THE OFFICE SUMMARIES

THE PARLIAMENTARY OFFICE FOR SCIENTIFIC AND TECHNOLOGICAL ASSESSMENT

November 2025

Science in the fray for a sporting nation

A legacy of the Paris 2024 Games to be preserved

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Sport is at the heart of many issues: economic, financial, political and power issues, but also human and public health issues.

Science and technology are increasingly being used to optimise athletes' performance and influence competition results. However, their use also has adverse effects, such as increasing inequalities between athletes, the technologisation of performance to the detriment of athletes' health, the risks associated with doping, and the quest for "enhanced humans". Besides, research conducted for high-level sport has significant and positive impacts in the fields of medicine, equipment for people with disabilities and leisure activities.

Although there is now broad scientific consensus on the benefits of physical activity for human health, the physical condition of the French population continues to deteriorate. This major public health problem requires the implementation of appropriate, effective and sustainable interventions.

The Office's report analyses the repercussion of science and technology on both high-level sport and physical activity. It makes recommendations to strengthen scientific support for sporting performance and activity in the long term and to make France a sporting nation, not just a nation of sportspeople.

David ROS, Senator

Science and technology have a considerable impact on the performance factors of high-level athletes, even if their use is not without adverse effects.

❖ The major role of science and technology in improving materials and equipment

➢ Lighter and stronger materials

For example, over the course of a century, Tour de France bikes have gone from steel models weighing nearly 15 kg to models weighing 6.8 kg (the minimum weight imposed by the International Cycling Union) made from carbon, aluminium alloys or new materials such as titanium.

➢ Aerodynamic and hydrodynamic equipment

The focus on the aerodynamics and hydrodynamics of equipment aims to reduce air or water resistance and increase speed.

Foils have been added under the boats to allow the hull to rise out of the water and significantly reduce wave drag and friction drag, enabling much higher speeds than with conventional boats.

➢ Safer and more comfortable equipment

The safety and comfort of athletes is another major area of innovation. Gymnastics mats have been designed to absorb shocks and prevent injuries. Replacing the vaulting horse with the vaulting table has significantly reduced accidents. In football and rugby, the emergence of hybrid pitches, combining synthetic fibres and natural grass, has resulted in more stable, safer and more comfortable surfaces. Finally, the focus on thermoregulatory textiles and customised footwear and soles illustrates the constant quest for athlete well-being.

➢ Characterising materials to improve performance

Scientific research does not just invent new materials: it also characterises the performance of equipment and refines its settings.

For the 2024 Paralympic Games, for example, a CIFRE thesis was devoted to optimising the choice and adjustments of wheelchairs used on clay courts in order to minimise resistance and facilitate player movement.

➢ **Customised equipment for parasports athletes**

The aim is to meet the specific needs of each athlete, taking into account their physical characteristics, body type, injury history and the demands of their sport. For example, wheelchairs used for wheelchair rugby are designed for manoeuvrability, while fencing wheelchairs are characterised by their stability.

❖ Science and technology at the service of identifying high potential

➢ **Existing biases in identifying high potential**

According to a literature review of 189 studies, 89.2% of high-level junior athletes do not maintain this level as adults. Conversely, not all elite adult athletes were identified as such during their teenage years. Only 29% of current players in the French rugby team had followed the traditional path through academies from the age of 15.

Science has highlighted the biases in selection:

- excessive focus by selectors on the relative age[1] of young athletes, which leads to favouring those born at the beginning of the year;
- insufficient consideration of biological age;
- a lack of knowledge of the athlete's history of practice and training, which regularly leads to the selection of those with the most hours of practice in the youth categories, even though early specialisation can lead young athletes to acquire very specific motor skills to the detriment of their overall development and confront them with a skills barrier that will make it more difficult for them to progress to higher levels.

➢ **The development of performance corridors**

Science shows that raw performance is of little relevance when assessing the potential of young athletes and that it is necessary to focus on the kinetics of progress.

Tools such as "performance corridors", which compare individual trajectories with the careers of the world's best athletes, make it possible to assess a young athlete's progress.

➢ **The added value of field experts**

Field experts, particularly coaches, remain indispensable despite the growing use of data to assess athletes' potential. Their ability to analyse psychological, social and cognitive qualities usefully complements scientific data. The combination of human expertise and technological analysis currently seems to be the best way to identify high-potential athletes.

❖ The importance of science and technology in athlete preparation

Athlete preparation is essential for improving performance, reducing the risk of injury and maintaining performance levels over time. It benefits greatly from the contributions of sports science.

➢ **Many sciences at the service of performance**

Biomechanics provides the scientific principles for understanding how movements are generated and optimised.

Exercise physiology studies how the human body adapts to physical exertion, with a particular focus on the cardiovascular, respiratory and muscular systems, as well as energy metabolism.

Motor skills and neuroscience are closely linked, as movement is controlled by the central nervous system, which includes the brain and spinal cord. Thanks to research on motor control, brain plasticity, proprioception and motor learning, neuroscience contributes to our understanding of the complexity of motor skills.

Other sciences play an important role in the preparation of athletes, such as psychology, which provides the scientific basis for mental preparation, and sociology, which provides a better understanding of the social and cultural factors that influence performance.

➢ **Scientific support for physical training**

Training programmes rely heavily on sports science to:

- characterise the discipline and assess the qualities required to excel in the sport in question;
- analyse the athlete's physical abilities (endurance, speed, strength, power) using biomarkers (muscle activity, maximum oxygen consumption, *etc.*);
- individualise and monitor physical preparation.

➢ **Adaptation to environmental factors**

The external environment can have a significant impact not only on performance, but also on the health of athletes. In order to adapt athletes to these environmental factors, hypoxia or climate chambers, which simulate altitude or heat conditions respectively, are used to improve their endurance and physical capacity.

➢ **Fatigue management**

Both physical and mental fatigue have a detrimental impact on performance and even on the athlete's health. Managing fatigue has therefore become a priority. It is based on both subjective measures (daily questionnaires on mood, sleep, pain) and objective measures (heart rate variability, electromyography, MRI). This monitoring allows training to be adapted in real time and prevents overtraining. Science has highlighted the fundamental role of recovery in combating fatigue.

[1] Which refers to the month of birth for individuals in the same age group.

Nutrition and sleep play a key role in recovery. However, between 49% and 64% of elite athletes suffer from sleep disorders, hence the importance of a research project such as D-Day[1] focusing on recovery methods that impact sleep quality and quantity.

Research is underway to try to explain the phenomenon of fatigue through brain biology, with the aim of identifying metabolic targets that cause brain fatigue and thus developing drug interventions for this type of syndrome.

➢ **Injury prevention**

This is crucial for athletes, but also for professional federations and clubs. Artificial intelligence could play an increasing role in preventing the risk of injury in athletes by anticipating the risks associated with muscle fatigue, postural imbalances or excessive training loads.

However, two conditions, concussions and exercise-induced heatstroke, are still insufficiently prevented and managed, both in high-level and amateur sport.

➢ **The growing role of mental preparation**

Long underestimated in France, mental preparation plays an essential role in athletes' performance.

Individual mental preparation aims to develop mental skills in athletes to regulate their thoughts, emotions and behaviours in order to better cope with pressure and overcome certain mental blocks that can affect their physical performance or prevent them from progressing.

Collective mental preparation aims to optimise group dynamics in order to improve team performance.

➢ **Technology at the service of tactical and technical preparation**

Technology has revolutionised athletes' tactical and technical preparation. Increasingly sophisticated motion capture systems have been developed to enable athletes to analyse their movements more effectively and adjust their posture for greater motor efficiency.

Preparation for sporting events has taken centre stage in the lives of athletes. Video analysis combined with AI has become an indispensable tool both before matches and during competitions – to provide strategic recommendations – and after matches, to assess players' performances.

❖ The harmful effects of the 'technologisation' of performance in sport

➢ **The reinforcement of inequalities**

The rise of science in performance support is exacerbating inequalities:

- between nations and clubs: only the big clubs, the most developed nations and well-funded organisations can benefit from the most advanced innovations;
- between men and women[2] , even though women's physiological characteristics have an impact on their performance.

➢ **Increased monitoring of athletes**

Scientific performance support leads to increased monitoring of athletes and psychological pressure. The data collected throughout the day provides important information about athletes' physical condition, performance and even health. They may feel constantly monitored, especially as their consent to this data collection may be biased, particularly due to competition between athletes and their dependence on federations, clubs or sponsors.

Data collection also raises the question of data storage in a sovereign context, as most of the companies that process and store data are American or Australian.

➢ **Is the technologisation of performance detrimental to athletes' health?**

By helping to push human physical and psychological boundaries, science can be accused of contributing to the development of "spectator sport" at the expense of athletes' health. The changes made possible by science in physical training and nutrition have led to a significant physical transformation in athletes. Rugby players, for example, have become taller and heavier. Changes in body type increase the intensity of collisions and lead to a high incidence of injuries.

The hopes placed in science to prevent and better treat injuries could therefore lead the world of sport to exempt itself from reflecting on the evolution of practices and, in the case of rugby in particular, on the fact that the human body is not designed to withstand such impacts.

➢ **The drift towards doping and human enhancement**

The line between technological innovation and doping is often blurred, and innovations are regularly accompanied by controversy, as was the case with polyurethane swimming suits in 2008 and carbon fibre running shoes in 2016.

The fight against doping led by the World Anti-Doping Agency and national agencies does not prevent the development of new forms of doping (genetic doping, brain doping).

Furthermore, humans are always seeking to exceed their limits, and this ability of healthy human beings to improve themselves has been greatly enhanced by advances in medicine, surgery and pharmacy. The blurring of the boundaries between therapeutic medicine and enhancement medicine is leading some to defend the concept of the 'augmented' human and the organisation of 'augmented' competitions that would allow doping in order to enable athletes to exceed their own limits.

[1] Funded as part of the priority research programme "High-performance sport".
[2] Over the last five years, 9% of studies focused exclusively on women, compared to 71% that focused exclusively on men.

Doping would then be considered as just one technique among others for increasing or highlighting the differences that are decisive in a given competition.

➢ **The development of pseudo-scientific practices**

Physical and mental preparation are key factors in improving athletes' performance. However, in the absence of regulation of sports coaching professions, these sectors have seen the emergence of numerous pseudo-scientific practices that often amount to quackery and can pose risks to athletes and coaches.

The strategy adopted by France in the run-up to the Games has encouraged the scientific optimisation of performance, but certain obstacles still need to be overcome in order to maintain it in the long term

❖ Efforts to structure and fund research for high-performance sport

France has long lagged behind its main competitors in terms of research, innovation and the use of *data* to improve sporting performance.

➢ **The "High-Performance Sport" PPR**

With a view to the 2024 Olympic and Paralympic Games in Paris, in 2020 the government launched the "High-Performance Sport" priority research programme (PPR). Funded to the tune of €20 million over five years by the France 2030 plan, this programme brought together research teams and sports federations with a threefold objective:

- to provide scientific and technological solutions to help elite athletes achieve optimal performance;
- to translate research advances into athlete training through applied and innovative projects;
- to reduce France's lag behind its competitors in terms of research and innovation in the field of sport. Two calls for projects have enabled the funding of 11 research projects involving 21 Olympic and Paralympic federations.

➢ **The creation of a sports science ecosystem**

The laboratories of the Staps (Sciences and Techniques of Physical and Sports Activities) training and research units, long-standing players in French sports research, remain essential. However, the launch of the Sciences[2024]programme has highlighted the role of other organisations (engineering schools, CNRS, National Defence Sports Centre).

The creation of the Sports and Physical Activities Research Group (GDR) in 2019 has also helped to bring together all those involved in sport and physical activity, particularly life sciences laboratories. The GDR has launched a programme of doctoral contracts, several of which have supported research projects under the Sciences[2024]programme.

❖ The reorganisation of high-level sport: the creation of the National Sports Agency (ANS)

In July 2020, the ANS's "high performance" division presented a strategy and action plan called "Ambition bleue" (Blue Ambition) aimed at radically transforming the model of high-performance sport in France and maximising the chances of success at the 2024 Games.

One of the ANS's flagship projects was the creation of the Sport Data Hub (SDH) to facilitate the collection, processing and analysis of data from the French sports ecosystem and to offer athletes and their coaches personalised solutions and analysis of the performance of international competitors.

❖ An overall positive assessment despite persistent obstacles

The "High-Performance Sport" PPR has fostered strong cooperation between the scientific and sporting worlds and has helped to structure a sustainable research ecosystem for sport. It has also accelerated the implementation of scientific support for performance in federations that have appointed scientific advisors responsible for facilitating the transfer of research results to the "field".

However, obstacles remain in the scientific support of sporting performance. These are of three types:

- administrative: the committees for the protection of persons (CPP) responsible for ensuring that research projects involving human subjects comply with various criteria sometimes exceed their powers and take decisions that are not consistent;
- Cultural: awareness among athletes, coaches and federation leaders of the contribution of science and technology to improving performance varies. On the scientific side, understanding the needs and issues of sport, as well as the time constraints of athletes, is essential for constructive collaboration;
- financial and organisational: depending on the financial resources of the federations and the priorities of the national technical management.

Research and innovation aimed at improving the performance of elite athletes has applications in the fields medicine, equipment and leisure.

❖ A *continuum* between performance and medicine

➢ Strong cooperation between sports performance research and clinical research

The movement sciences aim to analyse and understand human movement in all its forms, from performance to disability. Cooperation between sports science laboratories and university hospitals has therefore increased over time. University courses combining sport and health have also developed.

➢ Areas of research common to high-performance sport and medicine

Studies on neuroplasticity aimed at understanding motor learning mechanisms in athletes have applications in the rehabilitation of stroke patients. Similarly, research on muscle and mental fatigue, which aims to optimise athletes' recovery, can be applied to the care of people suffering from chronic fatigue in the context of conditions such as cancer or multiple sclerosis.

Whether aimed at athletes or patients, research in movement sciences shares the same concern: to develop individualised training programmes that are as closely tailored as possible to the needs of the people for whom they are intended, in order to improve their performance.

❖ Interactions in the field of prosthetics

➢ Movement analysis and biomechanics in the service of prosthetics

Biomechanics and movement analysis are essential in the field of prosthetics for people with impaired mobility, particularly for the manufacture of prostheses. By breaking down movement into different phases (e.g. during walking between the stance phase and the swing phase), movement analysis provides an understanding of how the prosthesis should function at each stage. Biomechanics helps to select the appropriate materials and design structures that can withstand these stresses without causing damage to surrounding tissues. Biomechanical analysis also guides design to reduce the user's energy expenditure by optimising force transmission and promoting more natural and less tiring movements.

➢ The challenges of democratising equipment and adapting standards to technological developments

Equipment adapted to the physical activity of people with disabilities remains a niche market, however, and its price is a major obstacle to the widespread practice of sport, even though the 2024 Games have led to a significant increase in funding for technical aids (sports blades, sports wheelchairs).

The use of digital technology and 3D printing should help to reduce costs. However, the incorporation of technological developments into medical devices and technical aids is hampered by the very slow evolution of standards.

❖ The transfer of technology from elite sport to recreational sport

Thanks to mobile applications and technological advances, amateur athletes can now track all kinds of parameters relating to their performance and health.

However, the use of connected devices remains socially differentiated, which would explain their relatively limited impact on long-term engagement in physical activity: men, urban dwellers, higher education graduates and executives with above-average incomes, healthy working people who exercise regularly and are aged between 30 and 49 are over-represented.

The future of personal data collected by apps raises many questions.

State-of-the-art equipment is also finding its way into the leisure sports sector. Carbon-fibre shoes, once reserved for an elite few, are now sold in sports shops for all runners. Smart textiles, offering thermoregulation and protection from the elements, benefit the entire population. This widespread availability helps to improve the comfort and safety of those who exercise, while stimulating industrial innovation.

The benefits of physical activity on human health are scientifically proven, but the physical condition of the population continues to deteriorate. A special effort must be made to identify obstacles and implement effective and sustainable interventions.

❖ The impacts of physical activity and sedentary lifestyles on health

➢ Physical inactivity and sedentary lifestyles: two complementary concepts

Physical inactivity refers to failure to meet the minimum physical activity recommendations set by the World Health Organisation, namely:

- at least 60 minutes of moderate to vigorous physical activity per day for children and young people aged 5 to 17;
- 150 minutes of moderate-intensity activity or 75 minutes of vigorous-intensity activity per week for adults.

Sedentary behaviour, on the other hand, refers to the amount of time spent sitting or lying down outside of sleep.

Physical activity and sedentary behaviour are not mutually exclusive. For example, a person can meet the WHO recommendations by exercising for one hour a day while still being sedentary if they spend the rest of their time sitting in front of a screen.

This distinction is important because both behaviours independently increase the risk of chronic disease and premature mortality.

➢ **The risks associated with physical inactivity and sedentary lifestyles**

With 5.3 million deaths linked to physical inactivity, it is considered the fourth leading risk factor for mortality worldwide, ahead of tobacco use. A recent study estimates that 15.7% of premature deaths could be prevented if people who are insufficiently active followed the WHO recommendations.

A sedentary lifestyle is a risk factor for early mortality regardless of the level of physical activity. The risk of mortality increases when people spend more than 9 hours a day sitting down, with an overall mortality risk increased by 48% when sedentary behaviour rises to 10 hours a day and a mortality risk multiplied by almost three when sedentary behaviour reaches 12 hours a day. A sedentary lifestyle is a major risk factor for cardiovascular disease and is associated with an increased risk of several types of cancer.

➢ **Scientific consensus on the health benefits of physical activity**

Physical activity improves cardio-respiratory and muscular capacity, regulates blood pressure and helps maintain a healthy body weight. It plays a key preventive role against type 2 diabetes, high blood pressure, osteoporosis and certain cancers.

The cognitive and mental benefits are also considerable. Physical activity improves memory and concentration, reduces anxiety and depressive symptoms, and helps delay age-related cognitive decline. Numerous studies have shown that regular physical activity reduces the incidence of Alzheimer's disease and improves the quality of life of people with neurodegenerative disorders.

In older people, physical activity helps to preserve independence, prevent falls and delay the onset of dependency. It is therefore a valuable tool for combating isolation and improving quality of life in the last decades of life.

Finally, physical activity not only prevents most chronic non-communicable diseases, but also has an undeniable curative role for many pathologies. In the context of certain chronic diseases, such as cancer, diabetes or heart disease, adapted physical activity is now prescribed as a treatment in its own right, complementary to drug-based approaches.

❖ The worrying rise in sedentary lifestyles and physical inactivity and the continuing deterioration in the physical condition of the population

➢ **An alarming situation**

In France, only 11.5% of men and 10.6% of women are active and non-sedentary. Children and adolescents are also affected. 66% of them present a worrying health risk, characterised by exceeding two health thresholds simultaneously: more than 2 hours of screen time and less than 60 minutes of physical activity per day. The increase in screen time, exacerbated by the COVID-19 pandemic, has a lasting detrimental effect on physical activity, particularly among children and adolescents. However, adolescence is a pivotal period during which habits acquired tend to become permanent, or even more pronounced in adulthood, with associated effects on health.

➢ **The continuing deterioration in the physical condition of the French population**

The concomitant rise in sedentary lifestyles and physical inactivity has a direct impact on the physical condition of the French population. Studies show a continuous decline in the respiratory, muscular and cardiovascular capacities of children and adolescents over several decades. Three out of five children are unable to perform four consecutive hops on one foot when they start secondary school.

➢ **Already high healthcare costs set to rise with an ageing population**

The physical decline of the French population is not just an individual problem: it has major economic and social consequences. The costs associated with physical inactivity amount to tens of billions of euros each year, including hospitalisations, drug treatments and productivity losses. Absenteeism at work and disability pensions also represent a significant burden on society. Increased life expectancy is accompanied by an increase in the number of years lived with disability, which represents a time bomb for public finances.

❖ The relative failure of public policies to promote physical activity and combat sedentary lifestyles

For more than 25 years, public authorities have been stepping up initiatives to promote physical activity, both through legislation and through the National Nutrition and Health Plans since 2001, supplemented since 2019 by the National Sport and Health Strategy. In 2024, the promotion of physical activity was declared a major national cause. However, the results remain limited.

Several structural obstacles explain this relative failure.

Physical activity and sports participation are characterised by significant social and gender inequalities.

Schools play an important role in pupils' physical activity through physical education and sports (PES). However, this is often considered a secondary subject and serves as an adjustment variable. Furthermore, schools contribute to sedentary lifestyles by keeping pupils seated.

Sport and physical activity are not sufficiently valued in society.

Adapted physical activity is little known among doctors who are likely to prescribe it and is not covered by health insurance.

Public policies suffer from a lack of evaluation. The indicators available on the physical condition of French people are rare, fragmented and rarely updated, making it difficult to adjust strategies.

The impact of the Paris 2024 Olympic Games, which could have been a major lever for reviving mass participation in sport, is likely to be limited in the absence of a sustainable strategy to promote physical activity.

❖ The prospects of science in encouraging physical activity

To reverse this trend, research in the humanities and social sciences offers several promising avenues.

➢ Preliminary analysis of barriers and drivers of physical activity for more effective physical activity promotion initiatives

Enjoyment plays a fundamental role in getting people to take up and stick with physical activity. However, government communications on physical activity primarily highlight its health benefits.

The school environment is the ideal place to promote physical activity, but often negative experiences in physical education classes leave a lasting impression and discourage people from continuing to exercise.

Finally, the decline in participation in sport between childhood and adolescence largely explains the low level of physical activity among young people. Preventing young people from giving up sport should be a priority.

➢ The role of physical literacy

Like literacy in reading or mathematics, physical literacy refers to the ability to understand, appreciate and engage in physical activity on a long-term basis. Introduced from childhood, it gives individuals the skills and confidence they need to engage in such activity throughout their lives.

➢ The importance of personalising and optimising recommendations

Recommendations for physical activity to achieve health benefits are uniform and sometimes simplistic, such as "10,000 steps a day". Prescribing appropriate physical activity must take into account the biological and behavioural characteristics of the individual as well as their socio-economic context in order to adapt to a diversity of profiles. Advice must be individualised to be more effective and motivating.

➢ The contribution of implementation sciences

Implementation science opens up new perspectives. Its purpose is to translate public policy into effective interventions in the field. It highlights the importance of cross-sector partnerships: the fields of health, education, urban planning, transport and sport must work together to create environments that encourage physical activity.

➢ Technological innovations for the sporting and physical activity of tomorrow

Accelerometers can be used to analyse different types of behaviour (sleep, time spent sitting, time spent standing, slow walking, fast walking, physical exercise) and increase active phases according to individuals' constraints and desires.

Virtual reality and *exergames* (video games designed to encourage physical activity) are promising technologies for encouraging people with disabilities, older people and those who are "resistant" to sport to take part in physical activity.

THE OFFICE'S RECOMMENDATIONS

AXIS 1: PUTTING SCIENCE AT THE SERVICE OF PERFORMANCE AND SPORTING ACTIVITY

- Recommendation No. 1: protect and expand research programmes related to high-level sport (particularly those focusing on women's specificities), while involving federations more closely
- Recommendation No. 2: strengthen the expertise of federations and the resources of INSEP and the National Sports Agency
- Recommendation No. 3: task the National Sports Agency with representing all sports federations and clubs in relations with data providers in order to influence negotiations on technical aspects and data sovereignty relating to French athletes
- Recommendation No. 4: ensure that the spirit of the Jardé law on research involving human subjects is respected
- Recommendation No. 5: make the prevention of concussions and heatstroke a public health priority, particularly in extreme competitions and for young audiences
- Recommendation No. 6: regulate mental preparation in sport and standardise the qualifications of physical trainers.

AXIS 2: MAKE FRANCE AN ACTIVE AND SPORTY NATION

- Recommendation No. 7: regularly update data on sedentary lifestyles, physical activity, screen time and the physical condition of French people
- Recommendation No. 8: make the prescription of appropriate physical activity a major focus of non-drug treatment for chronic diseases and mental health disorders
- Recommendation No. 9: promote research on reducing sedentary lifestyles and encouraging physical activity, as well as on motivation and long-term adherence to physical activity
- Recommendation No. 10: restore the importance of daily physical activity at all ages: from nursery school to medical facilities

National Assembly Report No. 2074 (XVII^{e} legislature) – Senate No. 121 (2025-2026)

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