

Chapter 3 THE SCIENCE of TRAINING 第3章 科学地训练

Having all the sports knowledge in the world, having all the best coaches, having all the best equipment, will that win a gold medal for you? No. But not having all that can lose it for you.

-- CHRIS CARMICHAEL

It was not until the 1960s that the study of exercise as a science became wide-spread and not until the 1970s before it began to significantly change the way serious cyclists trained. In the 1980s, exercise science made a quantum leap. We learned more about the human athlete in those ten years than in the previous eighty.

The earliest scientists learned more from studying the methods of top athletes than they did from independent study in their ivory towers. That is still the case today; the people in white lab coats seek an explanation for why some athletes succeed and others do not.

Even in the early days, riders learned through trial and error that they couldn't develop both maximal endurance and maximal power simultaneously. Coaches and athletes found that by first establishing an aerobic endurance base and later by adding faster riding, they could come into top form at the right time. This method of training was often imposed on them by the weather. Winter made long, cosy rides a necessary, while summer favored faster riding.

Since those leather shoe and wool jersey days, we've learned a lot from the best athletes, coaches, and scientists. It's been a long and winding road. The entire range of training elements, including nutrition, recovery, strength, mental skills, fitness measurement, and workouts, has been explored and greatly refined. Still, many athletes continue to train as if it were 1912. They go out the door day after day with no plan, deciding as the ride develops what they will do. Some are successful despite their backward ways. Could they do better? Probably. Will you improve if you adopt a more scientific way of training as described in this book? I believe you will.

掌握目前所知所有运动科学知识，拥有这个世界上最好的教练，配备最好的器械，是否能为你赢得一枚金牌？当然不能。但若没有上述元素的话，你注定失去这枚金牌。

--CHRIS CARMICHAEL

直到 20 世纪 60 年代，运动研究才作为一门科学学科开始广泛传播，并从 70 年代开始显著改变了严肃车手们的训练方式。在 80 年代，运动科学研究取得了巨大突破。在这十年中我们对人类运动员的了解超过了之前的 80 年的总和。

早年的科学家更多的是研究顶级运动员的训练方法，而不是躲在他们的象牙塔里做独立研究。直在今天仍就如此，穿白大褂的学者想获取一个解释：为什么有些运动员成功了，而有些却失败了。

即便在很早的时候，车手们已经从试验和失败中得出结论，他们无法同时发展最大耐力和最大力量。教练们和运动员们发现，先建立有氧耐力基础，然后增加快速骑行，这样他们可以在适当时候达到高峰状态。这种训练方法常常是被天气所左右的。比如冬天需要进行长距离的慢速骑行，而夏天则倾向于快速骑行。

从使用真皮鞋和羊毛衫的时代至今，我们从那些最好的运动员，教练和科学家们那里学到了很多。这是个漫长而崎岖的路。全系列的训练要素——包括营养，恢复，力量，心智，体质测量，和训练课——都得到了深度拓展和极大的改进。然而，仍有很多运动员好象还生活在 1912 年一样。他们日复一日无计划的训练，随心所欲地决定如何骑车。当然他们中还是有些人成功的，但他们是否能做的更好呢？很有可能。如果你采取本书中所述的某些更科学的训练方法，会否获取进步呢？我相信你会的。

I hope to help you reach toward your potential by taking advantage of the most recent training knowledge available. This knowledge has been gleaned from research studies, from the training methods of top cyclists and coaches, and from athletes and coaches in other sports such as swimming, running, rowing, and triathlon. Some of it is proven beyond doubt, but much is still theory. You need to determine how everything applies to you and your training. Even well-established and proven practices may not be applicable given your unique set of circumstances. Some things may not work for you although they do for others.

Before getting scientific, I want to explain a few basics about training for cycling. These may be so elementary that they seem evident, but I'll describe them just in case.

No one starts out at the top. Many of those who get there make it because they are more patient than others. Training has a cumulative effect from year to year. If done correctly, a cyclist should see improvement over time. Don't expect miracles overnight.

Physical and psychological breaks from training are normal and necessary. No one can improve at an uninterrupted pace forever. If you don't build rest and recovery into your training plan, your body will force you to. It doesn't matter how mentally strong you are: You need frequent breaks from training.

If you're new to cycling, the most important thing you can do is ride consistently and steadily for a year. Don't be concerned about all of the detail stuff this book will describe until you've put at least one season under your belt. Then you can begin to plug in the finer elements of training.

我希望能利用目前最新训练知识来帮助你达到你最大的潜能。这些知识是从专题研究，以及从顶级自行车运动员和教练们和其他项目诸如游泳、赛跑、划船和铁人三项等运动的训练方法中收集获得。有些已经毫无疑问的得到了验证，但大多数仍停留在理论阶段。你需要确定如何将这些理论应用于你及你的训练中。甚至那些已经很完善并得到验证的方法也不一定适用于你的特定的环境背景。有些东西对他人起作用，但不一定适用于你。

在进入科学训练前，我想先解释一些自行车训练的基础知识。这些都是非常基本的，甚至显而易见的知识，但我会描述一遍以防有人不知道。

没人一开始就是顶级的。大多数顶级运动员成功的原因是他们比普通人更有耐心。训练成果是年复一年地积累的。只要方法得当，通过时间的累积，车手们应该可以看到自身的进步，但不要指望奇迹会一夕出现。

训练期间的生理和心理休息是正常和必须的。没人能按一个永不间断的步伐一直训练且不断进步。如果你不在你的训练计划中设立休息和恢复，你的身体会迫使你这么做。不管你意志多么顽强，你也需要在训练期间经常休息。

如果你是个新手，你能做的最重要的事情就是长期地，稳定地骑行一年。不要去关注本书叙述的所有详细资料，直到你已经至少骑了一个赛季。然后你才可以在训练中加入一些好的训练要素。

Physiology and Fitness

How can we measure physical fitness? Science has discovered three of its most basic components – aerobic capacity, lactate threshold, and economy. The top riders have excellent values for all three physiological traits.

生理学和身体素质

我们如何测定身体素质？目前科学研究已发现了三种组成身体素质的基本指标——有氧代谢能力，乳酸阈值和运动效率。顶级骑手在这三项生理指标上都非常出色。

Aerobic Capacity

Aerobic capacity is a measure of the amount of oxygen the body can consume during all-out endurance exercise. It is also referred to as VO₂max – the maximal volume of oxygen your body can process to produce movement. VO₂max can be measured in the lab during a “graded” test in which the athlete, wearing a device that measures oxygen uptake, increases the intensity of exercise every few minutes until exhaustion. VO₂max is expressed in terms of milliliters of oxygen used per kilogram of body weight per minute (ml/kg/min). World-class male riders usually produce numbers in the 70- to 80-ml/kg/min range. By comparison, normally active male college students typically test in the range of 40- to 50-ml/kg/min. On average, women's aerobic capacities are about 10 percent lower than men's.

Aerobic capacity is largely determined by genetics and is limited by such physiological factors as heart size, heart rate, heart stroke volume, blood hemoglobin content, aerobic enzyme concentrations, mitochondrial density, and muscle fiber type. It is, however, trainable to a certain extent. Typically, in otherwise well-trained athletes, it takes six to eight weeks of high-intensity training to significantly elevate VO₂max peak values.

As we get older, aerobic capacity usually drops by as much as 1 percent per year after age 25 in sedentary people. For those who train seriously, especially by regularly including high-intensity workouts, the loss will be far smaller and may not occur until they are well into their thirties or even later.

Lactate Threshold

Aerobic capacity is not a good predictor of endurance performance. If all of the riders in a race category were tested for aerobic capacity, the race finishing results would not necessarily correlate to their VO₂max test values. The

有氧代谢能力

有氧代谢能力是测试在竭尽全力的耐力测验中身体能消耗的最大氧气量。也被称为 VO₂max（最大摄氧量）—— 你的身体为产生动能所能消耗的最大氧气量。VO₂max 可在实验室通过分级测试法测量。在测试中，运动员戴上测量摄氧量的设备，每隔数分钟增加一点运动强度，一直到无法继续增加强度为止。VO₂max 以每分钟每公斤体重消耗的氧气量来表示（ml/kg/min）。世界级男性骑手的最大摄氧量大概在 70+ 到 80+ml/kg/min 的范围内。相比之下，一般的好动的男大学生的代表性测试结果是在 40+ 到 50+ml/kg/min 的范围。女性的有氧代谢能力平均比男性低大约 10%。

有氧代谢能力很大程度上取决于遗传，并受如心脏大小、心率、每搏输出量、血红素数量、有氧代谢酶浓度、线粒体密度和肌肉纤维种类等身体因素的限制。但通过训练，仍可在一定程度提高。比较典型就是，一些经过良好训练的运动员，在经过 6 到 8 周的高强度训练后能够极大地提高他们的 VO₂max 的峰值水平。

随着我们年龄的增长，对久坐人群来说，在 25 岁后通常有氧代谢能力每年下降 1%。对那些认真训练的人，尤其是经常参加高强度训练和比赛的人来说，这个下降的比例会小很多，并且直到他们 30 多岁或更晚时才会发生。

乳酸阈值

有氧代谢能力不能很好地预测耐力水平。假如所有参加比赛的骑手都测试了他们的有氧代谢能力的话，那么比赛的结果与他们的 VO₂max 测试值不见得有关联。VO₂max 测试值最高的运

athletes with the highest VO₂max values would not necessarily finish high in the rankings. But the highest value of VO₂max that one can maintain for an extended period of time is a good predictor of racing capacity. This sustainable high value is a reflection of the lactate threshold.

Lactate threshold, sometimes called “anaerobic threshold,” is the level of exercise intensity above which lactate begins to rapidly accumulate in the blood. At this point metabolism rapidly shifts from dependence on the combustion of fat and oxygen in the production of energy to dependence on glycogen – the storage form of carbohydrates. The higher this threshold is as a percentage of VO₂max, the faster the athlete can ride for an extended period of time, as in a race. Once lactate threshold reaches a high enough level, there is no option but to slow down in order to clear it from the blood.

Sedentary individuals experience lactate thresholds at 40 to 50 percent of VO₂max. In trained athletes, the lactate threshold typically occurs at 80 to 90 percent of VO₂max. So it is obvious that if two riders have the same aerobic capacity, but rider A's lactate threshold is 90 percent and B's is 80 percent, then A should be able to maintain a higher average velocity and has quite a physiological advantage in a head-to-head endurance race (unless rider B is smart enough to protect himself from the wind and has a great sprint).

Compared with aerobic capacity, lactate threshold is highly trainable. Much of the training detailed in this book is intended to elevate the lactate threshold.

Economy

Compared with recreational riders, elite cyclists use less oxygen to hold a given, steady, submaximal velocity. The elite riders are using less energy to produce the same power output. This is similar to automobile fuel efficiency ratings that tell prospective buyers which cars are gas guzzlers. Using less fuel to produce the same amount of power is an obvious advantage in competition.

运动员的比赛排名不一定会好。但能维持 VO₂max 的摄氧水平所持续的时间值就是一个很好的比赛能力的指标。这个可维持的比较高的值就反应了乳酸阈值水平。

乳酸阈值，有时被称为“无氧阈值”，反应了一种运动强度水平，超过该运动强度时乳酸开始迅速在血液里堆积。此时，新陈代谢方式迅速地从燃烧脂肪和氧气供能转换为依靠糖元——碳水化合物在身体中的储存形式——来供能。这个阈值占 VO₂max 的百分比越高，在一定时间内运动员骑得就越快。当乳酸堆积达到一个足够高的水平时，运动员只能被迫慢下来以便将血液中的乳酸清理出去。

久坐人群的乳酸阈值大概为 VO₂max 的 40–50%。受训的运动员，乳酸阈值可达到 VO₂max 的 80–90%。假设两个骑手 A 和 B，他们的有氧代谢能力一样，但骑手 A 的乳酸阈值为 90%，而骑手 B 为 80%，那么很明显，骑手 A 应该能够维持一个较高的平均速度。这样，在个人对决式的比赛中 A 就有相当大的体能优势（除非骑手 B 能足够聪明地靠降低风阻来保护自己，并有很好的冲刺能力）

与有氧代谢能力相比，乳酸阈值可更多地通过训练提高。本书内详述的许多训练方法都旨在提高乳酸阈值。

运动效率

与“骑游派”骑士相比，精英车手在保持一个特定的、稳定的、较高的速度时，消耗较少氧气。精英骑手用较少氧气来产生同样多的能量输出。这有点类似于汽车的耗油率。想买车的人都会看各种车型的百公里油耗的排名，从而了解哪部车耗油最厉害。如果能用较少的消耗输出同样的能量，在竞赛中就会是很明显的优势。

Studies reveal that an endurance athlete's economy improves if he or she:

- Has a high percentage of slow-twitch muscle fibers (largely genetic)
- Has a low body mass (weight to height relationship)
- Has low psychological stress
- Uses light and aerodynamic equipment that fits properly
- Limits body frontal area exposed to the wind at higher velocities
- Eliminates useless and energy-wasting movements

Fatigue negatively impacts economy as muscles that are not normally called upon are recruited to carry the load. That's just one reason why it's critical to go into important races well rested. Near the end of a race, when economy deteriorates due to fatigue, you may sense that your pedaling and technical handling skills are "getting sloppy." The longer the race is, the more critical economy becomes in determining the outcome.

Just as with lactate threshold, economy is highly trainable. Not only does it improve by increasing all aspects of endurance, but it also rises as you refine bike skills. This is why I emphasize drill work for pedaling in the winter training months and a commitment to improving skills year-round.

Perspective

The preceding discussion probably makes it sound as if fitness can be easily quantified, and, perhaps, used to predict or even produce top athletes. Fortunately, that's not the case. The best scientists in the world can take a group of the most fit cyclists into a state-of-the-art lab, test, poke, prod, measure, and analyze them, then predict how they will do in a race – and fail miserably. Labs are not the real world of racing, where many variables beyond the ken of science escape quantification.

研究表明，如果做到以下几点，耐力运动员的运动效率可达到改善：

- 拥有较高比例的慢肌纤维（很大程度上由遗传决定）
- 拥有较轻的身重（身高和体重的比例）
- 精神压力较轻
- 恰当使用较轻的，风阻较小的装备
- 减少在高速骑行时身体的正面挡风面积
- 去除无用的，费力的动作

疲劳对运动效率有消极影响，会迫使那些通常使用不到的肌肉来承担负荷。这也是在重要赛事前需要好好休息的一个原因。在一场比赛临近结束时，当运动效率由于疲劳开始降低时，你可能会感觉你的踩踏技术和操控技巧越来越不中用了。比赛时间越长，运动效率对比赛结果的影响也越大。

与乳酸阈值一样，运动效率也是可以训练提高的。它不但可通过增加耐力的各个方面来得到改善，还会随着你车上技术的提高而提高。这也是我为什么强调冬训期间的踏频训练和每年计划投入时间来提高技巧的原因。

笔者观点

前面的讨论，可能会让人觉得身体素质很容易改善，以及身体素质或许能用来预测甚至产生顶级运动员。幸运的是，事实并不是这样。假如世上最好的科学家和一群体质最棒的骑手一起进入一间梦幻级的实验室，试图通过测试，督促，激励，测量和分析这些人，然后预言他们在比赛中将能如何如何——结果一定是悲惨的失败。实验室不是真实的赛场，在那里有很多科学领域外的变数是无法量化的。

Training Stress

There are five terms used repeatedly in this book that relate to the stresses applied in training; it is important to understand these terms. By carefully changing workout *frequency*, *duration*, and *intensity* throughout the season, the body's comfortable state is disturbed, forcing it to adapt with the positive changes we call "fitness". This manipulation has to do with *volume* and *workload*. Let's briefly examine each of these terms.

Frequency

This refers to how often training sessions are done. Novice riders may work out three to five times a week and experience a rapid change in fitness, perhaps in the range of 10- to 20-percent improvement in a short period of time. Experienced cyclists train with greater frequency, often doing two workouts a day at certain times of the year. An Olympic hopeful might work out twelve to fifteen times in a week, but such high frequency may only produce a 1-percent gain in fitness, since these athletes are already so close to their potential.

Studies have found that training three to five times a week brings the greatest gain for the time invested, and that additional workouts have diminishing returns. If you are trying to realize your racing potential, however, those small gains are worth it since the competition will be quite close in ability.

Should a novice try to train at the same high level as the more experienced rider, he or she may actually see a decrease in fitness due to overtraining. If the experienced rider trains for a substantial length of time at the novice's low level, there will also be a loss of fitness because of undertraining – the frequency is too low.

The frequency at which you work out is dependent on what your body is currently adapted to. For example, even if you're an experienced

训练压力

在本书中，当涉及训练引起的压力时有 5 个术语被反复提到，理解这些术语非常重要。在整个赛季中，通过小心地改变高强度训练的 *频率*，*持续时间*和*强度*，身体原先的舒适状态被打破，并迫使它调适到一个新的状态。其中包括我们渴望改变的东西——被称为“身体素质”。我们需要和*训练量*及*训练负荷*联系起来操作，下面让我们简单地解释一下这些术语。

训练频率

这是指每隔多少时间进行一次训练。新车手可能每周进行三到五次训练，就能感觉到身体素质突飞猛进，也许在短期内就能获取 10%—20% 的进步。有经验的骑手训练得更频繁，常常在一年的某段时间里每天训练两次。一个为奥运会备战的选手可能每周训练 12 到 15 次，但如此高的训练频率可能只产生 1% 的身体素质改善，因为这些运动员已经非常接近他们的身体潜能了。

研究发现，相比于投入的时间，每周训练 3 到 5 次获得的收益最高，如再投入更多的训练时间，其回报将逐渐减少。然而，如果你的目标是激发你的比赛潜能，那么这些很少的回报也是很有价值的，因为在比赛中，竞争对手之间的实力非常接近。

当一个新手尝试做与那些有经验的骑手一样的高级别训练时，他或她可能会因为过度训练而导致事实上的体质衰退。如果一个老手按一个新手的低级别的训练时间来训练时，同样会由于训练压力不足而导致体质衰退——因为频率太低。

你的训练频率应该由你的身体目前的适应性来决定。比如，即使你是个有经验的骑手，

rider but have not trained for several weeks, it's best to start with a lower frequency and gradually increase it.

但已经有数周末训练了，那么，你最好还是从较低的训练频率开始，然后逐渐增加频率。

Duration

持续时间

Training sessions may vary considerably in length. Some last several hours in order to improve aerobic endurance. Others are short to allow for higher efforts or to promote recovery. Just as with frequency, workout duration is determined by experience level, with seasoned riders doing the longest sessions. Duration may be measured in time or in distance covered. *The Cyclist's Training Bible* bases training sessions on time.

每次训练的时间跨度都可能有所不同。有些训练会持续数小时以改进有氧耐力，而有些则持续较短时间从而达到较高的强度或为了促进恢复。和频率一样，训练持续时间取决于个人经验的水平。经验最丰富的骑手训练持续时间最长。训练持续长度可用时间或所骑里程来表示。本书《自行车训练圣经》所指的训练持续长度用时间表示。

The appropriate time for long rides is largely determined by the anticipated duration of your races. Typically, the longest workouts are about the same duration as the longest race the athlete will compete in or slightly longer. Early in the season, the higher-intensity workouts are done on lower-duration days, but as the racing season approaches, harder workouts incorporate both long duration and high intensity. This prepares the body for the stresses of racing.

长途骑行的合适的持续时间很大程度上取决于你预计的比赛长度。一般来说，最长的训练持续时间和运动员将要参加的比赛的最长持续长度一样或略长一点。在赛季早期，高强度训练一般持续长度较短；但随着赛季的临近，训练会越来越艰苦，表现在持续时间和训练强度同时提高。这能让身体为比赛压力做好准备。

Intensity, Volume and Workload

强度，训练量和训练负荷

Frequency and duration are easy to quantify, so athletes often refer to them in describing their training program. They may, for example, say that they rode seven times last week for a total of fourteen hours. This actually only describes a portion of their training – the portion called “volume”. Volume is the combination of frequency and duration and it does, indeed, provide an idea of what an athlete's training is like. But volume is an incomplete description of the stress of training.

频率和持续时间很容易量化，所以运动员在描述他们的训练规划时常引用这两项。例如，他们可能会说，上个星期他们骑行了7次，总骑行时间为14个小时。实际上这只说明了他们训练的一个部分——所谓“训练量”的那部分。训练量是频率和持续时间的组合，它确实反映了运动员训练的大致情况。但训练量还不能完全描述训练的压力。

A better summary of one's training is “workload”, defined as the combination of volume and intensity. By also knowing how hard the rider trained – how much effort or power went into each workout – the stress magnitude is more completely defined. The problem for the average

对训练的更好概括是“训练负荷”，这是训练量和训练强度的组合。通过了解骑手的训练时的困难程度——每次训练所付出的努力和输出功率——我们就能更完整地定义训练压力的量级。一般水平的骑手会遇到这样的问题，

rider is that it's difficult to quantify intensity in the same way that frequency and duration are quantified. One way to do this is to assign an average exertion level to each training session when it is completed, using a 1 to 10 scale with 1 being extremely easy and 10 an all-out race effort. By multiplying the number of minutes of the session by the exertion level, the workload is adequately quantified.

For example, let's say you rode for sixty minutes including a warm-up, several high-intensity hill repeats, and a cool-down. Assume that you assigned an average effort level of 7 to this entire session. Your workload might then be expressed as 420 (7*60).

To determine weekly workload, which includes frequency, add up the daily workload values. By comparing the workloads for a number of weeks, you can see how the stress experienced by the body changes.

Training intensity is the stressor that athletes most often get wrong. They ride a little too intensely when they should be taking it easy and, as a consequence, are slightly tired when a high-intensity workout is needed. All training therefore shifts toward mediocrity as the easy rides become too hard and the hard rides too easy. For most cyclists, getting the intensity right is the key to moving up to the next level of performance. Chapter 4 offers greater detail on this complex issue.

Volume versus Intensity

Which is more important – volume or intensity? Given the finite amounts of physical resources available to the rider, should he or she get in as many miles as possible, or ride fewer miles with high intensity?

The answers to such questions depend on the rider's level of experience in the sports. Those new to cycling will improve rapidly merely by riding frequently and with relatively high durations. As the rider becomes more experienced – and fit – increases in volume have less and less impact on performance and variations in training intensity become critical.

即训练强度无法象频率和持续时间一样量化。解决这个问题一个方法是，在每次训练科目结束后为其设定一个平均努力程度，用数值 1–10 来分级，1 表示非常容易，10 表示竭尽全力。把努力程度乘以每个训练项目的持续时间（分钟数），训练负荷就被充分量化了。

举个例子，你骑了 60 分钟，包括从热身，到数个高强度的重复爬坡，以及冷却身体。假定你为这个训练科目设定的平均努力程度为 7，那么你的训练负荷就可表示为 420 (7×60)。

为了测定每周的训练负荷，其中包括多次训练，我们只需将每天的训练负荷相加即可。通过比较某段时间内每周的训练负荷，你就可以了解训练压力对身体的改变。

训练强度是一种经常被运动员误解的刺激源。在需要慢慢骑的时候，他们骑得太快，结果是，在需要进行高强度训练时他们的身体已经有点疲劳了。这样一来所有的训练都趋向平庸，因为低强度训练时强度不低而高强度训练时强度又不够。对大多数骑手来说，正确安排训练强度，是让他们的能力更上一层楼的关键。在第四章中将详细叙述这一复杂话题。

训练量 vs. 训练强度

训练量和训练强度，二者哪个更重要？在骑手有限的体力允许的范围内，他或她应该尽可能骑地更远些呢，还是应该骑较少距离但强度高些？

上述问题的回答，取决于骑手对这项运动的经验水平。对那些新骑手来说，只要骑车频率和训练时间多一些，就能得到快速的提高。但随着骑手经验的增加——和身体素质的提高——训练量的增加对运动能力的影响越来越小，这时强调训练强度就变地很重要了。

Fatigue

Were it not for fatigue we would all be champions. How quickly and to what extent we experience fatigue is a great determiner of our fitness level – it is a primary reason for training. The fittest athletes are those who can best resist its slowing effects.

There are several causes of fatigue, but the ones the cyclist is most concerned with are:

- Lactate accumulation
- Glycogen depletion
- Muscle failure

A sound training program improves fitness by stressing the body's systems associated with these causes of fatigue. Let's briefly examine each.

Lactate Accumulation

Energy for pedaling the bike comes largely from two sources – fat and carbohydrates. The body's storage form of carbohydrates is called "glycogen". As glycogen is broken down to produce energy, lactic acid appears in the working muscle cells. The lactic acid gradually seeps out of the cells and into the surrounding body fluids, where it is picked up in the bloodstream. As it leaves the cells, hydrogen ions are released and the resulting salt is called "lactate". If the concentration of lactate becomes great enough, its acidic nature reduces the ability of the muscle cells to contract, causing the rider to slow down.

Lactate is always present in the blood as the body uses carbohydrates along with fat for fuel at all levels of exertion – including the exertion involved in reading this page. But during exercise, as the use of glycogen increases, there is a concurrent rise in blood lactate levels. At low levels the body has no trouble removing and buffering the acid. But as the intensity of exercise shifts from aerobic (light breathing) to anaerobic (labored breathing), the lactate eventually reaches

疲劳

要不是因为疲劳，我们都会成为冠军。骑多久后会觉得累，有多累，这都是我们的身体素质水平的重要限定因素——也是训练的最主要原因。最优秀的运动员就是那些最能够抵御疲劳的人。

引起疲劳的原因有很多，但骑手最关心的是：

- 乳酸堆积
- 糖元耗尽
- 肌肉失效

合理的训练，通过联系这些因素来给身体施压，以此改善身体素质。以下我们来逐个简单了解一下。

乳酸堆积

踩自行车所需的能量，主要来自两种能源——脂肪和碳水化合物。贮存在体内的碳水化合物被称为“糖元”，当糖元分解产生能量时，在做功的肌肉细胞内便出现了乳酸。乳酸慢慢地从细胞渗透到周围的体液内，然后又被吸收进血液里。当乳酸离开细胞时，会释放出氢离子，变成所谓的“乳酸盐”。当乳酸盐的浓度高到一定程度时，它的酸性会降低肌肉细胞的收缩能力，导致骑手慢下来。

乳酸盐在血液里一直存在，只要身体需要消耗碳水化合物和脂肪来供应各级努力程度的活动所需要的能量——包括你阅读本页内容。但是在运动中，随着糖元消耗的增加，血液中的乳酸盐水平也相应增加。在乳酸盐浓度较低时，身体可以毫无困难地消除和存储这些酸。但随着训练强度从有氧（呼吸轻快）转为无氧（呼吸粗重），乳酸盐最终会达到某个非常高的浓度水平，以致于身体消除它的速度再

so great a level that the body is no longer able to remove it at the same rate it is produced. The resulting lactate accumulation causes short-term fatigue. The only way the rider can deal with it now is to slow down so lactate production is decreased and the body can catch up.

This type of fatigue occurs during brief but extremely high-intensity efforts such as long sprints, bridging to a break or climbing a hill. Thus, the way to improve your body's ability to clear and buffer lactate is by doing short-duration interval workouts that replicate these race conditions.

Depletion of Glycogen

Fat is the primary source of fuel for every ride you do, but as the intensity of the ride varies, the contribution of carbohydrates to energy demand rises and falls considerably. Figure 3.1 illustrates this shift.

Carbohydrates are stored in the muscles and liver as glycogen and in the blood as glucose. A well-nourished athlete has about 1,500 to 2,000 kilocalories of glycogen and glucose packed away, depending on body size and fitness level. That's not much energy. Most of this, about 75 percent, is in the muscles.

The problem is that when glycogen and glucose stores run low, exercise slows considerably, since the body must now rely primarily on fat for fuel, as shown in Figure 3.1. This is called "bonking".

A 2.5-hour race may have an energy cost of 3,000 kilocalories, with perhaps half of that coming from carbohydrate sources. If the rider starts with a low level of glycogen on board and these carbohydrate calories are not replaced during the race, he or she may be forced to abandon the race. The same sorry results may also occur if the rider pedals the bike uneconomically or if general aerobic fitness is poor.

Research reveals that a well-trained athlete is capable of storing greater amounts of carbohydrates while using it more sparingly than

也跟不上它产生的速度。那些堆积的乳酸盐导致短期的疲劳。现在骑手唯一能做的便是减速，从而降低乳酸盐的产生，以便使身体消除乳酸盐的速度能够跟上来。

这种类型的疲劳出现在短促但强度极高的运动环节，比如长冲刺、摆脱大部队和爬坡。因此，增加身体消除和容纳乳酸盐能力的方法便是靠短时间的间歇训练来模拟这样的比赛情况。

糖原耗尽

脂肪是供给你每次骑行的主要能量来源，但随着骑行强度的改变，碳水化合物所供应的能量也相应地增加或降低。图 3.1 展示了这种变化。

碳水化合物以糖原的形式贮存在肌肉和肝脏内，以血糖的形式存储在血液内。一个营养良好的运动员贮存的糖元和血糖大约有 1500—2000 千卡，根据体型和身体素质状况略有不同。这些能量不算多，其中大部分，大约 75%，存储在肌肉里。

当糖元和血糖储备过低时问题就来了，运动不得不相应地放慢，因为现在身体必须主要依靠脂肪来供能了，如图 3.1 所示。我们称之为“糖原耗尽”。

一个 2.5 小时的比赛需要消耗大约 3000 千卡的能量，其中大约一半来自于碳水化合物。如果比赛开始的时候骑手身体存储的糖原水平较低，而在比赛中也没有补充碳水化合物，那么他或她有可能被迫放弃比赛。如果骑手的运动效率不高，或有氧代谢能力不足时，同样会发生这样遗憾的结果。

研究表明，一个良好训练的运动员比起一个没受过训练的人，能储存更多的碳水化合物，并且能更经济地消耗它们。你所习惯的饮

an untrained person. The diet you habitually eat also determines how much fuel is soaked away and how rapidly it is used up. This is discussed in greater detail in Chapter 16.

食也决定了你能吸收多少能量，以及多久后才被耗光。本书 16 章将更详细地讨论之。

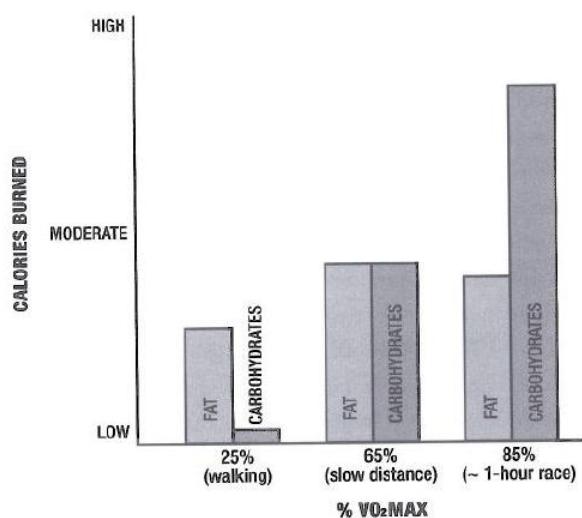


Figure 3.1 Relative contribution of fat and carbohydrate (glycogen and glucose) to exercise fuel at three levels of aerobic capacity (VO₂max).

图 3.1 脂肪与碳水化合物（糖原和血糖）在三种不同有氧能力水平下供能的相对比例。

Muscle Failure

Exactly what causes the cyclist's working muscles to fail to contract forcefully near the end of a long and grueling race is unknown. It is probably related to chemical failure at the point of connection between the nerve and the muscle, or by a protective mechanism in the central nervous system intended to prevent muscle damage.

High-intensity training may help to fortify the body against muscle failure by training the nervous system to recruit more muscles for endurance activity. Working out at high intensity, as when doing intervals, involves more fast-twitch muscles than riding long and slow, which favors slow-twitch muscles. Fast-twitch muscles are not called upon until the effort becomes so great that the slow-twitch muscles can no longer handle the effort. As fast twitchers are recruited to support the slow twitchers during what is basically an endurance activity, such as intervals, they begin to take on some of the slow-twitch

肌肉失效

目前仍然搞不清楚，在一个长而艰苦的比赛临近结束时，骑手的做功肌肉为什么会无法强制收缩。这可能和神经与肌肉之间连接点的化学反应失效有关，或者是中枢神经系统为防止肌肉损伤所做出的保护性机制。

高强度训练能够训练神经系统征召更多肌肉参加耐力运动，从而帮助身体增强抵抗肌肉失效的能力。进行高强度间歇训练更多地使用快收缩肌，而长时间的慢速骑行更多地使用慢收缩肌。快收缩肌只有在运动强度达到慢收缩肌无法满足要求时才会被使用。如果快收缩肌常被用来帮助慢收缩肌完成以耐力为主的运动，比如间歇训练时，它们便开始拥有一些慢收缩肌的特性。这对耐力型运动员来说很有好处。

characteristics. This is of great benefit to the endurance athlete.

Principles of Training

The principles upon which periodization training is based are individualization, progression, overload and specificity. Bear with me here as these may sound somewhat scientific and theoretical. Understanding the principles will make you a better cyclist – one capable of smart self-coaching.

Individualization

The capacity of an athlete to handle a given workload is unique. Each athlete can be considered an ecosystem influenced by three categories of factors – sociocultural, biological, and psychological. Each of these categories has the potential to impede or promote improvement.

Sociocultural factors such as lagging career progression, economic pressure, and poor interpersonal relationships often undercut how much time and energy, both mental and physical, is available for training. Examples of biological factors are allergies, use of drugs, and inadequate nutrition. These factors may restrict the individual's physical ability to train successfully. Psychological factors are perhaps the most overlooked, yet the most likely to compromise the benefits of training. Some examples are fear of failure, low self-esteem, and the unreasonable expectations of others.

In addition, some athletes are “fast responders” while others are “slow responders”. This means that if you and a teammate do exactly the same training in precisely the same way, you probably won't reach a common level of fitness by a given race. Being a slow or fast responder is probably genetic – you may have inherited a body that changes at a given rate. Generally, four to eight weeks of a given type of training are necessary to show significant results. While you can't change how quickly your body responds, you can learn to design your training program

训练原则

周期性训练基于的原则是个性化，阶段性进步，过载和确切性。请多多包涵，这些名词听上去有些学术化和理论化。充分理解这些原则将使你成为更好的车手——一个可以聪明地自我训练的人。

个性化

每个运动员都有独特的方式处理给定的运动负荷。每个运动员都可被视为受三类因素影响的生态系统——社会文化因素，生物学因素和心理学因素。这三类因素中的每一项都可能阻碍或促进你的进步。

社会文化因素，比如职业生涯不顺利，经济压力，和糟糕的人际关系，都会在精神和生理上消耗掉不少本可用于训练的时间和精力。生物学因素的例子，包括过敏，对药物的使用以及营养不足。这些因素会限制个人进行成功的训练所需的体能。心理学因素可能是最容易被忽视，但却最有可能降低训练成效的因素。最典型的例子如：害怕失败，自尊心不足，和对他人的不切实际的期望。

另外，有些运动员是“快速反应者”，而有些是“慢速反应者”。这就意味着，如果你和你的队友以完全相同的方式进行同样的训练，但你可能无法在指定比赛中达到其他人的身体素质水平。你是快速反应者还是慢速反应者主要由遗传决定——你的身体生来就按它自己的节奏来适应变化。一般来说，指定类型的训练要表现明显的效果，需要进行至少4到8周时间。由于你不能改变身体的反应速度，你可以学习根据你独特的个性来设计训练计划。

around your unique characteristics.

The bottom line is that you cannot simply do what others are doing and expect to get the same benefits – or any benefits at all. What is an easy day for one rider may be race effort for another. Chapter 5 and 6 will address the issue of individualizing training to fit your unique set of abilities.

Progression

Have you ever done a workout so hard that you were sore for days afterward and did not have the energy to even ride easily? We've all done that. Such a workout violated the progression principle. The body didn't get stronger, it lost fitness. The workout caused you to waste two very precious resources: time and energy.

The workload must be gradually increased, with intermittent periods of rest and recovery, as the athlete focuses fitness for the most important races of the season. The stresses must be greater than the body is accustomed to handling. The workloads, especially the intensity component, are increased in small increments, usually of 5 to 15 percent. This allows the cyclist to avoid overtraining and injury, yet provides enough stress to allow adaptation to occur. Workload increases are largely individual matters, especially with regard to intensity. Chapter 5 and 6 will guide you through the maze of building race fitness progressively.

Overload

The object of training is to cause the body to positively change in order to better manage the physiological stresses of racing. In order to stress the body, it must be presented with a load that challenges its current state of fitness. Such a load will cause fatigue, followed by recovery and eventually a greater level of fitness known as "over-compensation" (see Figure 3.2)

底线是你不能简单地模仿其他人所做的事，并冀望能获取同样的收益——或哪怕一点点收益。对某个骑手来说很轻松的训练，对另一个人来说可能需要比赛级的努力才能完成。本书第5和第6章讲述了如何根据你特定的能力来制定个性化的训练。

阶段性进步

你有没有做过这样高强度的训练，以致于在接下来的几天中，肌肉一直酸疼，甚至连轻松骑行都无法做？我们都有这样的经历。这样的训练违背了阶段性进步的原则。身体素质并没有因此变得强壮，反而下降了。这种训练浪费了你的两项宝贵资源：时间和精力。

运动负荷必须慢慢增加，并在其中安插一些的休息和恢复期，因为运动员得为赛季里最重要的比赛积累体能。训练压力必须比身体所习惯处理的稍大一些。运动负荷，尤其是强度部分，要一点一点的增加，通常为5—15%。这样骑手就可以避免训练过度和受伤，同时也保持足够的压力让身体适应。运动负荷的增加很大程度上是取决于个人，尤其是涉及强度时。本书第5和第6章将指点你走过迷津，阶段性地建立比赛所需的身体素质。

过载

训练的目的是为了引导身体产生积极的改变，以便能更好地适应比赛时的身体压力。为了给身体压力，就必须施加目前身体素质状态不适应的训练负荷。这样的负荷会引起疲劳，疲劳恢复后，最终将达到一个更高的身体素质水平，这被称为“过量补偿”（参看图3.2）。



Figure 3.2 Overcompensation resulting from a training overload

图 3.2 训练过载引起的过量补偿

Top-level performance is the result of years of well-planned overload resulting in adaptation. This optimum training repeatedly places measured stresses on the athlete. If the workloads are of the right magnitude, slightly more than the body can handle, adaptation occurs and fitness steadily improves.

顶级的运动能力，是多年来周密计划的过载训练经身体适应后的累积结果。这种最优化的训练反复对运动员施加定量的压力。如果训练负荷定量正确，略大于身体所习惯的级别，身体的适应性将发挥作用并使身体素质稳步提高。

It is important to note that overload happens during workouts, but adaptation occurs during rest. It is as if the potential for fitness is produced by training, but the realization of fitness occurs during subsequent rest. If you repeatedly short-change your rest, the body will not continue to improve. You'll actually lose fitness. This is called "overtraining". The biggest mistake I see self-coached athletes make is disregarding their need for rest. Smart athletes know when to abandon a workout early. They know when to do less instead of more. In short, they understand and listen to their bodies. You must learn to do the same. In Chapter 15, I'll teach you some techniques to help you refine this skill.

需要强调的是：过载发生在训练中，而适应发生在休息时。身体素质的潜能，乍一看是由训练产生的，但实际上是在训练后的休息阶段实现的。如果你老是缩短你的休息时间，那么，身体将无法继续进步，从而导致身体素质的损失。这就是“训练过度”。我见过的自我指导的运动员犯的最大错误，就是忽视身体对休息的需要。聪明的运动员知道何时该放弃训练，早早休息，何时该降低训练量。简而言之，他们理解并听从从他们的身体。你必须学习这种能力。在第 15 章，我将教你一些技巧，来帮助你改进这种能力。

If the load of training is decreased for extended periods, the body adapts to lower levels of fitness. We call this "being out of shape". But once a rider has reached optimal fitness, it can be maintained with infrequent, but regular and judiciously spaced stress allowing for increased recovery between hard workouts.

如果在一段时期内训练负荷降低，身体便会自适应并降格到较低的身体素质水平。我们称之为“走样”。不过一旦一个骑手达到了一个理想的身体素质状态，便可通过不太频繁，但有规律的，仔细规定的训练压力来维持，在高难度训练之间可以有较长的恢复期。

Specificity

According to this principle, the stresses applied in training must be similar to the stresses expected in racing. Sometimes the workload must include long, steady distance. At others, brief bouts of high intensity are required to bring the needed changes. Riding slow all the time is just as wrong as always going hard. In Chapter 6, I'll teach you how to isolate the various stresses required in road races and show you how to blend them into a comprehensive program.

确切性

根据这一原则，在训练中施加的压力应和比赛中预计的压力相似。有时训练负荷必须包括一个长而稳定的距离。而其他时间，需要进行高强度的每回合时间较短的间歇训练以促使身体的改变。总是做慢速骑行和一直进行高强度训练都是错误的。在第 6 章，我将教你怎么分析公路赛中需要的各种压力，以及如何将它们融入训练计划中。