training programmes, or sporting situations involving repeated failures. The intensive practice of sport can cause stress reactions, particularly in the case of anxious, fragile, unfit or elderly people.

Conversely, the relationships between recreational physical activity of low intensity and reduced anxiety have been highlighted in the general adult population. The literature reviews conclude that physical exercise is associated with reduced anxiety and its physiological indicators. The degrees of proof are considered low or moderate but nevertheless significant. It appears that this reduction of anxiety is found mainly among people in poor physical condition and with a high level of anxiety.

With non-anxious persons, the effects would seem to be felt in the "state anxiety" (fleeting, situational) throughout the duration of the activity, and to generally persist for two hours after the end of the activity. While a decrease in the state anxiety is observed in most studies, this reduction tends to be more correlated with exercise of low-to-moderate intensity. As to the type of activity (aerobic or resistance), this does not seem to play a leading role.

Among subjects with high or moderate anxiety, the state anxiety may also be reduced. The admittedly low number of studies on people with profound anxiety disorders all conclude that physical activity should be proposed as a "complement" to conventional therapies.

Nowadays 15% of the population is affected by depression. We know that depression affects self- and body-image, and many studies have sought to find how lack of activity is associated with depression, and how, on the other hand, regular practice is correlated with a low score of depression. Numerous transversal and longitudinal epidemiological studies on this subject (more than 1,000 articles in 2001), show that "active" people have a lower depression score than "non-active" persons in various inventories of depression (although the direction of this relationship has not been shown). Some authors find no connection with the practice of sport after adjustment for age, gender and social class, while others find a decreased risk of depression among young people practising a team sport (but again, it may be thought that young people attracted to team sports are less depressed than those preferring an individual sport).

The meta-analyses performed from 1990 to 2006 on a wide range of populations highlight converging results: the practice of physical activity, whether in the short or long term, leads to a decrease in the level of depression as measured by various scales or questionnaires. The effect is significant but low. This "limited" effect in the demonstration of proof may be explained in particular by the low number of subjects making up the experimental protocols, the extreme diversity of populations, types of interventions, assessment methodologies, etc.

There are relatively few studies comparing the effects of therapy through physical activity with drug treatment, behavioural therapy, analytical therapy or mixed therapies, but these studies observe the same reduction in the level of depression, whatever the form of therapy, at the end of a follow-up period of 3 to 4 months. The type of exercise does not seem to play a leading role but the environment is important (presence of a private coach or practice in small groups). A reduction in the depression score is particularly visible with moderate depression but the effects seem to diminish with time. A recent meta-analysis confirms that all the studies are too heterogeneous in terms of groups, practices, duration and treatment to conclude that physical activity is a more effective treatment of depression when compared with other protocols. However, the positive effects are widely demonstrated with regard to the secondary repercussions of the affection, physical condition and quality of life. Physical activity should be recommended in any treatment of depression.

A model of intervention in physical activity designed to reduce levels of anxiety and depression has been proposed: aerobic or resistance-type work; 3 to 5 times per week; moderate intensity: 30-minute sequences; commitment to physical activity of 12 weeks or more (effective as from 8 weeks); group work or individual work with a coach.

The mechanisms of action remain the subject of much debate. Some authors argue in favour of the importance of psychological factors: positive perception on the part of others, break with negative thoughts, new skills, encounters, sense of control, entertainment effect, decreased bodily anxiety, etc. According to other researchers, physiological factors are predominant and all these developments are the result of improvements in physical condition. Endomorphines and the concentration of monoamines should also be taken into account, together with the hormonal secretions mobilised by stress (cortisol). There are undoubtedly many factors involved, varying according to type of activity, intensity of practice, duration, presence of participants, presence of spectators, etc.

With regard to those suffering from severe mental disorders such as autism or schizophrenia, there is a lack of controlled research and a variety of results. The authors of a recent meta-analysis estimate that, in view of the low number of publications and despite the "clinically" positive results revealed, it is impossible to draw "scientifically validated"

conclusions on the therapeutic effects of physical activity among schizophrenics. Attention should be paid, however, to the poor state of health of schizophrenics, 89% of whom are inactive. Their lifestyle should be changed and physical activity is particularly recommended in their case. Indeed, its contribution to improving quality of life seems so obvious that its adoption should be strongly advocated. There are no major contraindications in the association of drug treatments and recreational physical activity.

Other publications have reported the benefits of physical activity (judo, climbing, swimming, dancing, etc.) among adolescents with autism. It should also be noted that the participation of autistic children and adults in an activity shared with others in the context of sports provides them with a rewarding sense of belonging to a group, and facilitates their social integration.

Can intensive physical activity become an addiction?

In the early 1970s, only a small number of individuals, qualified as "idiosyncratic" in the New England Journal of Medicine, were involved in jogging. Fifteen years later, the Health Science Center of the University of Arizona estimated the number of American runners at 31 million and the emerging market thus generated at billions of dollars. At the same time, more and more proof was forthcoming from the international scientific and medical literature as to the physiological and psychological benefits of this popularisation of physical exercise, along with theories attempting to explain these benefits. There simultaneously appeared in the literature a clinical description of the phenomenon of addiction to physical exercise, a term that we owe to Baekeland (1970) who was the first to publish a study on the psychological effects of the discontinuation of sports activity, especially on sleep. Indeed, it was these episodes of forced discontinuation that made it possible to observe a withdrawal syndrome typical of addictions in general: irritability, sleep disorders, depression, eating disorders accompanied by a high level of guilt, all attached to various somatic symptoms.

However, the positive effects of physical activity led to this addiction, for a long time, being considered as a "positive addiction", defined as a psychological and physical dependence, but characterised as "positive" because the subjects appeared to derive benefits in terms of physical and psychological well-being. However – and this is the crux of the problem – a shift may gradually occur towards an obsessive relationship with physical activity. The placing of physical activity above other everyday life considerations would appear to lead to a switch, in some subjects, from "positive addiction" to "negative addiction", in other words, to a true addiction.

It is important to know the factors of vulnerability in this shift. The problem is principally methodological in nature because it is a question of defining criteria and validating instruments for measuring this negative addiction.

The clinical signs for describing addiction to physical activity have been matched with the criteria concerning addictions to substances. The validity of this relationship is, however, subject to the validation of criteria of dependence to physical activity. But we must take note of the extreme heterogeneity of the measuring instruments. The terms used themselves indiscriminately cover concepts, criteria and variables as they relate to different theoretical foundations. Similarly, a dozen measurement scales have been used since 1979 to measure addiction, not always with a proper validation of the items concerned.

However, these criteria have been refined and validated on the strength of the most recent studies. We note:

- A reduced repertoire of exercises culminating in a stereotyped and daily physical activity
- This activity takes pride of place before all others
- An increased tolerance of intensive physical activity
- Withdrawal symptoms at voluntary or forced discontinuation
- Withdrawal symptoms are attenuated or disappear upon resumption of physical activity
- A subjective perception of a compulsive need for exercise
- Recurrence of compulsive activity after an interruption
- Continuation of activity despite illness and behaviour going against medical advice
- Difficulties (linked to exercise) or conflicts with family, friends and work
- Self-inflicted obligation to lose weight

As far as inter-individual vulnerability is concerned, recent works have put the number of persons in the general sports population liable to gradually slip into addiction at about 4%. However, gender (girls are less vulnerable), type of sport (individual or team sport, etc), level of practice, but also more psychological factors such as socio-familial environment, "thrill-seeking", etc. are all factors amplifying or limiting this vulnerability. These data strongly suggest that in the genesis and the expression of these phenomena, there is no single factor involved, but rather a multifactor aetiology that should be comprehended in all its complexity.

One major consequence of this type of addiction, arising from a phenomenon observed in chemical addictions, is polydrug use. Would a possible addiction to physical activity, if confirmed, constitute a source of vulnerability to the consumption of substances such as alcohol, tobacco or illicit substances? This problem has led to a fairly sizable amount of literature in population studies (the last survey to date was conducted in 2006 in France in the Provence-Alpes-Côte d'Azur region) as well as in animal studies. Although it is difficult to establish a clear boundary between recreational and intensive physical activity (especially for long-distance running and body building), some work on humans and animals has been able to distinguish between the positive and negative effects of the two, in the sense that the first (moderate recreational activity) makes the subject less "vulnerable" (or gives more protection) than the second (intensive physical activity) to the consumption of alcohol and illicit substances.

Links have been highlighted between competitive sport and violence and the consumption of psychoactive substances. These links persist after adjustment according to gender, age and social class. More than the practice itself, it is perhaps stress that is involved in this link, but is not stress inherent in competitive sport?

The practice of competitive sport, involving a small portion of the population, is not without risk in terms of negative psychological repercussions and the emergence of psychopathological disorders. These disorders are not described very much in the scientific literature, since top athletes are not monitored on a regular basis at psychological level (unlike medical and biological follow-up). Most work focuses on adolescent sports practitioners. It is observed that eating disorders are more common among athletes compared to non-athletes. Some risk factors have been identified (weight instability, fear of puberty, negative body image, etc.). High-risk behaviour is found among young people practising competitive sports (violence, alcohol, consumption of illicit drugs, use of psychostimulant drugs, doping, excessive risk-taking in sport, etc.). This behaviour is linked

to a search for sensation and a low perception of danger. Anxiety disorders and depression associated with intensive practice and its constraints have received little study apart from crisis situations (injury, cessation of movement). There has been little research on the predicament of athletes at the end of their career or on the question of career change. A kind of personality typical of some sports competitors characterised by the restriction of affects with an operative-type (alexithymia) or "narcissistic" psychological functioning, provides an explanation of certain high-risk conduct and specific psychopathologies. Our knowledge of the psychopathology of athletes remains very fragmentary.

Finally, emphasis should be placed on the small fraction of subjects vulnerable to addiction. This particularly concerns a significant section of persons involved in long-distance running, marathons and body building (sports for which a large body of data is available). These enthusiasts, despite a quasi-professional kind of training schedule, are nonetheless "amateur" athletes not belonging to any club or federation. As such, they do not have the benefit of an institutional or medical organisation capable of detecting, diagnosing and monitoring those who might be prone to addiction.

Physical activity is a development factor for children and adolescents but there are risks involved

With children and adolescents, physical activity is considered as a means of combating excessive weight and obesity, boredom and loss of academic and social interest. It is also a means of channelling aggressiveness, controlling attention, developing cognitive and social abilities, adapting to new situations and gaining in self-esteem. These advantages would seem to exist irrespective of the discipline practised.

As to the practice of high-level sport, while it is considered generally beneficial, it also carries risks, both physical (risk of accidents, risk of excessive training) and psychological (internal and external pressure of success, erosion of self-esteem in the case of repeated failures, over-exclusive involvement in the chosen discipline).

The studies all agree that boys practise sports more than girls, and the gap widens with age. A child's physical activity is associated with that of his/her parents, irrespective of socio-economic status.

Practice diminishes with age for everyone, but more for girls than for boys. This decline in sports activity among girls has been observed in most countries and also in France. It seems to result from the effect of social and environmental variables, rather than from motivation or the self-perception profile. One of the factors explaining this phenomenon is the perception among parents of risk factors. A quarter of parents discourage their children aged between 5-12 years from practising sports with a high risk of accident. This attitude on the part of parents is directed more at boys (35%) than girls (17%), probably because of boys' tendency to choose higher-risk sports.

There is a "continuum" between practising sport when young and as an adult. A physical activity during childhood increases the chances of a physical activity in adulthood.

Numerous studies point to a positive link between sport and emotional well-being. However, the link between sport and the well-being of adolescents is not easy to study as many confounding factors may influence the practice of sport in addition to the feeling of well-being. However, one study shows that sports activity plays a more important role on well-being than academic variables (marks in mathematics, school atmosphere).

Young people with a physical activity have a better self-image and suffer from less anxiety than those who do not practise a physical activity. Girls who are more sedentary would seem to be more depressed. It is also worth mentioning that most research on the "sports activity/ well-being" link has been limited to transversal surveys, i.e. the relationship between two events (in this case the practice of sport and health) at a given time. One may legitimately query the meaning of the relationship observed. Does sport have a positive effect on health or is it that the fact of being healthy increases the practice of sport? We are probably confronted with a "circular" relationship in which good health works in favour of the practice of sport which in turn serves to increase good health, etc. All the authors acknowledge the need for longitudinal surveys, and particularly long-term longitudinal studies, as this is a sensitive issue where the stakes in terms of public action are high.

When different groups of practitioners are contrasted (for example “intense” versus “moderate” practitioners or “competitive” versus “non-competitive practitioners), the results become complex. The relationship between mental health and physical activity is linear: the more time spent practising sport, the less time young people have to engage in suicidal thoughts or attempted suicide, but there is a U-curve relationship in the case of high-risk behaviour, such as the consumption of substances or violent conduct. Social functioning could partly explain this U curve. If sport promotes socialisation, it may be assumed that "intense" practitioners are subject to group pressure, especially after victories. More and more authors find that “competitive” practitioners display more high-risk behaviour (consumption of psychoactive substances, violent conduct) than "non-competitors”. These results suggest that psychological assistance for top athletes should be considered systematically, especially in training centres as from the age of adolescence.

A number of studies, in particular those carried out by sports psychologists, show that the frequent practice of an endurance sport improves self-image. Several intervention studies have given special emphasis to aerobics, as this is a sport which is both inexpensive and easy to generalise. Most of these studies concern the female population because the decline in sports activity is most substantial among teenage girls. These evaluation studies currently fall short of the mark because they are for the most part limited to short-term effects.

While overall participation in sport seems to improve the perceived state of health, psychological well-being or self-esteem, and to reduce social anxiety, the protective value of sport still needs to be assessed in long-term longitudinal studies.

Physical and sports activity has specific effects at different stages of a woman’s life

From a very early age, physical exercise is significantly lower in girls than in boys. This difference occurs from the age of 4 years, remains constant in the 9-10 year age bracket and continues through adolescence. With girls, the level of physical activity decreases with age, irrespective of the value of the level of physical activity (active, moderately active or inactive girls).

The decline of physical activity is most marked during adolescence. The results reveal two major variables of diminished physical activity during this sensitive period. Firstly, time: this is the major constraint and is inversely associated with physical activity. Secondly, the support and assistance provided by parents, teachers and friends are positively associated with physical activity. Girls mostly practise sports activities as a means of losing weight or having fun. During adolescence, physical and sports activities tend to become more

organised and the fun factor is gradually replaced by objectives of health and physical condition.

Adolescent girls tend to under-rate and under-estimate their aptitude, their potential and their ability for sports and physical activity. Compared to boys, they cite a greater number of obstacles such as time, money, resources and safety. There are no recommendations for physical activity specifically aimed at adolescent girls.

In adulthood, there is a significant difference between men and women with regard to the pattern of physical activity. Women expend less energy in their physical activities than men. And yet, few studies have focused exclusively on women. The predictive variables of the practice of a physical activity are age, the social role attached to physical activity, the encouragement of the family and environmental parameters.

In the general population, the recommendations for women are 30 minutes of physical activity per day at moderate intensity. This amounts to an energy expenditure of at least 4,200 kJ per week, necessary for the prevention of early mortality through the reduction of the risks of cardiovascular diseases and certain cancers.

The literature sheds some light on the characteristics of a physical activity most likely to attract women. The actual nature of the activity does not appear to be a major determinant. However, pleasure, the length of sessions, appropriate and suitable premises, a good level of skill and a personalised programme would appear to be factors promoting the regular practice of a physical activity among women.

During pregnancy, regular, moderate physical activity of 30 minutes every day of the week has beneficial effects on weight control and fitness. The recommended activities are walking, work on an exercise bike and swimming. Deep-sea diving should be avoided during this period insofar as the foetus is subject to an increased risk linked to decompression phenomena. Some very precise recommendations have been drawn up by the Society of Obstetricians and Gynecologists of Canada and the Canadian Society for Exercise Physiology.

At menopause, women who have practised a regular physical activity during their lives tend to have higher bone mass. There is a positive relationship between muscle exercise and bone mineral density after adjustment for all factors that can act on bone mass, particularly taking into account the existence or otherwise of an estrogen replacement therapy.

After a huge loss of bone mass in the first years following the onset of menopause, average bone loss settles at the rate of about 1% per year. A recent meta-analysis encompassing all the publications between 1966 and 1996 significantly shows that the regular practice of a physical activity can prevent and even reverse this bone loss linked to the ageing process with respect to both the vertebrae and the neck of femur. Over the age of 70, physical activity continues to exercise a beneficial effect by diminishing (but not completely eradicating) the degree of bone loss.

The relative risk of fracture of the neck of femur is reduced by 6% for each energy expenditure equivalent to 1 hour of walking per week. Women walking for at least 4 hours per week are 40% less at risk than sedentary women walking for less than 1 hour per week. This suggests that even a physical activity with a low-level impact with regard to the stress imposed on the bone, for example walking, can reduce the risk of fracture. Bone would seem to gain in resistance to mechanical stress, and this would appear to be much greater than the gain in bone density to prevent fractures.

At a practical level, all the studies agree on the following points:

- Regular physical activity must be accompanied by a calcium intake of at least 1 g per day
- Only "weight-bearing" exercises (running, muscular training, brisk walking, climbing stairs) have been shown to be effective. Exercises involving no weight-bearing (swimming, cycling) have little or no effect. It should be noted that muscular training is effective because it increases muscle strength and hence the extent of the mechanical stress transmitted by the muscle on the bone
- The bone sites react locally in response to mechanical stimulation whereas other distance sites do not significantly benefit from this osteoformation
- Both non-menopaused and postmenopausal women can take advantage of the beneficial effects of regular muscle exercise on bone density
- Training programmes can be effective at both prophylactic and therapeutic level
- In all cases, the benefits obtained are not acquired indefinitely. They will only continue if regular physical activity is maintained.

Among postmenopausal women, the recommendations listed in the literature suggest a physical activity consisting of 3 to 5 weekly sessions of 30 minutes at moderate intensity. The type of activity recommended is walking associated with strength training twice a week. Some particularly beneficial effects on body composition, the musculoskeletal system, physical fitness, carbohydrate and lipid profiles have been obtained with this type of programme.

Among non-menopaused women engaged in an intensive sports activity, luteal insufficiency and the anovulatory cycle are the most frequently encountered cycle disorders. However, most of these disorders are not diagnosed because of their asymptomatic character (they can only be diagnosed on plasma or urinary measurements of ovarian hormones). Among women who run regularly, the frequency of short luteal phase cycle disorders (cycle times <24 days) or oligomenorrhea (cycle times >35 days) ranges from 20% to 40% (or even 80%) depending on the authors, compared to 9% in the population of sedentary women. The frequency of amenorrhea is higher among women engaged in endurance sports (30%), in the so-called "aesthetic" sports (figure skating, gymnastics) (35%) and sports based on body weight (20%) for which the mechanical stress imposed by weight is a limit to performance. The frequency (around 12%) among women practising non-weight-dependent sports (swimming and cycling) is similar to that found in the general population. Thus, amenorrhea is more common with female sports practitioners for whom the control of body composition is a success factor, and who go on diets aiming to maintain a low body fat. However, the frequency of cycle disorders is not higher among women with an intensive sports activity (up to 12 to 18 hours of training per week) in the so-called technical sports (golf, diving, curling, riding, shooting) or ball sports. The frequency of the anovulatory cycles suggests a reduced average fertility among women practising sports.

The changes in ovarian function in women engaged in sports activity are of central origin (hypothalamic-pituitary) in connection with the energy metabolism and not with exercise stress (hyperthermia, repeated and prolonged secretion of cortisol, etc.). The cycle disorders result from a chronic mismatch between inadequate dietary intake and increased energy expenditure due to muscle exercise. Moreover, the involvement of nutritional factors in the pathophysiology of the hypoestrogenia of sportswomen is both quantitative and qualitative, with a global nutritional deficit in relation to energy expenditure (-700 to -1,000 kcal/day) and a qualitative deficit in lipid intake (12 to 15% of the daily food ration) in the sportswoman experiencing amenorrhea. It has been shown that prolonged muscle exercises or intense training situations rendering the energy balance negative will result in a decrease

in the plasma concentration of leptin. This hormonal evolution would seem to be one of the principal signals informing the body and particularly the central nervous system of an energy deficit. The administration of recombinant leptin for 3 months among sportswomen experiencing amenorrhea increases the concentration of the hypothalamic hormones controlling ovarian activity and improves the reproductive functions. Leptin, a marker of an adequate level of energy reserves, is therefore necessary for a normal reproduction function and neuroendocrine function.

Another consequence of the impact of intense physical training on the reproductive functions is delayed puberty. Some sports are more concerned than others, such as those requiring a mastery of body composition like dancing or gymnastics. In this case too, it is well established that this delay is linked to energy deficit.

Paradoxically, sportswomen experiencing amenorrhea have, as a result of the discontinuation of estrogen production, endothelial function disorders (endothelial inflammatory activation) and an atherogenous lipid profile.

This amenorrhea is accompanied by an extremely pejorative bone prognosis since the deficiency in estrogens induces a bone loss which is the same as that observed in menopaused women. In particular, this bone loss is at its highest during the first years following the installation of amenorrhea. It is therefore important to identify and treat it at an early stage. Cycle disorders that are less serious than amenorrhea (oligomenorrhea or even anovulation) also have osseous repercussions. There is a relation between the severity of the cycle disorders and osseous mineral density. Moreover, when regular cycles resume after several years of menstrual irregularities, bone density is not completely restored with women having a weight-based physical activity.

Physical activity of moderate intensity plays a very positive role in the health of the elderly

The regular practice of physical activity delays or slows down certain deleterious processes linked to ageing. This being so, it seems essential to maintain physical capacity in order to preserve autonomy and quality of life during the ageing process. While the functional limitations observed in the elderly can be reduced through the practice of a physical activity, this may not be enough to prevent disabilities.

The spiral of functional decline which takes root in the course of ageing is to a large extent the result of a gradually worsening muscle function characterised by reduced muscle mass or sarcopenia. The practice of a physical activity therefore helps to maintain the necessary muscle function for ensuring mobility with the elderly. However, the role played by physical activity in preserving mobility in elderly persons has been very little explored: it has been shown that a high level of physical activity in adults is associated with better mobility at a later age compared to less active people. In point of fact, muscle weakness is often associated with reduced mobility, an increased risk of disability and falls. This impairment of muscle function can potentially be reversed by following a programme of physical activity based on resistance or endurance exercises. It is today well established that muscle strength can be increased through training programmes, even at a very advanced age, with the same sort of gains as those observed with young adults.

Programmes combining balance, lower-limb muscle strengthening, suppleness and/or endurance exercises help to reduce the risk of falls in elderly persons. Several studies have shown an incidence of femoral neck fractures which is 20 to 40% lower in persons stating that they are physically active compared with sedentary subjects.

Physical activity acts not only on physical health but also on the mental health of old people by contributing to their well-being and quality of life. The beneficial effects of exercise programmes on the quality of life have been particularly observed in the physical sphere. Several studies show that physical activity has beneficial effects on cognitive decline. Indeed, in most of these studies, persons with physical training enjoy better cognitive performances than those without training, irrespective of the initial cognitive status.

Similarly, regular physical activity is considered to be a factor in the prevention of cognitive disorders. Improved oxygenation of the brain through regular physical activity has a conclusive effect on the elderly in terms of reactivity, memory and reasoning. Globally, the effect of physical activity on cognitive functioning is low but significant. Research on a large number of people emphasises the correlation between increased aerobic capacity and increased cognitive performance. Other possible explanations are the stimulation of the central nervous system, the improvement of the vascular and cardiac system and social stimulation. The most recent studies point to both short- and long-term effects, leading certain authors to consider physical activity as an element in the prevention of Alzheimer's disease, and more generally, as protection against the deficiencies linked to chronic diseases or ageing.

Even with people in fragile condition, physical activity can be of particular interest by virtue of its beneficial action on various parameters. Studies have in fact shown very significant gains in terms of mobility, balance, flexibility and muscle strength, and also with regard to falls and associated injuries, in this population.

On the strength of current knowledge, it is possible to make general recommendations for adults

The recommendations are designed to stand as benchmarks for the general public, for health professionals, for health policy decision-makers and for the bodies responsible for monitoring the state of public health. The recommendations concerning physical activity for the general population or for specific groups arise directly from knowledge on the dose-response relation, between a given volume of physical activity (the dose) and a physiological modification, making it possible to evaluate an effect on a health criterion (the response). The dose is usually defined by the intensity, frequency and duration per session of the activity, resulting in a total quantity of activity.

Before the 1980s, the recommendations were based on a "physical training - physical condition" model and were aimed primarily at improving cardiorespiratory capacity. The type of activity called for in this case was of relatively high intensity and based on the assessment of the maximum heart rate.

As from the mid 1990s, the recommendations have adhered more to a "physical activity - health condition" model and are focused on the physical activity necessary to reduce the risk of chronic disease in general and cardiovascular pathologies in particular. These recommendations are more pragmatic than the earlier set, and are clearly aimed at the general population and in particular, those that are inactive or only marginally active, with a view to promoting physical activity in the broadest sense.

In 1995, the US health monitoring authorities USA – the CDCs (Centers for Disease Control and Prevention) and the ACSM (American College of Sports Medicine) – published an initial recommendation which was included in the Surgeon General's report. People of all ages are ideally advised to incorporate a minimum of 30 minutes of physical activity of moderate intensity (such as brisk walking) every day of the week. It is also recognised that for most

people, the best health benefits can be obtained through a physical activity of higher intensity or longer duration. The American recommendations have been adopted by the World Health Organisation (WHO) and the International Federation of Sports Medicine (IFMS). It is worth noting the degree to which the recommendations for health promotion (Health-Enhancing Physical Activity, or HEPA) differ from earlier recommendations focused on cardiorespiratory capacity. Several points should be emphasised: the recommended intensity is deemed "moderate", e.g. brisk walking; the daily aspect of the activity; the concept of accumulated physical activity (the recommended duration of 30 minutes can be divided into 2 or 3 times 10 minutes); many everyday life or routine physical activities carried out in the workplace, at home or close to home, or while travelling should be taken into consideration.

In 2007, the American College of Sports Medicine (ACSM) and the American Heart Association AHA) jointly published an update of the recommendations on physical health activities for maintaining good health.

Adults aged 18 to 65 years: moderate-intensity aerobic (endurance) physical activity for a minimum of 30 minutes on five days each week, or vigorous-intensity aerobic physical activity for a minimum of 20 minutes on three days each week. Combinations of moderate- and vigorous-intensity activity can be performed to meet this recommendation. For example, a person can walk briskly for 30 minutes twice during the week and then jog for 20 minutes on two other days.

This update pinpoints certain recommendations compared to those drawn up in 1995:

- The frequency of the activities of moderate intensity is 5 times a week
- High-intensity activities are explicitly incorporated in the new recommendations. The physical activities of moderate and high intensity are considered as complementary in terms of benefit for health
- Activities of varying intensity may be combined in order to reach the recommended level
- The recommended quantity of aerobic-type physical activity should be added to the minimum everyday-life physical activities which are of low intensity or which last for less than 10 minutes. On the other hand, moderate-to-high everyday activities performed for 10 minutes or more non-stop are accumulated in order to reach the recommended level. This notion is very important, particularly in the interpretation of physical activity questionnaires, for example in population studies
- Supplementary health benefits in terms of health may be obtained by exceeding the minimum recommended level
- The minimum duration for a significant session is 10 minutes
- Endurance (or aerobic) activities are differentiated from strength training activities (against resistance) which are now part of the recommendations

There is still a need to find a better definition of the optimum combination of moderate and high-intensity activities, depending on the person (age, gender, physical ability, etc.), the activity practised or the result sought.

The inclusion of strength training exercises in the new recommendations reflects the data obtained in recent years showing the beneficial effects of this kind of exercise on muscle strength and endurance in middle-aged subjects, thus complementing the data already known for elderly persons. The new recommendations specify that these activities should be

performed on at least two, non-consecutive days each week, in the form of 8 to 10 exercises using the major muscle groups (with 8 to 12 repetitions of each exercise).

In line with the findings of other documents, it is stated that preventing weight gain (and the prevention of regaining weight after weight loss) in adults requires a level of physical activity of moderate intensity equivalent to respectively 45-60 minutes and 60-90 minutes per day. In the specific case of weight control, nutritional context must be taken into account in order to integrate the energy input and expenditure into the reasoning. It should also be noted that the minimum level of activity recommended, for example 30 minutes per day of activity of moderate intensity 5 days per week, is already likely to bring benefits, even among overweight subjects. Finally, the practice of even moderate physical activity can bring major health benefits among overweight people, regardless of the effects of the activity on the weight itself.

In the absence of properly conducted or sufficiently long prospective studies or randomised intervention studies, we do not possess sufficient data for children (unlike adults) to draw up a precise picture of the amount and kind of physical activity required to have a positive effect on the immediate and future health of young people.

It was originally suggested that the same recommendations as those for adults should be used, i.e. at least 30 minutes per day of moderate-intensity activity. However, the conclusions of recent consensus conferences all agree that this is probably not enough. A daily minimum of 60 (and not 30) minutes of physical activity of moderate-to-high intensity, in the form of sports, games or everyday activities, is desirable for children. Everyone should be involved in the promotion of a physically active lifestyle (family, physical education teachers, schools, medical and sports centres, local authorities, etc.). It should be noted that these recommendations are based on the concept of a minimum threshold or a set of supposedly optimal recommendations for health, a concept for which there is currently no epidemiological or experimental evidence for children.

In France, efforts to limit the sedentary nature of modern life and to promote a regular physical activity of moderate intensity are two of the main lines of action of the National Nutrition Health Programme (PNNS) introduced by the Ministry of Health in 2001, and integrated in the Law governing public health policy of 9 August 2004. Thus, the health authorities were anxious to include an encouragement to regular physical activity in the general population as part of the PNNS. The aim is to "increase the proportion of adults practising the equivalent of 30 minutes of brisk walking per day by 25%"; in addition, "the sedentary lifestyle should be combated from childhood since it is a risk factor"[18]. By the year 2008, the proportion of people, all ages taken into account, engaged in the equivalent of at least 30 minutes of physical activity of moderate intensity at least 5 times per week should rise from 60 to 75% (for men) and from 40 to 60% (for women).

In 2004, a national campaign was conducted in order to promote physical activity as part of the PNNS programme[19]. These actions complement the campaigns designed to encourage the practice of a sports activity ("sport for all") conducted by the Ministry of Youth, Sports and Community Development.

[18] www.sante.gouv.fr rubrique Nutrition

[19] www.mangerbouger.fr

Specific recommendations have been published for adults aged over 65 years and for patients suffering from chronic diseases over the age of 50 years

In the case of adults aged over 65 years and patients suffering from chronic diseases over the age of 50 years, specific recommendations in addition to those mentioned above were published and updated in 2007 by the aforementioned societies (American College of Sports Medicine (ACSM) and the American Heart Association (AHA).

The recommendations in terms of duration and frequency appear to be identical to those recommended for young adults: aerobic-type activities (endurance) of moderate intensity for a minimum of 30 minutes per day, 5 days per week, or of high intensive for 20 minutes per day, 3 days per week.

However, special emphasis is placed on two points. Firstly, the individualisation of the intensity of the physical activity is advocated by using a simple parameter: a visual analogue scale. On a scale running from 0 to 10, with the seated position corresponding to level 0 and an extreme exercise to level 10, a moderate activity corresponds to 5-6. This produces a clear increase in heart rate and ventilation. On the same scale, intense activity corresponds to a level of 7-8 and leads to a significant increase in heart rate and ventilation. Given the different levels of physical ability among the elderly, an activity of moderate intensity will correspond to standard walking for some people, while for others it will involve walking at a brisk pace.

Secondly, the emphasis is on diversification of activities: in addition to endurance (or aerobic exercise), strength training (activity against resistance), which is particularly important in the elderly or with pathological patients, should also be added, along with balance activities for maintaining flexibility and guarding against falls. Moderate and intense activities may be combined. However, these exercises are in addition to everyday-life activities or moderate-intensity exercises lasting less than 10 minutes (household chores, walking to the car park, shopping centre, etc.).

At least twice a week, on non-consecutive days, the elderly should engage in strength training exercises (resistance work) on the main muscle groups. These may include weight-lifting exercises. The intensity of the exercise may be modulated (considered as moderate or high) depending on the subject, using the aforementioned analogue scale. It is suggested that 8 to 10 muscle groups (forearms, arms, shoulders, right and left quadriceps, etc.) should be worked. Exercises should be repeated from 10 to 15 times for each muscle group.

In order to maintain the suppleness required for everyday activities, the elderly should engage in suppleness exercises (neck, shoulder, waist, hips, etc.) at least two days a week for at least 10 minutes. Balance exercises are recommended on 2 other days per week (walking along a line marked on the floor, stepping over blocks placed on this line, etc.) so as to reduce the risks of injuries from falls in the case of the most sedentary members of this age group, for example those with a chronic disease.

Because of the dose-response relationship between physical activity and health, elderly people wishing to improve their physical fitness and hence reduce the risk of chronic diseases, prevent overweight, etc. will derive benefit from a minimum increase in the previously described aerobic or strength training physical activity. Conversely, several months of activities at a level lower than that recommended may be appropriate for certain subjects who are particularly old or have a particularly low physical capacity. In all cases, the elderly should be encouraged to self-monitor their activities (for example, using the analogue scale) and to assess themselves regularly so as to reconsider their programme in the light of

changes in their physical capacity. In order to maintain their state of health, the elderly should maintain a physical activity throughout their lives.

Sedentary adults not suffering from chronic illnesses should follow a programme incorporating an incremental approach so as to gradually increase their level of physical activity over time.

Subjects aged over 50 years with a chronic illness (for which a physical activity is a therapy) must respect the precautions inherent in this disease (example of cardiovascular diseases). They should take the aforementioned recommendations into account and follow a programme of physical activity adapted to their illness, adjusting it over time according to the improvement or worsening of their condition.

Recommendations

What is physical activity? According to WHO, it is “any bodily movement produced by the skeletal muscles that results in energy expenditure above resting level”.

Is physical activity synonymous with sports activity? Physical and sports activities represent a continuum ranging from inactivity to at least moderate activity and the practice of high-intensity activities on a regular basis (as with high-level sports practitioners). According to WHO, sport is a “specialised and organised subset of physical activity”; it is an "activity in the form of exercises and/or competitions, facilitated by sports organisations". In other words, sport is the most sophisticated form of physical activity, but physical activity is not limited to sport: it also includes physical activity in everyday life, at home, at work, during travel and non-competitive leisure.

The objective of this collective expert report has been to review the concept of physical activity, its social dimension, its importance in terms of public health in the world today, and to answer questions arising on the environmental, social and psychological determinants of the practice of physical activity and the patterns of physiological and therapeutic actions of physical and sports activity. The methodology adopted in the expert report is based on the analysis of international scientific knowledge. The group of experts has focused on data drawn from rigorous studies, in most cases validated in terms of "evidence-based science".

The group of experts looked at the reality of the practice of physical activity in France, and has endeavoured to identify the obstacles standing in the way of its development, whether these be of an individual, sociological or environmental nature…

The group asked itself whether or not physical activity was an essential determinant of people’s state of health, irrespective of their age, and what its impact was on the somatic and psychic functions. Can regular physical activity reduce mortality, limit weight increase, prevent cardiovascular diseases, obesity and cancer, and preserve mental health and quality of life? Can physical activity form part of the treatment of a chronic illness?

Does physical activity always exert a favourable influence regardless of its intensity and volume? Or, as is often the case in other spheres, can excessive activity prove harmful?

Upon completion of the analysis and synthesis, the group of experts has proposed recommendations for different populations at the individual or collective level, for the attention of public health officials, policy makers, scientists and institutions.

Promoting physical activities for all and preventive programmes

Most adults, adolescents and children, in France as in Europe as a whole, do not practise the level of physical activity recommended for having an impact on health and quality of life. In the seven days preceding the 2005 Baromètre Santé survey, less than half of French people between the ages of 15 and 74 (45.7%) practised a physical activity at a health-enhancing level. According to the international HBSC survey[20] en 2001-2002, only 11% of 11-year-old girls and 25% of boys of the same age in France practise an activity conforming to the public health recommendations.

[20] Health Behaviour in School-aged Children

On the strength of this observation, traditional approaches to the promotion of physical activity based on changes in behaviour at the individual level seeking to develop physical activity during leisure time and to reinforce physical education at school will probably not be equal to the task. We must also act on environmental and socio-economic determinants which play a major role in shaping our lifestyles. Changing these determinants goes far beyond the sphere of influence and responsibility of the health sector. New partnerships must be involved in order to exert a direct influence on urban planning, transport, labour policies, education, housing, recreation and sports.

The recommendations must therefore reflect a clearly stated political commitment to a genuine national "Physical Activity and Health" programme. This programme must involve and harness the necessary means for its implementation. The promotion of physical activity for all must involve all age groups and be organised and coordinated right up to departmental and local levels. It should be broken down into different actions, the most important of which are set out below.

DISSEMINATING BROADLY THE CURRENT PHYSICAL ACTIVITY RECOMMENDATIONS FOR THE GENERAL PUBLIC

The public must first of all be kept informed of progress in our knowledge of the effects of physical activity on health, and of the international recommendations updated in the light of this progress.

In 2007, the public health recommendations defined at international level are as follows: for all adults aged from 18 to 65 years, it is recommended to maintain and improve health by practising at least 30 minutes of physical activity of moderate intensity (such as aerobics or endurance: for example intensity comparable to walking at a brisk pace) at least 5 days a week, or practising physical activity of high intensity for 20 minutes 3 days per week (such as aerobics or endurance: for example intensity comparable to jogging). For those over 65 years, brisk walking will be considered as high intensity and normal walking as moderate intensity. This volume of activity may be divided into periods of at least 10 minutes. It is also advisable to perform strength training exercises (against resistance or muscle training) on 2 non-consecutive days per week. With the elderly, exercises for maintaining muscle and joint suppleness are recommended, together with balance exercises for preventing falls. An activity started at any age is beneficial. The benefits of physical activity are not acquired once and for all but remain for as long as the physical activity is continued. Those who wish to further improve their physical capacity, reduce their risk of chronic disease and disability or prevent excessive weight gain can benefit by exceeding the minimum physical activity recommended.

With children and adolescents, the conclusions of recent consensus conferences all agree that a daily minimum of 60 minutes of physical activity of moderate-to-high intensity, in the form of sports, games or everyday activities, is desirable.

The group of experts recommends the organising of large-scale information campaigns on the strength of these physical activity recommendations for the population as a whole, by involving different media and carrying out an in-depth evaluation of the impact of these campaigns.

INCREASING AWARENESS AMONG DIFFERENT SECTIONS OF THE POPULATION, ACCORDING TO GENDER AND AGE, THROUGH INITIATIVES AT LOCAL LEVEL (HOME, PLACE OF WORK, ETC.)

The practice of leisure physical and sports activities varies according to age and sex: children, teenagers and young adults practise such activities more than their elders, and boys more than girls. Women more often indulge in sport for reasons of health or appearance whereas for men it is more a question of pleasure and competition. With adolescents, the three reasons most often mentioned for giving up a physical and sports activity are poor technique, the feeling of not being very proficient (especially for boys) and the constraints related to training (more for girls). As people get older, those that do practise a sport tend to do so more for reasons of health. Social support and sociability play an important role: the more other people in one's family circle, friends, etc. practise a physical and sports activity, the more likely one is to do so oneself.

Considered as behaviour, physical activity is notable for taking place in well-defined places or circumstances. The concept of micro-and macro-environment is thus very important in pinpointing the possible areas of intervention. Indeed, these interventions should be based on the dynamic interactions between individuals and their physical and socio-cultural environment.

Thus, the target audiences for awareness and mobilisation actions on the question of health through exercise are broken down according to age bracket and living environment: young children and adolescents at school and in extracurricular activities, adults at work, elderly people in their everyday life, etc.

The group of experts recommends promoting more fun-type physical activities in schools, especially for young children entering elementary school. It emphasises the need to make the National Education authorities aware of the importance of ensuring that all children "move about", including those with disabilities. These activities should be coupled with good education on the importance of a varied and balanced diet. In the case of adolescents, it recommends free access to extracurricular multi-sport activities.

The group of experts recommends urging companies to set aside areas for physical activities at the workplace during working hours. This implies the promotion of a corporate culture which integrates physical activity.

The group of experts recommends setting aside care centres for young children whose parents practise or would like to practise a physical activity in sports clubs.

The group of experts recommends adapting living areas and transport facilities to the needs of the elderly as a means of ensuring that they maintain a certain degree of autonomy.

TAKING ACCOUNT OF THE SPECIFIC SITUATIONS OF CERTAIN POPULATIONS IN ORDER TO TARGET INFORMATION AND ACTION CAMPAIGNS

Whether with respect to motivations or economic determining factors, the practice of a physical and sports activity is linked to the level of social inclusion. A low level of socialization leads to a reduced likelihood of practising a physical and sports activity.

The general population surveys in France bring out very clearly those sectors on whom information and awareness campaigns should be focused in the first instance: girls aged 12 to 17 years, particularly those from disadvantaged families, and people experiencing social integration difficulties (some housewives, single parents with children and job seekers), and more particularly those with a low educational and qualification level.

The group of experts recommends that the campaign initiators take account of special problems linked to integration difficulties or cultural differences in proposing physical activities. In this context, interventions to promote physical activity may be based on individual incentives for adopting new patterns of behaviour. Intra-personal factors such as attitudes, values, positive expectations, capabilities and skills can be marshalled in order to increase the level of physical activity, provided that they take into account the specific cultural populations considered.

The group of experts draws attention to those periods of life where there is a particular risk of discontinuing physical activity. These times correspond to changes in personal life such as the transition from high school to university, the loss of a job or end of a professional activity, moving house, etc. In addition, with very sedentary persons, the resumption of physical activity should be based on the recommendations developed by medical specialists.

Top-level sports practitioners or people engaged in intense physical activity should receive psychological assistance, especially during periods at risk (injuries, prolonged fatigue, diminished performance, etc.) and throughout sports careers dispensed by professionals (psychologists, psychiatrists, etc.).

ASSOCIATING DIFFERENT METHODS FOR INTRODUCING MEASURES TO COMBAT SEDENTARITY

The different studies examined show very clearly a greater effectiveness when awareness campaigns make allowances for the lifestyles and cultures of the persons concerned. For longstanding results it is therefore essential for these aspects to be taken into account.

As far as young people are concerned, the actions must involve both parents and their children. Everyone should be involved in the promotion of a physically active lifestyle (family, physical education teachers, schools, medical and sports centres, local authorities, healthcare professionals, etc.). The group of experts recommends that the family dimension be integrated in the information campaigns. Indeed, the practice of sport in a family setting (children, parents, grandparents) not only increases physical activity, it also encourages intergenerational contact and fosters accrued attention to the needs of each generation.

Awareness campaigns involving adults must be complemented by the introduction of individualised advice, whether through consulting on matters of prevention, programmes for launching or monitoring physical activity or medical care for specific health problems. The group of experts recommends integrating different methods of implementing awareness and intervention campaigns for specific populations: posters, correspondence, telephone calls, Internet, individualised contacts, etc.

This advice must take on board not only the culture of the persons concerned, but also the environment (security and availability of facilities) in which they live and the time at their disposal. Learning how to manage time and make use of the available facilities are the essential preconditions for ensuring the long-term practice of a physical activity. The advice must be pragmatic, concrete and feasible. Programmes already developed abroad may be used as a basis for designing and developing such projects.

The encouragement of regular physical activity in the general population is one of the pillars of the National Nutrition Health Programme (PNNS)[21] introduced by the Ministry of Health in 2001, and integrated in the Law governing public health policy of 9 August 2004. Between now and 2008, the objective is to increase the proportion of persons (from 60 to 75% for men and from 40 to 60% for women) practising the equivalent of at least 30 minutes of physical

[21] www.sante.gouv.fr rubrique Nutrition

activity of moderate intensity per day, 5 times per week. With overweight people, and quite apart from the effects on weight itself, the practice of a physical activity can bring major health benefits. Prevention of weight gain and of putting on weight again after an initial weight loss would necessitate, on the part of an adult, a level of physical activity of moderate intensity corresponding to 45-60 minutes per day and 60-90 minutes per day.

The group of experts recommends that the actions carried out within the framework of the PNNS should be coordinated with the campaigns designed to encourage the practice of a sports activity ("sport for all") conducted by the Ministry of Youth, Sports and Community Development.

RENDERING THE INSTITUTIONAL RELAYS OPERATIONAL AND REINFORCING MEANS

Some intervention strategies focus on changing individual behaviour, others relate to environmental changes (broadly defined). A large number of educational measures will prove ineffective in the absence of prior actions on the living environments of the persons concerned. Thus, for example, it makes no sense to promote walking unless safety is ensured. The challenge is therefore to find the dynamic between these two kinds of strategy.

The various actions may also be considered by sector (for example, the education sector in the broadest sense, the sports sector, the health sector, the transport sector, etc.) and by place (for example, school, company, all sports facilities, etc.). The aim is to promote communication between these different partners.

The promotion of physical activity becomes operational at local level, but the national approach is of great importance in marshalling political support and for coordinating campaigns and programmes. The purpose is to promote inspiring programmes for putting national policy into effect, with media relays and a reappropriation at local and even micro-local level. This proactive reappropriation is often on a community or association basis (federations, multisports and schools) with a view to developing an atmosphere of conviviality and recreational sociability.

This would be the whole point of mobilisation at interministerial level (so as not to upset separate spheres such as sport, health, national education, employment and social solidarity). Several partners may be evoked for this action.

The sports movement as a whole and the CNOSF (French National Olympic and Sports Committee) in particular have a part to play here. First, they must help to promote sport at competition level, to constitute and renew an elite representing France in major international events. Secondly, they must contribute to the promotion of sport for all. The delegated and single-sport federations have gradually become active in these two kinds of task; they will need to become more involved in physical activity/sport for all.

Multisport and similar federations are effective institutional relays; they are available for this action and possess a competent staff, as can be seen from the interest they have shown in questions of health through physical activity and the reception of young handicapped persons in the ordinary context of sports sociability, to take but two examples.

The National Education System is an important partner in encouraging the cooperation of the various actors of the school environment (school life, health personnel, natural sciences and sports teachers, etc.) engaged in health education information and development initiatives.

Such a programme must be expressed at regional, departmental and municipal (town and village) level. The network formed by a proper decentralisation of State services, with the

regional and departmental echelons of the Mouvement sportif and the local authorities must be in a position to ensure that these actions are sustainable and to provide support for them.

Local initiatives, at the level of municipalities, clubs or other associations, schools or even corporate clubs or works committees, proposed in line with ministerial encouragements, should be encouraged and supported.

The group of experts recommends that the national network of reference experts for the "Physical Activity and Health" programme should be reinforced. The département is the competent administrative unit for dealing with questions of socio-geographical equity, solidarity and social cohesion. Students in the "Adapted Physical Activity" and health sector receive training in the supervision of handicapped persons, the elderly (including those in retirement homes) and young social misfits in deprived areas, and would be fully capable of acting as instigators, instructors, resource providers and coordinators, in relation with healthcare professionals.

ADAPTING URBAN AREAS AND MEANS OF TRANSPORT TO PHYSICAL ACTIVITY FOR ALL

Urban density, the geographical distribution of services, traffic lanes reserved for pedestrians or cyclists all have an influence on physical exercise during travelling/commuting. The social representations associated with these aspects are also factors that should be taken into account in efforts to improve the situation. This approach is as yet little developed in France; it is nevertheless essential to the implementation of policies aimed at increasing physical activity practices integrated into daily life. Mayors and town councillors should be more actively involved in this action.

Making improvements to the environmental framework with a view to promoting physical activity involves, for example, the development of attractive and secure communication channels: landscaped pavements, walkways, bicycle paths (especially around schools), quality public lighting, street furniture, etc. The group of experts recommends that this aspect be included in the specifications of any urban renewal operation or in the construction of new housing units. Adequate solutions must also be considered for rural areas, which have their own special characteristics. Cooperation between different municipalities should seriously be considered for these matters.

The action programmes implemented, particularly in certain countries, generally comprise two dimensions: firstly, the promotion of regular and recreational physical and sports activities and/or, secondly, physical activities forming part of the daily routine of people's travel and commuting time and space, if necessary by accumulating several means of transport (on foot, on bicycle, by tram or commuter train, etc.). This is a multimodal conception of travel, involving voluntary physical activity. The group of experts recommends making changes to transport systems and the space-time of connections in favour of multimodal methods of travel (for example urban transport tickets valid for 1 hour and incorporating several different modes of travel) and safe parking facilities (for example, secure bicycle stations).

MAKING SPORTS AND HEALTH PROFESSIONALS MORE AWARE OF (AND GIVING THEM TRAINING IN) THE PREVENTIVE DIMENSION OF PHYSICAL ACTIVITY

The promotion of health through physical activity can be expressed through a wide range of interventions: organised activities such as physical education classes, activities in attractive

environments, advice and support, information campaigns and special events. The introduction of these measures calls for the training of the necessary personnel for such actions as well as mediators and instigators. The training must be characterised by a shared approach to the role of physical activity on health. Approved training programmes must be set up for trainers, health professionals and physical activity and sports professionals. This training must also concern early childhood specialists and teachers in junior and senior secondary schools.

The training of health professionals must emphasise physical activity as a tool in the prevention of the main chronic pathologies. For those involved in physical and sports activity, the accent should be put on the impact of physical activity on health (taking into account age, sex and handicap) and on the necessary prevention of accidents according to the type of sports activity.

The group of experts recommends that the information modules on the benefits of physical activity and the principles of how it should be introduced (individualised advice) should be incorporated in the initial and continuing training of these professionals.

At the same time, it is essential to distribute tools for measuring physical inactivity and sedentarity, so that professionals and users alike can assess the efforts that need to be deployed.

Lastly, improved communication and therefore coordination between the various professionals is essential. Health professionals can play a leading role in this process by fostering the dialogue between the sectors and partners involved and with a view to attracting the attention of new actors.

Promoting physical activity in patients suffering from chronic illnesses

Specific recommendations have been published for patients suffering from chronic illnesses. These recommendations in terms of duration and frequency appear to be identical to those recommended for healthy adults: aerobic-type activities (endurance) of moderate intensity for a minimum of 30 minutes per day, 5 days per week, or of high intensive for 20 minutes per day, 3 days per week. However, it is recommended to adapt the intensity of physical activity and to diversify activities. Moreover, the physical activity in question should be practised by respecting the rules of precaution inherent in each pathological situation (for example, type 2 diabetes, cardiovascular diseases, inflammatory attacks of rheumatism, evolution of neurological deficit); the activity should also evolve depending on whether the condition improves or worsens, particularly in the case of elderly persons.

Physical activity is a full-fledged treatment in the course of such chronic incapacitating affections as chronic obstructive pulmonary disease (COPD), ischemic cardiovascular diseases and metabolic diseases such as type 2 diabetes. It actually reduces the functional consequences of these diseases by improving the physical abilities of patients. In addition, it acts directly on the development of these diseases, resulting in a dramatic decrease in morbidity and cardiovascular mortality.

Physical activity contributes to the (additional) treatment of many other pathologies, and in particular neurological diseases (multiple sclerosis, hemiplegia, etc.) and rheumatic diseases (inflammatory diseases, arthrosis, etc.).

The development of a regular physical activity in the patient population emerges as a public health priority. The intervention programmes must be ambitious and focused on the long term, not overlooking any possible actions and harnessing the energies of a wide variety of

professionals and personnel working in the health, social and sports sectors. The economic benefit of such actions must be evaluated.

MAKING PATIENTS AWARE OF THE BENEFITS OF PHYSICAL ACTIVITY IN THE TREATMENT OF THEIR CONDITION

The notion of effort often arouses feelings of apprehension and anxiety in patients suffering from cardiovascular and respiratory illnesses. Indeed, it is during physical effort that fatigue and breathlessness occur most implicitly, and even the most feared painful phenomena such as angina or limping. Exercise is then perceived as a danger and patients find themselves caught in a spiral in which the induced hypoactivity serves to aggravate the deconditioning to effort and accentuates the clinical manifestations. In this way a cycle of auto-aggravation of the illness gradually sets in, thereby precipitating complications and resulting in an increase of morbidity/mortality. This is all the more frequent with elderly persons feeling themselves to be socially and culturally barred from a physical activity with connotations of sport, and often presenting deficiencies associated with the locomotive system (e.g. orthopedic or neurological deficits), and even visual or hearing disorders.

The group of experts recommends that repeated information and education campaigns should be aimed at patients and their family circle in order to combat this kind of image of physical activity. This educational effort must be adapted by emphasising the proven positive effects – reduction in the discomfort linked to deconditioning, greater autonomy and quality of life – associated with the recovery of a more rewarding image. The campaign should also bring out the decline in complications linked to the affection (and their repercussions in terms of medical treatment and hospitalisation), increased life expectancy, etc.

The group of experts stresses that the purpose is not to promote the same sports-type physical activity for all, but rather various physical activities adapted to each patient's abilities, the overall objective being to progress using the principles and methods of therapeutic education.

The group of experts also recommends that patients should be informed of the potential risks of physical activity at both cardiovascular and musculoskeletal level. In point of fact, the risks are limited when the activity is properly adapted. The usual signs of cardiovascular intolerance such as thoracic pains, epigastralgia, faintness, palpitations and unusual fatigue must be recognised and immediately give rise to a medical consultation. An additional safety measure would consist in educating as many people as possible in "life-saving acts" and an increasingly frequent installation of semi-automatic defibrillators in public places.

The group of experts recommends that a programme of physical activity should be proposed to each patient, taking into account his/her illnesses, the socio-professional and cultural context and the environmental conditions. Over and above this encouragement, support and re-motivation strategies for maintaining a regular physical activity should be introduced.

INFORMING AND TRAINING SPORTS AND HEALTH PROFESSIONALS REQUIRED TO IMPLEMENT TREATMENTS THROUGH PHYSICAL ACTIVITY

The beneficial effects demonstrated in many different patient populations are as yet imperfectly understood. The most clearly demonstrated effects concern the muscle metabolism, regulation of microcirculation, glycemic and lipid metabolism and neurohormonal abnormalities. These beneficial effects also explain the improved

cardiovascular-risk factors thanks to physical activity, first among which are high blood pressure and type-2 diabetes.

The group of experts recommends that students' medical studies should include a special module on physical activity in the management of chronic pathologies. It recommends that this question be addressed in professional training for general practitioners and specialists confronted on a daily basis with pathologies of the locomotive system and with the consequences of a sedentary lifestyle (rheumatologists, cardiologists, pneumologists, orthopedists, neurologists, geriatricians, physiotherapists, sports doctors).

Thanks to physical activity, the patient gains in terms of both duration and quality of life, with a significant reduction in the costs induced by the illness, linked to less recourse to hospitalisation and diagnostic and therapeutic technologies. Physical activity is thus an essential element in care depending on the evolution of the chronic pathology. The group of experts recommends having recourse to the Health Authority for defining, along with the professionals concerned, the place of physical activity in the "care package" as a whole.

Physical activity is also a key element in social and/or professional reintegration, and in the autonomy of patients with the most severe disabilities. The group of experts recommends the training of paramedical students (physiotherapists, occupational therapists, nurses, dieticians), candidates for the National Sports Instructor examination, and STAPS students (training centres for future instructors in sports and physical activity), on the benefits and modalities of physical activity in the course of chronic illnesses. The group stresses the importance of developing complementary teaching programmes (master's degrees, university diplomas, etc.) in this field.

Moreover, the group of experts emphasises the need for a regular promotion of first-aid training in cardiorespiratory resuscitation.

DEVELOPING NEW MEANS FOR THE ACCOMPANIMENT OF CARE

There are many places where a physical activity can be organised and perhaps supervised in the course of chronic illnesses: rehabilitation centres with units that can be specialised (cardiovascular, respiratory, neurological and orthopedic pathologies, obesity, diabetes, psychic disorders, addictive behaviour, etc.), physiotherapy practices, sports rooms, club and association premises, etc. The group of experts recommends drawing up a list of such places, and of defining the possibilities and arrangements for treatment and care by setting down levels of responsibility and competence (initial and continuing training).

In the context of the overall patient care system, the physical activity specialist (alongside the physiotherapist, the dietician, etc.) is assuming increasing importance. The group of experts recommends that this function should be recognised and specified. The details of care and treatment based on physical activity during chronic illnesses should give rise to financing procedures by the health insurance offices. In this context, the multidisciplinary networks and associations of patients must play a prominent role.

PROVIDING A CONSENSUAL DEFINITION OF THE PHYSICAL ACTIVITY MODALITIES TO BE SUBSEQUENTLY ADAPTED FOR EACH PATIENT

The modalities of physical activity are based on scientific knowledge which is as yet incomplete and on the consensuses reached by learned societies. Some aspects are still

poorly defined and leave much room for individual interpretation of the recommendations. Some general guidelines can nevertheless be set out.

The physical activity programme must be adapted to each patient in the light of his/her physical abilities and tastes, the type of pathology and its severity and the environmental conditions. The programme must seek the greatest possible efficacy in secondary prevention and in the improvement of physical abilities at the lowest possible risk.

Firstly, physical activity should not be confined to the organisation of specific exercises (e.g. gym exercises) but must be based on a different management of everyday activities, with the overall objective of making greater demands on the musculoskeletal system (moving about on foot or bicycle, taking the stairs instead of the lift, etc.). In the event of major motor incapacity, it is necessary whenever possible to help maintain autonomous walking by any therapeutic means (in particular rehabilitation and/or fitting with a prosthesis, etc.), avoiding as much as possible recourse to technical solutions such as electric wheelchairs.

Over and above these "everyday life" arrangements, the group of experts recommends daily physical training whenever possible for at least 30 minutes. If that is not possible, several short sequences can be spread over the course of the day so as to attain this minimum amount through accumulation.

The problem of the most appropriate intensity of effort has yet to be resolved. Violent efforts at close to maximum capacity should be prohibited insofar as they are most likely to cause the most serious cardiovascular complications (myocardial infarction, heart rhythm disturbances). At the other end of the scale, low-intensity exercises do not sufficiently solicit the cardiovascular, respiratory, metabolic and neurohormonal systems. A moderate or average level of intensity is usually recommended, resulting in a good implication of the muscle aerobic metabolism with the use of the fats and sugars available in the body. A balance is reached when the subject is able to negotiate his effort without difficulty and without excessive fatigue, maintaining easy breathing (that is to say speaking intelligibly while continuing his/her activity). The perception of the fatigue related to the exercise, the level of breathlessness and heart rate are the most readily accessible parameters.

The group of experts recommends a medical examination comprising in particular an evaluation of the adaptation to effort so that any contraindications to exercise can be eliminated and the practical details of the activity defined more efficiently. A session at a rehabilitation centre may also be necessary in order to begin the effort retraining in the best possible conditions. This rehabilitation should be proposed as a matter of priority to the most severely disabled persons.

DEFINING WITH THE PATIENT THE TYPES OF PHYSICAL ACTIVITY WHICH SUIT HIM/HER BEST

The very wide variety of exercises available is usually enough to cater for the many different situations and motivations encountered. Patients must be involved in drawing up their re-adaptation or re-education programme. In most cases global aerobic efforts (endurance) solicit considerable muscle volumes with optimum systemic effects. The easiest example to put into practice is walking (or road cycling). Here, it is easy to adjust the parameters in terms of speed, slope and duration. The use of various kinds of ergometers (treadmill, bicycle, rowing machine, stepper, etc.) is a good way of breaking free of environmental constraints and ensuring a regular and well-adjusted activity (e.g. the use of an upper-limb cycloergometer with a paraplegic patient). However, the choice of ergometer must allow for any locomotive handicaps (e.g. stepper and hip or knee pathologies, rowing machine and certain kinds of lumbago, etc.).

Each exercise must last long enough for efficient solicitation of the various effort adaptation systems. A minimum duration of 15 minutes is recommended, with the ultimate aim of reaching 20 to 30 minutes. It is best to allow 3 to 5 minutes for warming up and active recuperation so as to avoid sudden changes in heart rate, heart flow and blood pressure, and to limit manifestations of muscle intolerance with cramps.

Individual sports activity can represent a complement or even an alternative to the above. The same technical conditions should apply, with the addition of a recreational element (swimming, golf, Tai Chi, etc.). Competitive and collective sports where the level of effort is not controlled can only be authorised in rare cases under strict medical supervision, and depending on the pathology.

Resistance strength training, often referred to as "muscle training" can also be an interesting complement in that it potentiates the effects of global training while at the same time allowing for a variety of exercise types. Strength training is recommended at a frequency of 2 or even 3 sessions per week, with a solicitation of the muscle groups of the roots of the limbs: arm abductors and depressors, forearm flexors and extensors, hip and knee flexors and extensors, etc. Contractions of dynamic and concentric type (shortening of the muscle body) alternating with eccentric contractions (elongation) are especially useful, bearing in mind that static contractions (without varying the length of the muscle) increase the peripheral arterial resistances and reduce muscle oxygenation by diminishing the local flow and increasing the pressure within the muscle lodges.

The resistance to movement must promote the oxidative muscle metabolism while preventing tendino-muscle accidents, and should therefore lie between 50 and 60% of maximum strength. This presupposes that the maximum muscle strength has been previously evaluated or that adjustment is made during the repetition of movements (usually ten or twelve). This must be well tolerated while at the same time generating muscle work seen as effective by the patient. It should be noted that the effects of specifically isokinetic or eccentric exercises have not as yet been sufficiently demonstrated and their regular practice cannot therefore be recommended.

Gymnastic exercises represent an interesting complement to strength training, whether global or analytical. Beyond their muscle effects, they make it possible to improve coordination and balance, which is often useful with the elderly. In this sense, they are an essential means of preventing falls and thus injuries in old people. They often include muscle-stretching techniques (stretching, contracting-release, etc.) which, by reducing or preventing peri-articular stiffness, facilitate movements involving in particular the pelvic and scapular bones. This is a simple physical resource which could improve the functional status of patients with repercussions on autonomy in everyday life (walking, use of the upper limbs, dressing, washing, picking up things from the floor, etc.), and on comfort (pain control for patients suffering from rachialgia). These gymnastic movements are usually slow, punctuated by long and deep breathing. The most validated forms of exercise are those represented by certain types of Chinese gymnastics such as Tai Chi and Quigong. This is often associated with a form of relaxation, contributing to a feeling of well-being.

Physical activity is henceforth absolutely essential as adjuvant treatment in the course of most chronic diseases. The group of experts recommends a programme tailor-made to the needs of each patient for best results in both the evolution of these pathologies and in their functional consequences, while ensuring minimum risk.

Developing research work

Research programmes on physical activity and its effects on health remain little developed in France. Research laboratories should therefore be informed of the problem areas concerning physical activity, and the public authorities should be encouraged to launch calls for tender on specific subjects (such as those initiated by the National Research Agency) in order to make up for lost time.

PROMOTING LONGITUDINAL STUDIES INCLUDING VALIDATED MEASUREMENT TOOLS FOR PHYSICAL ACTIVITY AND ENVIRONMENTAL FACTORS

The quality of the measurement of physical activity is an essential prerequisite on which both the quality of the results obtained and the ensuing interpretations depend. Physical activity is a polymorphous notion: the greater and more varied the activity, the more complex and difficult its evaluation. Hence the importance of contributing to the development and validation of tools for measuring physical activity in the general population – tools which are able to take the different dimensions or contexts into account (leisure, work, domestic, transport) and to determine their respective impact. The group of experts recommends the combined use of declarative (questionnaires) and objective (movement meters) methods in order to collect all the parameters relating to physical activity within the framework of epidemiological studies in the general population or in specific groups.

While it is today generally recognised that physical activity is beneficial to health, it is still difficult to identify the predictive (individual, environmental, etc.) factors for maintaining this activity over the long term. Indeed, it is not only essential to encourage people to practise a physical activity but also, and above all, to ensure that this activity continues in time in order to obtain the expected benefits. It is therefore vital to conduct research in this area. Moreover, an individual's perception of his/her social or physical environment has an impact on his/her level of physical activity. Thus, to complete the instruments for measuring physical activity, the group of experts recommends the development and validation of tools for measuring the environmental factors associated with physical activity (objective and perceived factors).

In order to get a clearer picture of the relations between physical activity and health, it is necessary to set up longitudinal studies or controlled trials. It would therefore also be desirable for these measurements of physical activity and environment to be systematically included in existing or future cohort studies. The study of the relations between usual physical activity and environmental factors has received little attention in France. Taken together, these studies would help to show the influence of the practice of physical activity throughout life, or during specific periods of life, on state of health and quality of life. They would also contribute to the drawing up of recommendations on the practice of physical activities according to age and the physical capacities to be maintained or developed.

COORDINATING THE COLLECTION OF INFORMATION ON PHYSICAL ACTIVITIES AND EVALUATING PROMOTION ACTIONS

The data on the physical activity of people in France are both insufficient and very heterogeneous. The group of experts recommends that, in the first instance, an inventory of the data available for the practice of physical and sports activities should be carried out and a

coordination unit set up to monitor their evolution and to plan promotion actions for the physical activity concerned.

According to the surveys examined by the group of experts, the quality of the environment would appear to be an incentive for regular physical activity. Furthermore, certain analyses show that the sociological variables characterising individuals (e.g. level of studies, cultural level, etc.), tend to be more important than the contextual variable (the environment). Studies seeking to pinpoint the relations between the "constructed" environment and physical activity habits (at individual level) are still fairly recent and not very developed in France.

The group of experts recommends in-depth and detailed studies on the range of motivations concerning physical activities, particularly those that could occur in the context of daily travel. These studies will come in useful when implementing town and country planning strategies designed to facilitate physical activity on a daily basis.

In a systematic approach, the key question is not simply to understand the behavioural determinants of physical activity, but also the communication on the principles and mechanisms of the promotion of health through physical activity. The group of experts recommends studying the sequence of the different levels of health promotion through physical and sports activity, beginning with a process of implementing health programmes or policies and culminating in an effective modification of an individual's state of health. The group stresses the importance of evaluating the impact of the interventions and the implementation of the actions, not forgetting the evaluation of the cost-benefit ratio of these actions.

PROMOTING STUDIES IN HEALTH ECONOMICS AND SOCIOLOGY

Lack of physical activity emerges as one of the causes of the development of chronic pathologies. An evaluation of its cost to the French health system would reinforce interest in promoting physical activity in the prevention and treatment of such conditions. At the same time, it is essential to evaluate the cost/benefit ratio of the management of chronic pathologies through physical activity. The group of experts recommends that studies should be set up in health economics as a contribution to the validation of the different interventions in preventing and treating chronic diseases.

By the same token, more sociological research on the role of the patient in the prescription/follow-up system of physical activity appears crucial to optimum patient management.

REACHING A BETTER DEFINITION OF THE CHARACTERISTICS OF PHYSICAL ACTIVITY AND ENERGY EXPENDITURE IN PATIENTS, AND STUDYING THE MEDIUM- AND LONG-TERM EFFECTS

Since physical activity is an integral part of the care and management of many diseases (cardiovascular, endocrinal, respiratory, neurological, rheumatic, cancer, mental illnesses, etc.), it seems essential to evaluate specific protocols geared to the maintenance or development of strength or endurance (or even mixed protocols), which will necessarily differ depending on the disease. Such information is for the most part not forthcoming at the present time. The group of experts recommends arriving at a better definition of the characteristics of physical activity (intensity, frequency, etc.) so as to determine the effect (dose-response) on different populations at risk and depending on the type of pathology. It

recommends a study of the benefits versus the harmful effects depending on the intensity of physical activity, in different diseases.

However, it is difficult to evaluate the intensity of exercise during practice "on site". At the present time, the methods for evaluating the intensity of exercises are complex or have not been validated. The group of experts recommends the development of simplified but reproducible collection methods in order to assess energy expenditure. An initial study could involve the assessment of walking speed (and thus energy expenditure) through the use of GPS devices and the remote transmission of this information so as to provide improved monitoring of patients.

All patient care, in the context of the pathology, requires a perfect knowledge of this condition, and an appreciation of the limits of physical exercise as a consequence (e.g. any inflammatory attack, side effects of certain medicines). It is therefore essential, in the view of the group of experts, to set up protocols for monitoring these patients, so as to better appreciate the medium and long-term effects of physical activities, including training for expertise networks (doctors, paramedics, physical activity and sports specialists), so that they can regularly share their skills and improve the quality of patient care.

STUDYING PHYSICAL ACTIVITY PROTOCOLS ADAPTED TO CERTAIN POPULATIONS

At the time of writing, we lack precise protocols proposing a physical activity adapted to disabled persons (mental or motor disabilities) and corresponding to the wishes of patients. There is a need to study the impact of these protocols on the acquisition of skills (coordination, cognition, emotions, social development, etc.). It seems necessary to develop physical activity programmes with a diverse set of objectives (development of coordination, strength, endurance, autonomy etc.), and to apply them to targeted populations so as to reach an objective judgement of their effectiveness. The group of experts recommends that pilot experiments should be conducted comparing different protocols before proposing them to a large population.

In the same vein, the group of experts recommends the introduction of protocols for monitoring patients with psychiatric disorders, people living on their own and certain older persons subject to psycho-sociological difficulties (physical activity programmes are often abandoned very quickly as a result of lack of supervision and motivation).

STUDYING PROGRAMMES FOR PREVENTING ACCIDENTS AND DAMAGE TO HEALTH

Some sports and even leisure activities increase the likelihood of injury which, in some cases, is not without repercussions on costs, in terms of health economics. This is particularly the case with the (very frequent) ruptures of the anterior-cruciate external ligament, especially in women. There is therefore a pressing need to propose programmes which have already proved their worth on targeted populations and sports for preventing such accidents in young adults, and to extend them to other sports. The aim is twofold: firstly, to reduce the number of surgical operations and days away from work, and secondly to restrict the incidence of osteoarthritis of the knee in the medium and long terms.

The intensive practice of sport may lead to addictive behaviour, with consequences that are both psychological (exclusive personal investment in training to the detriment of family and professional life, increased tolerance vis-à-vis the exercise, irrepressible pursuit of the activity with denial in the case of injury or disease, obsessive monitoring of weight) and

somatic (fatigue, depressive syndrome, sleeping disorders) in nature, particularly sensitive to the discontinuation of the activity and constituting a veritable withdrawal syndrome. The group of experts recommends the conducting of studies in this field, with a view to finding vulnerable populations and training intensities likely to provoke such disorders according to the subjects' age, gender and type of physical activity.

The group recommends that studies should be continued on the mechanisms governing addiction to physical activity. Are these mechanisms the same as for addiction to substances?

DEVELOPING RESEARCH ON THE EFFECT OF PHYSICAL ACTIVITY ON METABOLIC DISEASES

It has been clearly shown that the level of physical activity exercises an influence on the prevalence of metabolic diseases (obesity, type 2 diabetes and metabolic syndrome). The mechanisms involved are partially elucidated, the most clearly established facts focusing on improved sensitivity to insulin. However, there are still many questions concerning the interactions between the physiology of the adipose tissue, response to training and risk factors. Excessive weight on its own does not explain all the cardiovascular risk linked to obesity, and physical exercise seems to exercise a protective effect which goes beyond the action on the reduction of the fatty mass. This point can be illustrated by emphasising the emergence of a recent concept attributing a role to the adipose tissue on the production of an inflammatory state by means of different cytokines. This state would appear to be partly responsible for the risk factors. The group of experts recommends the continuation of studies seeking to understand the causal links between obesity, the sedentary state and the risk factors, with for corollary the limits of efficacy in the increase of the level of physical activity, and the level of response.

More generally, the adipocyte is increasingly considered as a cell secreting messengers and thus fulfilling a virtually endocrinal function. The role of physical activity on this function would repay study.

DEVELOPING STUDIES ON THE EFFECT OF PHYSICAL ACTIVITY ON THE PREVENTION OF HEART STUDIES

Numerous works have shown that physical exercise reduces cardiac morbidity and mortality thanks to an action on risk factors such as lipid profile, blood pressure, coagulation and physiology of the blood vessel walls (endothelium). In addition to these actions, physical training ensures a specific cardioprotection against the cardiac damage of the episodes of reperfusion ischemia observed during coronary disease. To advance the understanding and treatment of cardiac injuries resulting from cardiac episodes of reperfusion ischemia, research is needed in the area of the specific cardioprotective effect of physical training. This research should focus on the action of physical training on the functions of cardiac mitochondria and protection against the production of free radicals. Physical training also seems to reduce apoptosis of the heart cells by poorly understood mechanisms that would repay further investigation. In addition, it has been suggested that the signalling phenomena starting from the sarcolemma are modified by muscle exercise. The group of experts recommends the promotion of work on these different avenues of approach as a means of progress in the care of cardiac damage induced by ischemia.

DEVELOPING RESEARCH ON THE MECHANISMS LINKED TO CANCER

What are the mechanisms behind the protective effect of regular physical activity in the primary prevention of cancer? And in secondary prevention? And on the tolerance to treatment (mechanisms of the effect of regular physical activity on reducing fatigue)? It has been clearly demonstrated that physical exercise acts on a set of hormonal axes involved in the mechanisms of cancer such as the steroid hormones or the somatomedin axis. On the other hand, there is a need to specify the relations between these changes and the proteins acting on growth and cell differentiation such as p53. The group of experts recommends more detailed study of the mechanisms likely to be involved in the preventive and curative effect of physical activity (in association with treatment) on certain cancers.

DEVELOP RESEARCH IN RELATION WITH AGING AND SARCOPENIA

The ageing process is expressed in an overall decrease of physical fitness at metabolic and cardiovascular level and with respect to the contractile function of the muscles. It is now clearly shown that physical training can reduce this decline by acting on endurance capacities and muscle strength. In addition, the molecular determinants of the response of the skeletal and myocardial muscle to physical training are the subject of numerous studies helping to establish a hierarchy of the response mechanisms to endurance or strength training. On the one hand, endurance training increases muscle oxidative capacity, and on the other, strength training results in a stimulation of the molecular mechanisms of muscle growth. Recent data show that these two channels of response to training can either cooperate with each other or inhibit each other. A knowledge of these mechanisms specifies the best association between training in endurance or strength for optimum results in terms of muscle functions. The study of the molecular mechanisms of response to different types of training is required during the ageing process in order to clarify the nature of the most effective training plans. One of the most harmful consequences of ageing for the locomotive functions is muscular atrophy. The mechanisms involved in the prevention of muscle atrophy by physical training are incompletely known. The group of experts recommends specifying the relationship between the degradation and the regeneration (or even neosynthesis) channels of the muscle fibres. This type of study must be conducted for the different stages of ageing, by associating the parameters of intake of nutrition to the various forms of physical training.

DEVELOPING RESEARCH ON THE MECHANISMS OF ACTION OF PHYSICAL ACTIVITY ON CEREBRAL FUNCTIONS AND MENTAL HEALTH

It has been shown that physical activity influences synaptic plasticity and neurogenesis. An action on the different neuromediators involved in the regulation of behaviour has also been established. Lastly, it has been shown that physical exercise increases the cerebral blood flow. On the other hand, the functional link between these different functions of brain functioning and the preventive action on certain mental pathologies such as depression or the cognitive pathologies of ageing has not been established. A knowledge of these relationships would make it possible to specify the most efficient physical training for each type of prevention. Among the research projects for the prevention of diseases in the behavioural sphere, we may also include studies on the relationships between physical activity and the biological mechanisms of sleep and the nycthemeral rhythms. Physical activity acts as a powerful synchroniser of the biological rhythms with numerous

consequences on behaviours. The mechanisms at molecular level are still poorly understood and further studies are required in order to draw up recommendations in the field of mental health.

PROPOSING STUDIES ON THE ROLE OF THE SUPPORT TISSUES ON THE ENERGY METABOLISM

It seems necessary to prepare a report on the existence of a dose effect and the existence of a threshold effect on the mechanisms of the biological response to regular physical activity of the support tissues, bone and muscle, in relation to the systems regulating energy flow. The support tissues record the level of the mechanical and metabolic constraints by means of specific receptors. It has recently been shown that the bone can regulate the energy metabolism through the osteocalcin. This mediator of the bone metabolism, which reacts to mechanical constraints, is able to reduce lipogenesis and regulate the glucose metabolism by acting on the secretion of insulin and adiponectin. In addition, it has been demonstrated that physical training acts on osteocalcin. It therefore seems logical to propose studying the action of the mechanical stresses sustained by the bone on the regulation of the metabolism in response to training. Furthermore, since the level of development of the support tissues reflects all the constraints imposed by physical exercise, it is legitimate to think that there is a functional link between the development of the structures and their energy supply. The group of experts recommends searching for deeper knowledge of these mechanisms, making it possible to specify the type of physical activities providing the best development of the support structures for the best adaptation of energy.

STUDYING THE PREDICTIBILITY OF BIOLOGICAL RESPONSE

The results of several studies show that the response to physical training in general is influenced by genetic inheritance. Moreover, it seems that the response to a specific type of activity can modulate the expression of genotype predisposing to pathological factors. This type of effect has been considered only for a limited number of interactions between type of physical training and risk factors. For example, mention may be made of the protective effects of endurance training on the risk of developing high blood pressure, whereas training in strength/speed activities does not seem to have the same impact. On the strength of the well-established epidemiological data, the group of experts recommends studying the mechanisms of action and the predictability of the response to a given type of training.

Appendix

Inserm collective expert review

Methodology

An Inserm collective expert review[22] sheds scientific light on a given subject in the field of health on the basis of a critical analysis and synthesis of the international scientific literature. The expert reviews are implemented at the request of institutions wishing for access to recent research data pertinent to their decision-making process with respect to public policy. An Inserm collective expert review is to be considered as an initial stage that is necessary but most frequently not sufficient to result in decision-making. The conclusions of the collective expert review contribute to, but cannot replace, debate between the professionals involved or society debate if the questions addressed are particularly complex and sensitive.

At the request of an institution, the Inserm collective expert review may be accompanied by an 'operational' expert review addressing application of the knowledge and recommendations and taking into account contextual factors (existing programs, structures, players, training, etc.). The latter type of expert review elicits contributions from the players in the field able to respond to the feasibility aspects, representatives of the administrations or institutions responsible for promoting applications in the field involved, experts having contributed to the reviews, and representatives of patient associations. The sharing of varied cultures and experience enables a complementary approach to the collective expert review in an operational framework. Moreover, a variety of work (recommendations for good practices, public hearings, etc.) implemented under the auspices of the High Authority for Health (HAS) may follow an Inserm collective expert review.

Collective expert review has been an Inserm mission since 1994. Some sixty collective expert reviews have been implemented in numerous health fields. The Institute guarantees the conditions under which the expert review is implemented (exhaustiveness of the document sources, qualification and independence of the experts, transparency of the process).

The Inserm Center for Collective Expert Reviews organizes the various stages of collective expert review from the initial problem statement through to communication of the report, with the assistance of Inserm departments. The Center team, consisting of engineers, researchers and a secretariat, implements the document searches, logistics and chairing of the expert review meetings. The team contributes to the scientific writing and to compiling the expert review products. Regular exchanges with other public organizations (EPST) implementing the same type of collective expert review have enabled similar procedures to be set up.

Problem statement

The problem statement phase enables definition of the institution's request, checking that accessible scientific literature on the issue raised is available and drawing up specifications which state the framework of the expert review (status report on the perimeter and main themes of the subject), its duration and budget, documented by a convention signed by the sponsor and Inserm.

[22] Inserm accredited label

During the problem statement phase, Inserm also organizes meetings with patient associations in order to ascertain the questions those associations wish to have addressed and the data sources available to them. The information is incorporated in the scientific program of the expert review. For certain subjects, exchanges with industrial partners are indispensable in order to obtain access to complementary data not available in the databases.

Expert review monitoring committee and assistance unit setup

A monitoring committee consisting of the institution and Inserm representatives is set up. The committee meets several times during the expert review to monitor the progress of the review, discuss any difficulties encountered in addressing the issues, ensure compliance with the specifications and examine any new factors in the regulatory and political context pertinent to the ongoing review. The committee also meets at the end of the expert review for presentation of the conclusions and prior to compilation of the final version of the report.

For expert reviews addressing sensitive issues, an assistance unit is also set up and consists in representatives of the Directorate General of Inserm, scientific board, ethical committee of Inserm, communication department, human and social science researchers and specialists in the history of science. The role of that unit is to identify, at the start of the expert review, the issues liable to have strong resonance for the professionals involved and civil society, and to suggest hearings of professionals in related fields, representatives of civil society and patient associations. In short, the unit is responsible for measuring the perception that the various recipients may have of the expert review. Before publication of the expert review report, the assistance unit pays special attention to the wording of the synthesis and recommendations, including, if necessary, the expression of the various points of view. Downstream of the expert review, the unit is responsible for strengthening and enhancing the circulation of the results of the expert review, for instance by holding colloquia or seminars with the professionals of the field and players involved or holding public debates with representatives of civil society. Those exchanges are to ensure enhanced understanding and adoption of the knowledge generated by the expert review.

Literature searching

The specifications drawn up with the institution are translated into an exhaustive list of scientific questions reflecting the perimeter of the expert review with the assistance of referral scientists in the field and members of Inserm. The scientific questions enable identification of the disciplines involved and construction of a key-word arborescence employed in the systematic searching of international biomedical databases. The articles and documents selected on the basis of their pertinence with respect to answering the scientific questions constitute the document base, which is forwarded to the experts. Each member of the group is asked to add to the document base over the course of the expert review.

Institutional reports (parliamentary, European, international, etc.), raw statistical data, associations' publications and other documents from the gray literature are also inventoried (non-exhaustive) in order to complement the academic publications provided to the experts. The experts are responsible for taking or not taking into account those sources depending on the interest and the quality of the information supplied. Lastly, a review of the main articles in the French press is supplied to the experts during the expert review in order to enable them to follow developments on the theme and the social repercussions.

Constitution of the expert group

The expert group is formed on the basis of the scientific skills necessary for analysis of the bibliography collected and on the basis of the complementarity of the group members' approaches. Since an Inserm collective expert review is defined as a critical analysis of the academic knowledge available, the choice of the experts is based on their scientific skills certified by publications in peer-review journals and their recognition by their peers. The expert recruitment logic, based on scientific skills and not on knowledge in the field, is to be stressed in that it is a frequent source of misunderstandings when the expert reviews are published.

The experts are selected from the French and international scientific community. They are to be independent of the partner sponsoring the expert review and recognized pressure groups. The composition of the expert group is validated by the Directorate General of Inserm.

Several scientists outside of the group may be requested to contribute occasionally to a particular theme during the expert review.

Expert review implementation lasts between 12 and 18 months, depending on the volume of literature to be reviewed and analyzed and the complexity of the subject.

Initial expert group meeting

Before the first meeting, the experts receive a document explaining their mission, the scientific program (issues to be addressed), schedule, the expert review bibliographic database to date and articles more specifically addressing certain experts on the basis of the skills.

During the first meeting, the expert group discusses the list of issues to be reviewed and completes or modifies it. The group also examines the document base and proposes supplementary searches with a view to enriching that base.

Expert critical analysis of the literature

During the meetings, each expert orally presents a critical analysis of the literature with respect to the aspect allocated to the expert in his/her field of expertise and communicates the accepted facts, uncertainties and controversies with respect to current knowledge. The questions, remarks and points of convergence or divergence elicited by the group analysis are taken into consideration in the section that each of the experts compiles. The analysis report, consisting of various sections, thus constitutes the state of the art for the various disciplines pertinent to the issue under review. The bibliographic references used by the expert are cited in and at the end of each section.

Synthesis and recommendations

The synthesis summarizes the broad lines of the literature analysis and identifies the main findings and principles. Contributions from contributors outside the group may be summarized in the synthesis.

The synthesis is more specifically intended for the institution and decision-makers with a view to use of the knowledge presented therein. The wording of the synthesis is to take into account the fact that it will be read by non-scientists.

As of report publication, the synthesis is posted on Inserm's website. The synthesis is translated into English and posted on the NCBI/NLM site (National Center for

Biotechnology Information of the National Library of Medicine) and Sinapse site (Scientific INformAtion for Policy Support in Europe, European Commission site).

If requested by the institution, certain collective expert reviews include 'recommendations'. Two types of 'recommendations' are formulated by the experts group. 'Principles for action' based on a validated scientific reference system with a view to defining future public health action (mainly in screening, prevention and management) but which are not under any circumstances to be considered 'operational' recommendations insofar as no economic or political components have been taken into account in the scientific analysis. 'Research orientations' are also proposed by the experts group with a view to filling in the gaps in scientific knowledge observed during the analysis. Once again, these proposals cannot be considered 'priority' research without their being put into perspective. That is the task of the pertinent authorities.

Critical review of the report and synthesis by prominent 'readers'

For certain expert reviews addressing sensitive subjects, a critical reading memorandum is requested from several prominent 'readers' selected on the basis of the scientific or medical knowledge and managing or evaluating French or European research programs or having contributed to ministerial working groups. Similarly, the report and synthesis (and recommendations) may be submitted to figures with good knowledge of the 'field' and able to grasp the socioeconomic and political issues associated with the knowledge (and proposals) presented in the expert review.

Presentation of the conclusions of the expert review and debate

A seminar open to the various sectors involved in the subject of the expert review (patient associations, professional associations, unions, institutions, etc.) enables an initial debate on the conclusions of the expert review. On the basis of that exchange, the final version of the synthesis document incorporating the various viewpoints expressed is compiled.