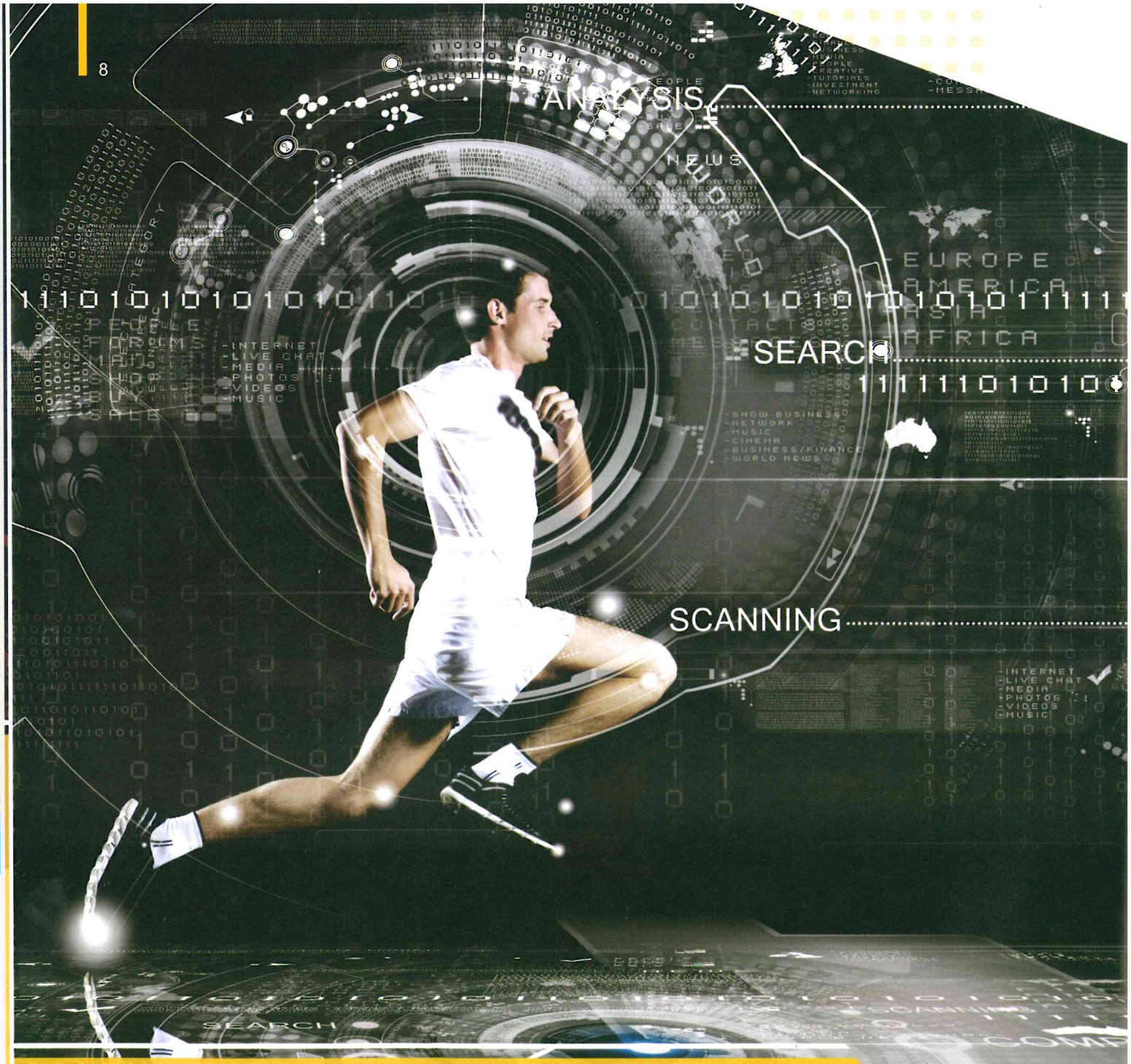


Searching for the peak of human performance
探索人類體能極限

How much stronger, faster and better can we get? As sports stars smash barriers that were thought to be impossible, it's a question that's long been asked by scientists as we explore the outer limits of human physiology and our athletic ability.

人類不斷在探索體能的外在極限和運動能力，當看見運動員一次又一次衝破以為不可能的障礙，科學家不禁要問，究竟人類的極限可推至多強、多快、多好。

Nature v nurture

While some training techniques have been around for a while, modern science is shedding light on our physiology and psychology in new and fascinating ways, as cutting-edge techniques and technologies help the stars of today - and tomorrow - reach new heights.

Within the scientific community, debates around nature and nurture have long dominated discussions, but Professor Julien Baker, Head of the Department of Sport and Physical Education and a leading expert in exercise science and physiology, says that recent breakthroughs in the field have transformed our understanding of how athletes are born, as well as made.

"I think that you've got to have a lot of the basics in terms of genetics to perform, but obviously there's a big interface between nature and nurture," says Professor Baker. "These days with modern science and improved diet, most offspring are very healthy and powerful when they're born, and you can almost predict performance from a good physiological examination of individuals."

With so many babies born healthy, and with modern diets and supplements covering all the nutrients we need, researchers are looking to other areas to find an edge. As a result, areas that were once perhaps overlooked, such as the role psychology plays in performance, are being examined and big changes are being made.

先天與後天之爭

許多運動今天仍沿用傳統的訓練方式，但現代科學正為其注入新元素。尖端技術和科技不斷提升人類的生理及心理狀態，造就現在和未來的運動健兒屢破紀錄。

運動精英究竟是先天條件過人還是後天培養有功，一直是科學家爭論不休的題目，體育及運動學系系主任Julien Baker教授指這方面的研究近期有突破性發展，扭轉了人們對運動員天賦和後天栽培的理解。

Baker教授是運動科學及生理學方面的專家，他認為：「遺傳因素固然能為運動員打下一定基礎，但明顯先天條件與後天培育互為影響。在現代科學及改良飲食的幫助下，大部分人出生時都十分健康及強壯，幾乎只要詳細剖析一個人的生理機能，已可大概預測他的體能表現。」

基於不少嬰兒出生時已相當健康，加上現代飲食習慣和補充劑包含人類所需營養，研究人員唯有在其他方面發掘優勢，探索一些被忽視的範疇，例如心理狀態對人類表現的影響，並已見到一些改變。

Professor Julien Baker
Julien Baker 教授

Mind and body

When we discuss what makes people an expert in certain fields, a specific number often emerges in conversations. In 2008, the journalist Malcolm Gladwell published *Outliers*, his bestselling book on success, which popularised the idea that experts and elite performers have often totalled over 10,000 hours of practice to reach that stage in their careers.

But while time is undoubtedly important, Professor Baker says that it's the quality of practice that makes a difference. "Hard work will only get you so far, but a lot of modern training is about the quality of practice, and breaking the performance down."

Within the world of sport, it is this approach to quality over quantity that has led to the emergence of deliberate practice, and a rigorous focus on improving specific areas which eventually leads to better overall performance.

"In sport, physiological and psychological aspects are equally important and deliberate practice lets us employ techniques to develop the athletes in a deliberate way. The way it works is that you identify the difficult component of a performance and develop strategies to improve those difficult parts. This can include psychological aspects, such as mental rehearsal techniques to stop people becoming nervous, as well as identifying particularly difficult parts of a performance using computers," he says.

When applied to marathon running, for example, the athletes in question may not actually run the full distance that often, as an average week may include five or six short, high-intensity runs and then a long run on a Sunday. Instead, these high-intensity runs provide an opportunity to focus on improving specific areas.

鍛鍊身心

在討論一個人如何成為某方面的專才，總會扯上一些數字。2008年，記者Malcolm Gladwell出版了一部論述成功故事的暢銷著作《異數》，當中提及專家精英分子都曾鍛鍊逾萬個小時，才能取得他們的成就。

Baker教授認為，鍛鍊的時間長短雖然重要，但鍛鍊的質素才是成功關鍵。「努力練習只會帶來有限度的進步，但現今不少訓練講求鍛鍊質素，並會對表現作詳盡分析。」

在運動培訓方面，由於重量更重質，刻意練習遂成為趨勢，更會針對某些特定範圍作嚴格鍛鍊，以提升運動員的整體表現。

Baker教授續說：「對於運動員來說，身心鍛鍊同樣重要，在刻意練習中，我們會特意利用一些技巧來訓練運動員，先確定其表現中最難克服的障礙，然後再敲定改善的策略。除了體能外，這方面的練習亦包含心理層面，例如運動員會採用心智演練法以防止賽前緊張，亦會利用電腦分析找出表現有問題的部分。」

以馬拉松訓練為例，進行刻意練習的跑手不會經常跑全馬距離，平常會進行五至六次短跑和高強度跑步訓練，到了周日則進行長跑訓練。而在高強度跑步練習中，跑手可針對特定範圍提升表現。

Baker教授說：「跑手可在短距離的練習中，針對指定範圍改善跑步技巧，例如你可仔細分析表現，集中改善跑步方式和效率，透過鍛鍊來提升整體表現。」

然而，近年體育界的重大轉變不僅是刻意練習的冒起。Baker教授指出，就運動員的表現作生物分析，以及對不同肌肉類型的生物化學和生理機能及其可造成的表現差別進行研究，對運動員成績

"On these runs you might be looking to enhance the running technique by isolating certain aspects over shorter distances. So, for example, you might break the performance down and focus on improving your running style and economy, as by educating the body you can get the best overall performance," says Professor Baker.

But such a focus on deliberate practice is not the only big change, as Professor Baker says that another development that has made a huge difference in recent years is the biological analysis of performance, as well as the biochemistry and physiology of different muscle types and the differences those can make. However, an increased understanding of how the body works has also led to athletes tweaking their biochemistry in more sinister ways to gain an advantage.

The lure of drugs

When Lance Armstrong, the famous American cyclist, was storming up mountains during the Tour de France on his way to seven victories in the late 90s and early 2000s, questions were inevitably asked about the nature of his performance, but it took a long time for the full extent of his cheating to come to light.

Illegal doping is a huge issue in modern sport, as despite years of dedicated training, the pressure on some stars can be suffocating, with the full glare of the media even pushing some towards illegal performance enhancing drugs, and the promise of even better performance for those who are willing to break the rules to achieve their dreams.

的影響更加顯著，但也因而誘使一些運動員以不正當手段改變其身體的生化結構，以增強優勢。

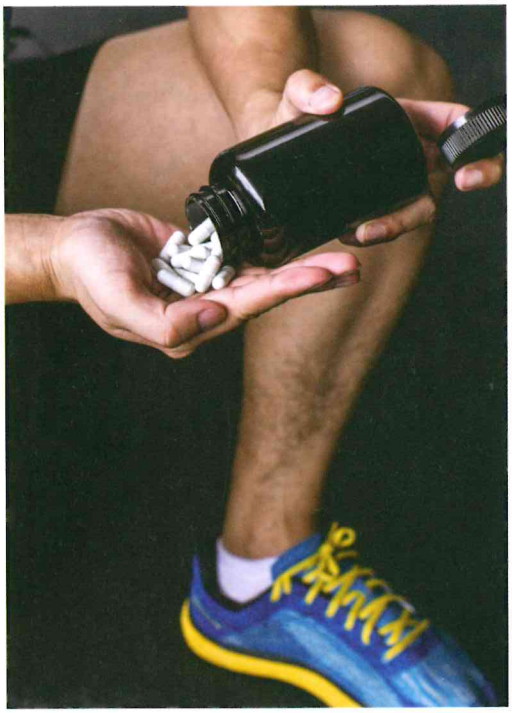
藥物誘惑

於90年代末至2000年代初，著名美國單車選手Lance Armstrong勇奪七屆環法單車賽冠軍，他的驚人表現難免引來多方質疑，但有關當局也花了很長時間始揭發他的欺詐行為。

禁藥是體育界長期面對的一大難題。縱然運動員經年累月用心鍛鍊，但一些知名運動員仍可能承受着難以抵禦的壓力，加上傳媒全方位關注，驅使一些運動員服用能提升表現的禁藥，有些更因服用禁藥後表現更佳，不惜違法以實現夢想。

Baker教授表示：「運動員的心理強度相當重要，例如足球賽事，球員身價影響深遠，他們為保表現不惜借助藥物，導致濫藥情況出現。」

他記起曾經有調查向100位運動員提問：「如果你在服用類固醇後能奪得金牌並且不會被追究，但五年內會死亡，你還會服用嗎？」所有受訪者都給予肯定答案。



Illegal doping is a huge issue in modern sport.
禁藥是體育界長期面對的一大難題。

"Mental strength is very important, and in sports such as football, price tags can have a big impact. This can also lead to substance abuse scenarios as there is so much pressure to resort to drugs," says Professor Baker.

He also recalls a survey where 100 athletes were asked the question: "If you could get away with taking steroids and winning a gold medal, but you died within five years, would you take them?" All of them said yes.

The reality of this behaviour in normal society was brought home by Professor Baker and colleagues in a study on steroid abuse published in the *British Journal of Pharmacology*, one of the top journals in the world for this area of research. When they looked at steroid usage in the UK, they found that the use of anabolic androgenic steroids (AASs) was expanding, with an estimated 411,000 adults saying that they had used an AAS. The drug, which is usually prescribed to those with low testosterone, can help build muscle, but it can also change behaviour.

"Its impact is absolutely massive in contact sports, such as boxing, rugby and football," says Professor Baker. "People are also taking masking agents to cover up growth hormones and other drugs. The only real way you can find out is by carrying out genetic testing and genotype analysis, which costs a fortune and therefore isn't feasible on a large scale."

As a result, while drug-testing methods continue to improve, it is still very hard to detect their use if athletes are carefully taking small doses to avoid detection. And with the rewards for a medal at the Olympics so great, perhaps it isn't a surprise that so many are willing to risk being caught for a shot at glory and sporting immortality.

Baker教授及其研究團隊曾在全球最權威的濫藥期刊之一《British Journal of Pharmacology》，發表有關濫用類固醇的研究。在探討英國的類固醇使用情況時，發現服用同化雄性類固醇的人數呈現上升趨勢，估計約411,000名成年人表示曾服用這種類固醇。同化雄性類固醇通常處方給睾丸激素偏低的人士，有助增強肌肉，但會導致服用者出現行為變化。

「在有身體接觸的運動中，例如拳擊、欖球或足球，同化雄性類固醇的效力相當驚人。」Baker教授說：「有些人會同時服用掩蔽劑，以防被測試出體內含有生長激素或其他藥物，只有採取基因測試或基因分型分析，才能驗出體內是否含有禁藥成分，但成本高昂，難以作大規模測試。」

因此，儘管藥物測試方法不斷改良，假如運動員刻意服用小劑量的藥物來避過檢測，要準確測試他們有否服用禁藥仍存在一定難度。此外，奪取奧運獎牌的回報豐厚，難怪不少運動員甘願以身犯險，以換取一刻的榮耀，甚至運動事業永垂不朽。

Technology and the future

With so many seismic shifts in sport over the past few decades, in some ways it's hard to see what else can change, but even now, new developments are emerging.

In late 2019, Eliud Kipchoge, a legendary Kenyan long-distance runner, broke the two-hour marathon barrier in Berlin wearing new running shoes from a famous brand. It was a time that was never supposed to be broken, yet new technology has facilitated what was once thought to be impossible.

"Athletes will keep on improving. Recently we've seen running times fall due to new running shoe designs, and other skills and parameters can also be improved by using deliberate practice. Artificial intelligence and big data will also be used more, and computer programs looking at physiology and biochemistry will further change things," says Professor Baker.

Indeed, advanced genotype analysis is already happening for rugby, and it's likely to spread out to other sports soon. But ultimately, while new developments will improve performances even more, Professor Baker believes the true message is the impact of exercise.

"For normal healthy people there's no medicine that's got the power of exercise to reduce blood pressure, increase the quality of life, enhance immune function, improve cardiovascular and diabetic profiles, and lose weight," he says.

技術與未來

體育運動在過去數十年出現了不少巨大變化，實在難以預計還有哪方面可以改變，但時至今日，仍不時見有一些新發展。

2019年年末，肯亞傳奇長跑選手Eliud Kipchoge在柏林穿着某著名品牌的全新跑鞋參賽，打破過往被認為無法超越的兩小時馬拉松紀錄，反映新科技能令不可能變為可能。

Baker教授說：「運動員不斷尋求進步，近期我們見到新的跑鞋設計令跑手跑得更快，而其他技術和參數亦可透過刻意練習而得以改善。人工智能和大數據亦會更常用，而一些針對生理學及生物化學的電腦程式亦能帶來進一步改變。」

事實上，欖球界已採用了先進基因型分析，這種技術亦可能陸續應用於其他類型的運動。不過無論如何，縱使科技上的新發展不斷令運動員提升表現，Baker教授認為運動對身體帶來的影響才是其真正的意義所在。

他表示：「對於一般健康人士，任何藥物都不能像運動般，具備降血壓、提升生活質素、增強免疫力、改善心血管及糖尿狀況和減重的功效。」

New developments will improve athletes' performances.
科技上的新發展不斷令運動員提升表現。