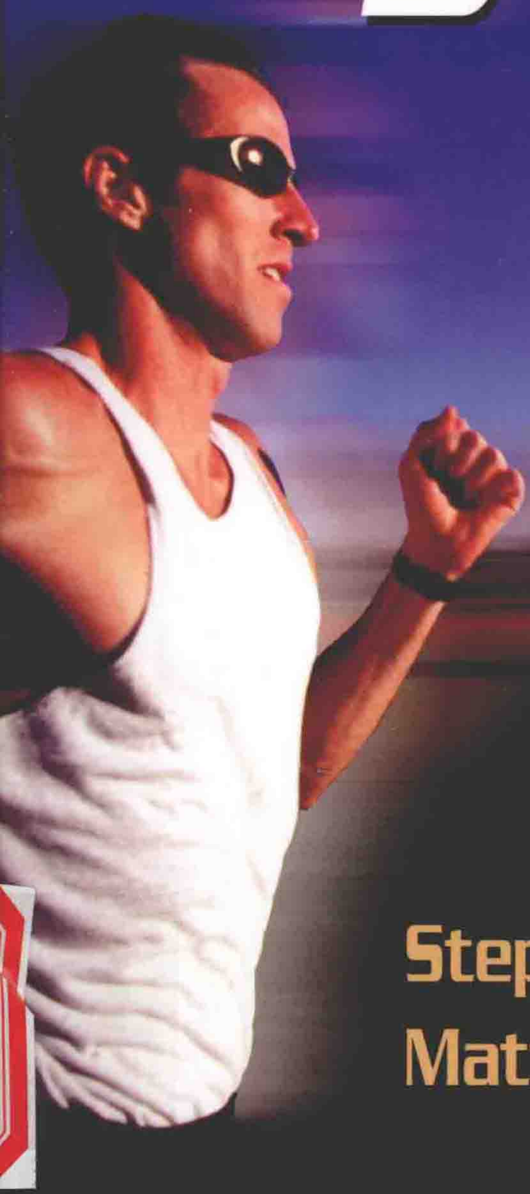
The Runner's Edge



High-tech training for peak performance

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To my mother, Patricia, who is always in my thoughts.

—Stephen McGregor

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Introduction

One of the virtues of the sport of running is how little equipment it requires. Shoes, socks, shorts, and a top are the essentials. Among competitive runners, a stopwatch has also been considered essential, because it allows runners to quantitatively monitor and control their training in ways that ultimately enable them to train more effectively and race faster.

The days of the stopwatch may be numbered, however. That's because a new type of device, commonly known as a speed and distance device, is now able to do what a stopwatch does and much more. A speed and distance device such as the Timex Ironman Triathlon Bodylink is able to measure not just elapsed time but also distance covered, speed (or pace), and elevation change. Many devices also have the capability of estimating calories burned and monitoring heart rate. Other special features vary by brand. For example, Polar speed and distance devices can be used to estimate and track changes in $\dot{V}O_2max$, or the maximum rate at which the body consumes oxygen during running—an important indicator of running fitness. What's more, the software applications that come bundled with speed and distance devices, as well as those that are purchased separately, allow runners to compile and analyze workout and race data in all kinds of helpful ways.

You don't have to be a supercompetitive runner or a gadget whiz to benefit from these technologies. They have something to offer every runner who wants to improve. In fact, thousands of runners of all abilities and levels of experience have already used the tools described in these pages to build greater speed and endurance. Few of these runners can be described as computer geeks. If you can work a stopwatch, you can learn how to manage your performance with a speed and distance device. And don't worry: This process will not strip running of its charming simplicity. In fact, it will allow you to run with an even greater sense of freedom that comes from acquiring the knowledge to truly coach yourself—with a little help from technology.

When the first modern speed and distance devices hit the market in 2002, some running coaches and exercise scientists, including us, quickly realized that they could be much more than just a better stopwatch. We saw that these devices had the potential to revolutionize how runners manage their performance. Essentially, the devices created the possibility for runners of all abilities to digitally coach themselves and to do so as effectively as the top professional coaches train their athletes.

Over the past several years we have worked independently and collaboratively to unleash the full potential of speed and distance devices. Stephen McGregor has done so by developing new training concepts and software tools that runners can use with a speed and distance device to monitor, analyze, and plan their training in ways that are impossible with a mere stopwatch. For example, a feature called normalized graded pace (NGP) or flat pace converts the actual pace on a running route with elevation change to an equivalent pace for level terrain so that runners can compare the challenge level of (and their performance in) workouts performed in different environments. Matt Fitzgerald created a tool called the pace zone index (PZI) that allows runners to easily score their current fitness level and choose the appropriate pace at which to perform each type of workout. Matt also created the first generation of training plains that are downloadable onto a speed and distance device.

Most runners are still unaware that such tools exist; even fewer know how to use them effectively. That's why we wrote this book. The typical runner uses a speed and distance device in more or less the same way drivers use the speedometer and odometer: as a source of basic information that is used in real time to stay within certain vaguely defined parameters. Only a fraction of runners even bother to download workout and race data from the speed and distance device to the computer. That's unfortunate, because the real power of the technology really begins with this action. The performance management software (as we call it) that works with a speed and distance device enables runners to analyze their runs more accurately and far more in depthly than ever before. As a runner, you can use this type of analysis to determine appropriate pace targets for all of your workouts and refine these targets as your fitness changes. You can also program workouts and even complete training plans based on your personal target pace zones and upload them to your speed and distance device.

And this is only the beginning. As you collect run data over time, you can use your software to determine your optimal long-term training load, identify and address strengths and weaknesses in your running fitness, identify periods of overreaching resulting in illness or overtraining, determine your optimal balance of training intensities, identify periods of stagnation in your training, ensure that your training is truly progressive, plan a taper, and define an optimal weekly training regimen. In other words, by learning how to fully exploit the power of your running technology you can achieve total digital performance management of your running. Your confidence and skill as a self-coached runner will reach a whole new level.

This book takes you through the whole process, from choosing a speed and distance device to using it in races. We begin in chapter 1 by describing the uses of speed and distance devices and heart-rate monitors (which may be purchased separately but are integrated within many speed and distance units) and the benefits of using them to their potential. In chapter 2 we present a comprehensive buyer's guide for speed and distance devices and performance management software programs that help runners get more out of their technologies. Chapters 3 through 6 describe the performance management system that we created to help you get the most out of your speed and distance device and the three steps of this system: monitor, analyze, and plan (or MAP). Chapters 7 to 9 will show you how to race with your speed and distance device and create pace-based training plans. We also provide a selection of ready-made plans for various types of runners. Chapter 10 presents specific advice for triathletes. You'll find guidelines on integrating swim, bike, and run training within a unified performance management system.

The workouts, examples, and scenarios presented in this text use a combination of metric and English measurements, such as meters, miles, 5K, 10K, half marathon, and marathon. If you use metric as the standard unit of measurement in all your training, know that all speed and distance devices feature metric options. You can easily convert the English measurements in the text to metric. A few metric conversions are included after imperial measurements in the text.

Acronyms and Abbreviations

ATL: acute training load
bpm: beats per minute
CTL: chronic training load
CV: critical velocity
DEXA: dual-energy X-ray absorptiometry
EPOC: excess postexercise oxygen consumption
FTP: functional threshold pace
GPS: global positioning system
GTC: Garmin Training Center
HRmax: maximum heart rate
IF: intensity factor
kpm: kilometers per hour
LT: lactate threshold
MAP: monitor, analyze, and plan
MLSSv: maximal lactate steady state velocity
mph: miles per hour
NGP: normalized graded pace
PZI: pace zone index
spm: strides per minute
TSB: training stress balance
TSS: training stress score

Contents

CHAPTER

1

Gaining the Technological Advantage

A run can be measured, or quantified, using two basic types of measurement. *Performance measurements*—which we might also call *external measurements*—put into numbers the work accomplished in a run. The two most familiar performance measurements are distance and pace. When you say something like "I ran 6 miles" or "I averaged 7 minutes per mile," you are speaking in terms of performance measurements. The other type of measurement is physiological, or internal. *Physiological measurements* may be used to quantify the effects of a run on the body—that is, how hard the body's various systems are working or how much stress they are being exposed to. Common physiological measurements in running include blood lactate levels, rate of oxygen consumption, and heart rate.

Both external and internal measurements are useful in planning and executing training. For example, by tracking your split times for intervals performed in a certain type of track workout, you can quantify improvements in performance as you periodically repeat the workout. Or by working with a coach who provides lactate testing, which involves giving tiny blood samples during a treadmill workout of increasing intensity, you can quantify improvements in your body's ability to handle the stress of running at any given pace.

Recent technologies have given runners the ability to use performance and physiological measurements more easily and effectively than in the past. Specifically, heart-rate monitors allow runners to monitor the contraction rate of the

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Dai Tamesue trains at Hosei University in Tokyo. Training devices can be used to quantify the work performed during training.

heart—a commonly used indicator of the overall physiological stress of a run—in real time throughout each run as well as during recovery periods in runs and at rest. Before the advent of modern heart-rate monitor technologies, there were no tools for physiological measurements that runners could use on their own. They had to go to university laboratories for $\dot{V}O_2max$ tests and other tests.

More recently, a new generation of speed and distance devices based on global positioning system (GPS) and accelerometer technologies has given runners the ability to make accurate and continuous performance measurements in every run. Previously, the best we could do was go to the local track and get split times at the end of every lap or measure road routes with a car odometer and make paint marks at every mile or kilometer.

Heart-rate monitors and speed and distance devices each have several specific uses that help runners train more effectively. But the greatest benefits accrue when runners integrate all of these individual uses within a cohesive system that we call performance management. Chapter 3 presents an overview of the three-step performance management system. Chapters 4, 5, and 6 provide concrete guidelines for executing each of these three steps: monitoring, analyzing, and planning. In this chapter, we focus on the specific uses of heart-rate monitors and speed and distance devices. This is a general overview of the benefits of running and racing with technology. The specific guidelines you will need in order to realize these benefits are detailed in subsequent chapters.

HEART RATE 101

A Finnish company, Polar Electro, developed the first wireless heart-rate monitor in 1977. This device used electrodes contained in a strap worn around the chest to capture the spikes in electrical activity that occur each time the heart muscle contracts. This captured information was then transmitted to a display watch worn on the wrist, which provided a real-time readout of heart rate. Today's heart-rate monitors offer many more bells and whistles, but they still perform their basic function of monitoring heart rate in the same way.

Heart-rate monitors became very popular among runners, cyclists, triathletes, other endurance athletes, and even general exercisers after the late 1970s. The rationale for their use was readily understood, especially by endurance athletes. Runners, for example, are accustomed to targeting one or more specific running intensities in workouts to stimulate a desired training effect—as each running intensity triggers slightly different physiological adaptations. Heart rate has a well-known positive correlation with exercise intensity. The more rapidly and forcefully the working muscles contract during exercise, the more rapidly the heart muscle must contract to provide enough oxygen to enable the working muscles to continue working as hard as they are trying to work. When consumer heart-rate monitors hit the market, runners immediately recognized these devices as tools enabling them to aim at fairly precise numerical targets in their efforts to perform each run at the correct physiological intensity for the workout's purpose, instead of just going by feel. For example, research has shown that the working muscles metabolize fat as fuel at the highest rate at an intensity that corresponds with 75 to 80 percent of maximum heart rate in the average trained endurance athlete. A runner with a heart-rate monitor can use this knowledge to control his or her pace to stay within this heart-rate zone when performing long runs designed to increase fat-burning ability. This physiological approach enhances endurance because fat is a far more abundant muscle fuel source than the other major muscle fuel, carbohydrate. Fatigue in prolonged efforts often occurs when the carbohydrate stores of the working muscles are depleted. When fat-burning capacity is increased, the runner is able to rely more on fat to fuel running and thereby spare carbohydrate and delay the point of fatigue.

The runners who chose to use heart-rate monitors, their coaches, and exercise scientists who conducted research with heart-rate monitors quickly developed a set of standard uses for the devices. Over the past 20 years or so, these standard uses have evolved slightly to account for certain limitations of heart-rate monitoring as a tool for physiological measurement. And most recently, the advent of speed and distance devices has provided runners with new uses for heart-rate monitoring in its rightful role as an adjunct to pace monitoring.

FOUR USES OF A HEART-RATE MONITOR

Heart-rate monitors have four main uses. Use the device to maintain target heart rates in workouts, track changes in fitness, monitor your recovery status, and quantify the stress of individual workouts.

Maintain Target Heart Rates in Workouts

By far the most common use for heart-rate monitors is to facilitate training at the appropriate intensity in workouts. If you know the heart-rate range that is associated with the specific training stimulus you seek in a given run, or segment of a run, then you can check your display watch periodically throughout the workout and adjust your pace as necessary without having to worry about your pace or having to rely entirely on perceived exertion to control your effort. Table 1.1 presents a summary of the primary physiological training effects associated with training at various heart rates.

Table 1.1 Physiological Adaptations Associated With Training at Various Heart Rates

Percentage of maximum heart rate	Physiological adaptation	Fitness benefit
60–70	Increased muscle mitochondria density Increased capillary density Increased aerobic enzyme activity Increased fat oxidation capacity	Increased aerobic capacity (minimal) Increased endurance (moderate)
71–75	Increased muscle mitochondria density Increased capillary density Increased aerobic enzyme activity Increase carbohydrate oxidation capacity Increased muscle glycogen storage	Increased aerobic capacity (minimal) Increased fatigue resistance at moderate paces (moderate)
76–80	Increased heart stroke volume Increased muscle mitochondria density Increased capillary density Increased aerobic enzyme activity Increase carbohydrate oxidation capacity Increased muscle glycogen storage Increased oxygen transport capacity	Increased aerobic capacity (moderate) Increased resistance to fatigue at marathon pace (strong)
81–90	Increased heart stroke volume Increased oxygen transport capacity Increased carbohydrate oxidation capacity Increased neuromuscular coordination Increased lactate shuttling and metabolism	Increased aerobic capacity (moderate) Increased running economy Increased fatigue resistance at half-marathon to 10K pace (strong)
91–100	Increased heart stroke volume Increased fast-twitch muscle fiber recruitment Increased resistance to muscle cell depolarization Increased stride power Increased neuromuscular coordination	Increased aerobic capacity (strong) Increased anaerobic capacity (moderate) Increased speed Increased running economy Increased fatigue resistance at 5K to 1,500 m pace (strong)

The earliest attempts to develop target heart-rate training methodologies were aimed at producing one-size-fits-all protocols that worked for people at all fitness levels in every sport. Simple formulas were used to establish heart-rate zones that divided the heart-rate continuum into levels between recovery intensity and maximum intensity. The simplest and most primitive methodology used the formula of 220 beats per minute (bpm) minus age in years to determine an individual maximum heart rate and a table such as table 1.1 to establish individual target heart-rate zones based on the maximum heart-rate value.

It didn't take very long for athletes, coaches, and exercise scientists to discover major flaws in such one-size-fits-all protocols. First of all, it was observed that maximum heart-rate values, as well as the percentage of maximum heart rate (HRmax) that could be sustained for any given time, varied considerably from activity to activity. For example, runners can generally achieve higher heart rates than cyclists, who in turn can achieve higher heart rates than swimmers.

Further complicating matters, testing showed that the formula of 220 minus age was inaccurate for most athletes. What's more, it was discovered that uniform target heart-rate zones based on percentages of maximum heart rate often were not appropriate for individual athletes, and typically became more or less appropriate for individual athletes as their fitness levels changed. For example, some target heart-rate zone tables established lactate threshold heart rate as 81 to 90 percent of HRmax. (Lactate threshold is the exercise intensity level above which lactate begins to accumulate rapidly in the blood, and it usually corresponds to roughly one hour of maximum effort in trained athletes.) There are three major problems with these zones:

1. The actual lactate threshold heart rate for any individual athlete is much more specific than a full 10 percentage point range.
2. As a percentage of maximum heart rate, lactate threshold values vary considerably among athletes, from as low as 70 percent of HRmax to more than 90 percent.
3. The lactate threshold heart rate of each athlete changes with his or her fitness level.

Fortunately, a few noteworthy experts have since developed better methodologies for establishing target heart-rate zones that overcome these flaws. One of the best was developed by our colleague Joe Friel. It ignores HRmax completely and instead bases target heart-rate zones on lactate threshold heart rate, which is determined through field testing. The simplest field test for lactate threshold heart rate is to run a 30-minute time trial (after a thorough warm-up) at a steady pace. Your average heart rate for the final 10 minutes is considered your lactate threshold heart rate, although it's actually somewhat higher than the value that would be arrived at through laboratory testing. You then look up this value on a table for your specific sport—in this case running—which gives you target heart-rate zones for all of the training zones in Friel's system. Following is a listing of the approximate heart-rate range associated with each zone for running. To establish your zones, you would multiply your lactate threshold heart rate (LT HR) by the percentage associated with the bottom and top of each zone.

Zone 1: Active recovery (>80% of LT HR)
Zone 2: Aerobic threshold (81 to 89% of LT HR)
Zone 3: Tempo (90 to 95% LT HR)
Zone 4: Sublactate threshold (96 to 99% LT HR)
Zone 5a: Lactate threshold (100 to 101% LT HR)
Zone 5b: Aerobic capacity (102 to 105% LT HR)
Zone 5c: Anaerobic capacity (>106% LT HR)

The final step in the process is to repeat your lactate threshold field test every few weeks and adjust your target heart-rate zones to match changes in your fitness level.

The advent of speed and distance technology has made possible an even simpler and more accurate way to establish target heart-rate zones. All you have to do is wear your heart-rate monitor while performing pace-based workouts such as those using the pace zone index (PZI) system presented in chapter 4. Press the Lap button on the display watch at the beginning and end of a segment of the run that is performed at a given target pace. After completing the workout, download the data and inspect the graph of each workout to determine the heart rate that is associated with each target pace. Since no single workout ever encompasses every target pace (there are six separate target pace zones in the PZI system), repeat this process in different workouts until you have covered all of the target pace zones and found the heart rate associated with each.

While we recommend that you rely mainly on pace to monitor and control the intensity of your runs, heart-rate zones established through pace-based training can be a good substitute whenever you are unable to train with your speed and distance device.

Track Changes in Fitness

You can use heart-rate monitors in a few different ways to track changes in fitness level. One way is called ***orthostatic testing***. Put on your heart-rate monitor, lie down for a few minutes, and note your heart rate. Now stand up, wait 15 seconds, and note your heart rate again. Your second heart-rate measurement most likely will be 15 to 30 bpm higher than the first. If you perform orthostatic testing regularly while training toward peak fitness, the difference between the