Sprint Interval Training - "It's a HIIT!"

A research paper discussing the superior health and performance benefits of high-intensity intermittent exercise over low- to moderate-intensity continuous exercise.

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Introduction

By HIIT, I do not mean that it is popular (although, finally and thankfully, it is certainly becoming so), but rather, that sprint interval training (SIT) is also referred to as high-intensity interval training or HIIT. It is of major importance that health care professionals make sure that the general public, as well as many contemporaries, get thoroughly educated about the superior health and fitness benefits of SIT, or "burst" training, as compared to low- to moderate-intensity continuous training (LMICT). This is because, despite research to the contrary, most people still believe that to develop a healthy heart and to lose weight, the best mode of exercise is long and continuous "cardio" exercise, which, inherently, requires a significant investment of time. And, of course, lack of time is the number one excuse given for not complying with an exercise program. Before getting into the health and fitness benefits of SIT or HIIT, I want to make some clarifications about the definitions and also make a few comments about training for individuals that want to take part or compete in endurance events.

Interval training refers to intermittent exercise involving periods of exercise followed by periods of recovery, which enables anyone to increase the intensity of the exercise workload. A pretty simple concept. The problem, however, with the term "high-intensity" is that it is descriptive and, obviously, relative to an individual's level of fitness and dependant upon one's tolerance to exertion. Running at five miles per hour may be an all-out effort for some, whereas, it may be a walk in the park for others. While it is easy to assign relative exercise intensities for both training and research purposes by first measuring maximal capacities, one also needs to understand that the term "high-intensity" is used in the scientific literature to describe intensities ranging from as low as 85% of maximal oxygen uptake (VO_2 max or aerobic capacity) to as high as 250%. These intensities also need clarifying for people who incorrectly assume that 100% VO_2 max indicates an all-out effort, which is not the case; if it did, studies could not prescribe intensities above 100% VO_2 max. These exercise intensities are related to the maximal workload achieved when measuring an individual's VO_2 max in a progressively-graded exercise stress test that can last for 10 or more minutes. This is not the same as asking someone to sprint as fast as they can for, say, 20 seconds; the workload or speed, in this case, would be considerably higher than the workload corresponding to 100% VO_2 max. For example, if the workload on a treadmill eliciting VO_2 max was 8 mph at a 5%

grade, then a workload corresponding to 150% VO_2 max would be 12 mph at a 5% grade (i.e., one and a half times the VO_2 max workload). Further, for many individuals, even this workload would be well short of an all-out effort. When one is exercising above 100% VO_2 max, it is termed "supra-maximal" and essentially defines SIT. Because of the wide range of intensities reported in the research for HIIT, the duration of the exercise interval can also range from as low as six seconds to as high as four minutes and sometimes even longer. Further, the recovery interval used in HIIT can vary considerably. As a consequence, these issues need to be elucidated when using the term "HIIT" because, when used alone, it can be limiting in terms of understanding the exercise prescription. In contrast, SIT defines a narrower range of intensities that essentially fall within a time constraint of one minute or less. This is simply because, for any human, the intensity of a maximal effort drops off precipitously when the duration goes beyond sixty seconds.

Now, the necessary LMICT that endurance athletes employ in their conditioning programs is irrelevant in the scope of this article since I am not arguing that endurance athletes do not need to do "volume" training. I will, however, argue that endurance athletes, while extremely impressive in their physical accomplishments, are not the healthier athletes when compared to sprinters. Further, while the endurance athlete has a need to maintain a high submaximal intensity for long periods to be successful, the vast majority of athletes, and certainly humans in general, have no need for this type of activity as will be discussed later. It is also noteworthy that interval training is not some new concept to the endurance athlete. They have long employed SIT and HIIT and, for many elite endurance athletes today, HIIT can comprise as much as 50 to 75% of their total training volume. I do not think the average person starting an exercise program realizes this; rather, I believe they think athletes such as Lance Armstrong simply ride their bikes nonstop to achieve their incredible levels of cardiovascular endurance. While there is considerable debate as to the magnitude of the intensity and how much interval training an endurance athlete should include in his or her conditioning program, all successful endurance athletes employ a significant amount of HIIT in their training protocols. However, the HIIT many typically employ is, relatively, at the low end of the intensity spectrum with work intervals often lasting four or more minutes in length. As will be demonstrated in this article, I believe even the endurance athlete would benefit considerably by reducing their volume training and supplementing their “low- to moderate-intensity” HIIT with a significant amount of supra-maximal HIIT. This thought is supported by a study that investigated the relationship between tests of anaerobic (non-oxidative metabolism) power and 10K running performance and which demonstrated that all tests of anaerobic power were significantly correlated with 10K run time and just one plyometric leap test accounted for nearly 75% of the variance in 10K run time[1]. When combined with the 300-m sprint time, the variance in 10K run time increased to nearly 80%. However, the wisdom of my recommendation to the endurance athlete is relatively unimportant when one considers that the most pressing issue for society is getting the general public to engage in a successful exercise program that improves their overall health, not to help them cross the finish line in April near Fenway Park.

Superior Benefits of High-Intensity Intermittent Exercise

So, back to the education about the superior health and fitness benefits of HIIT. I have been at the forefront of this issue since the mid-1990s and, I can say with experience, it has been an uphill battle to undo some very indoctrinated thinking. The reason for this indoctrination is likely due to a number of causes – chief among them is the fact that early sport science research focused, from a relative perspective, almost exclusively, on LMICT. This then led to a saturation of the scientific journals with this type of research. So why this focus?

Historical Perspective of Exercise Recommendations

One can never be certain as to why history takes its course; however, in my opinion, a pioneering article by Hollowszy in 1967 likely led the way for a concentrated examination of the effect continuous exercise had on oxidative metabolism[2]. The study demonstrated a twofold increase in mitochondrial enzymes (i.e., an increase in aerobic capacity) of rat skeletal muscle in response to strenuous treadmill running. While the majority of the early studies that followed continued to focus on the effect continuous exercise had on oxidative metabolism, some researchers did examine HIIT. Interestingly, Hollowszy’s running protocol, by the end of the 12-week training period, included 12, 30-second sprints. Unfortunately, the physiological effect of the sprints was not differentiated from the majority of the continuous running by the rats. Edwards, et al. conducted the first detailed analysis of cardiorespiratory and metabolic adaptations to continuous versus intermittent exercise as early as 1973[3]. Despite the equal power output of the exercise protocols, intermittent exercise, as compared to continuous exercise, was shown to elicit higher heart rate, ventilation, oxygen utilization and lactate production, which was attributed to a lower work efficiency with HIIT. While some may hear a lower work efficiency as a bad thing, when it comes to exercise and improving health and fitness, I am constantly telling people that we want to be like an inefficient high-octane fuel engine, much like a high performance Ferrari with poor gas milage, not a fuel-efficient diesel truck! In 1977, another study compared continuous versus interval training of a matched daily workload[4]. It was discovered that both training protocols had a similar improvement (i.e., approximately 26 minutes) in cycling time to exhaustion at 90% VO_2 max, despite the significantly lower time commitment of the interval training. So, although studies in the earlier days of exercise science did demonstrate the effectiveness of HIIT, another pioneering study by Gollnick et al. chose to examine the effect of continuous endurance training upon muscle physiology and further focused the spotlight on this type of training[5]. At around the same time, the running craze of the 70's, which made jogging a popular activity, coincided with the developing sport science discipline. Further, the metabolic respiratory equipment at that time did not have the ability to measure oxygen concentrations from small volumes of expired air (what is now called, breath by breath analysis) and it was less complicated to measure expired air from one long bout of continuous exercise rather than multiple bouts of high-intensity exercise. This likely biased the research toward activities that were of a long, continuous duration and, by natural default, activities that were of a low- to moderate-intensity. Try sprinting for 20 minutes or, for that matter, just more than only one minute. As a consequence, the published research from the late 70's to the mid 90's, which clearly resulted in a disproportionate focus on LMICT, had a profound influence on the medical community, the fitness industry, and even the sports conditioning world. It is somewhat ironic that one of the pioneers of exercise physiology, Per-Olof Åstrand, who presented the method of how to measure maximal aerobic capacity at the 1967 Proceedings of the International Symposium on Physical Activity and Cardiovascular Health, warned that "too often bold conclusions about the individual's physical fitness and maximal performance are drawn from knowledge of [their] maximal oxygen uptake."[6]

Ultimately, the training affect on the cardiovascular system and oxidative metabolism from LMICT led to it being labeled "cardio" or "aerobic" exercise and to the thought process that this type of training, and only this type of training, would positively condition the cardiovascular system. This same process and resultant thinking played out with the research examining fat metabolism and "burning" fat stores. It eventually lead to the early American College of Sports Medicine guidelines that spread the doctrine of engaging in rhythmical "aerobic" activities three to five times per week, for 20 to 60 minutes at an intensity of 60-90% of maximal heart rate reserve or 50-85% of maximal aerobic capacity[7]. As already noted, the recommended duration of exercise was heavily influenced by the metabolic equipment of that time, which, in turn, dictated the exercise intensity; anyone exercising at 60-90% of their maximal heart rate reserve will, by physiological default, last about 20 to 60 minutes. Further, I do not think it is a coincidence that the recommended frequency of exercise paralleled the timetable of academic classes of the students who invariably became subjects for the research that influenced these very recommendations!

While I do not dispute the positive effects reported in the research from LMICT, it is now clear from recent research that, when one factors in the overall health and performance benefits, as well as the investment of time, HIIT trumps LMICT every time. HIIT produces a whole host of health benefits, including cardiovascular health and fat loss, which are the most common reasons people engage in an exercise program in the first place. Whenever researchers have compared these two types of training regimes, side by side, the HIIT has always matched LMICT, and usually produced more favorable results, with a much lower investment of time. So, clearly, this message is extremely important given that the time commitment is invariably given as the main excuse for not starting or sticking with an exercise program. Well, effective HIIT programs for improving cardiovascular endurance and body composition require significantly less time than traditional "cardio" programs. So, with some simple education, we can immediately eradicate the main excuse for not exercising – I think that is a good reason to make sure that everyone is not ignorant to the research. The somewhat surprised look on the faces of the health care professionals attending the seminars I speak at transcends the depth of indoctrination the early research has created. The reason I say this is because if one simply stands back from science and looks at this from a common sense perspective, it is far more logical that HIIT would be more effective than LMICT.

High-intensity Intermittent Training from a Common Sense Viewpoint

Throughout humankind's development, short-duration, high-intensity exercise has been a prerequisite for both survival and human progression. In primal times, humans, for the most part, would not have moved long distances by running slowly or "jogging" as our modern world likes to call it; rather, they would have walked because, from an energy perspective, it is the most efficient form of gait. In comparison, humans running at high speeds are energetically inefficient[8]. Having said that, throughout a day, short, vigorous bouts of activity would be required for hunting, gathering, carrying, digging and escaping danger[9]. One can easily imagine that jogging through fields and forests would not be a particularly effective hunting strategy. However, research examining the few primitive tribes left on the planet demonstrated that a very healthy aerobic capacity, along with a lean physique, was always found without the daily 30 to 60 minutes of continuous "cardio" training that so many feel they need to endure to be lean and possess a healthy heart[10]. Further, the biochemical make-up of human muscle fibers is not comparable to truly superb endurance creatures[11]. In the animal kingdom, humans, while no cheetah, are a long way from, for example, ducks that can fly vast distances without breaking a sweat.

Athletes have long been held in high regard for their physiques and fitness levels. In the early days of sports, and prior to the professionalism of current day conditioning programs, athletes simply attained their fitness from engaging in their respective sport. Well, the vast majority of sports are interval based – meaning that the activity comprises short bursts of high-intensity exercise followed by rest or a recovery period of low-intensity. When I conduct my seminars, I usually ask the audience to shout out a list of sports. On many occasions, none of the sports that are offered fit the mold of a continuous endurance activity (which is not that surprising since so few sports do fit that description). When they are offered, such as distance running, cycling or swimming, they are vastly outnumbered by the deluge of sports the audience races to name. Go ahead, start naming a few of your favorites. Perhaps you are a fan of football, baseball, tennis, golf, basketball, hockey (ice or field - still the same), soccer, rugby, skiing, snow-boarding, volleyball, or . . . I think you get the point! The vast majority of sports are interval-based and you can get cardiovascularly fit and lose the fat by simply playing the sport, none of which, ever require engaging in moderate-intensity continuous activity[12]. In a very recent study published in the Journal of

Strength and Conditioning Research, it was shown that the ability to perform in high-intensity intermittent ice skating was poorly correlated to VO_2 max and that VO_2 max accounted for only 17.8% of the variance in performance[13]. However, it was further noted that the subjects did have high aerobic capacities attributable to the frequent HIIT commonly seen in hockey training. One can also simply observe athletes engaging in high-intensity activities of short duration and appreciate the stress and subsequent training effect upon the cardiovascular system. Last years' IAAF World Championships in Athletics (Track and Field) provided ample evidence of how cardiovascularly challenging high-intensity, short-duration events can be. The interviews with the winners of the 100, 200, and 400 meter sprints, events all lasting well under a minute, clearly demonstrated how out of breath the athletes were. If these events were not challenging to the cardiorespiratory system, common sense would tell you that the athletes would be able to converse without labored breathing.

Another common sense perspective is to think about the activity profiles of young children. An observational study of children playing under free-ranging natural conditions showed a pattern of very short bursts of intense physical activity interspersed with varying intervals of low and moderate intensity.[14] It seems to me that we are naturally wired for HIIT rather than LMICT.

Cardiovascular Health and High-intensity Intermittent Training Research

Okay, so let us take a look at some of the research that should help direct people in a more successful direction and might also bring some "cardio" junkies to discover a more effective and time-efficient exercise regime. One of the first points I like to emphasize is that in 1995, the American College of Sports Medicine (ACSM) and the Centers for Disease Control and Prevention (CDCP) convened to assess the, then, current research and to produce a position statement with respect to exercise guidelines[15]. Much of the motivation came from the lack of success that the guidelines of that time were producing. A pertinent conclusion from the study was "accumulation of physical activity in intermittent, short bouts is considered an appropriate approach to achieving the activity goal" and that activity goal should be to utilize between 120 and 210 calories a day due to exercise. It is worth noting here that this caloric goal is easily accomplished with HIIT in short order. Perhaps the most positive outcome of this position statement was that it appeared to trigger a much needed increase in research comparing HIIT with LMICT. Coincidence or not, in 1996, Tabata et al. examined the effect of six weeks of moderate-intensity endurance training (70% VO_2 max, 60 minutes per day, five days per week) compared to six weeks of HIIT (170% VO_2 max, 7-8 sets of 20 seconds with 10 seconds recovery between bouts; so SIT in this case)[16]. Both training methods significantly increased VO_2 max (aerobic capacity); however, while the endurance training had no impact on the anaerobic capacity, HIIT increased it by 28%. It was, therefore, concluded that the HIIT imposed intensive stimuli on both energy systems. A two for one then, anyone out there not wanting that? Of course, unless you understand the importance of having a well developed anaerobic metabolism one might not be impressed by these findings. Although one should, simply by the fact that the HIIT had the same improvement in the aerobic capacity in a fifteenth of the time. Yes, you did read that correctly. Compared to 60 minutes of endurance training, a high-intensity intermittent workout, lasting less than four minutes, produced a comparable increase in VO_2 max while simultaneously increasing the anaerobic capacity. And, having a high anaerobic capacity makes your overall functional capacity and resultant quality of life, as well as performance, much greater. Tabata's study demonstrates an extremely time-effective approach to exercise, particularly for those individuals who lack the time or desire for lengthy workouts. It also has obvious implications upon the training programs of athletes from interval-based sports, since they require a high anaerobic capacity and the endurance to reproduce multiple repetitions of high energy output. Studies such as this, that compare training protocols side by side, are particularly powerful. A very recent and similar study by Gibala, et al. compared the effect of low volume SIT with high volume endurance training (ET) upon exercise performance and muscle adaptations[17]. Both training protocols utilized six training sessions over the course of just two weeks, on the Monday, Wednesday and Friday of each week. The SIT consisted of four to six repeats of 30 second "all out" cycling (approximately 250% of VO_2 max) with four minutes of recovery between each repetition and the ET consisted of 90 to 120 minutes of continuous cycling at approximately 65% VO_2 max. This resulted in a 90%, yes 90%, lower training volume for the SIT (630 kJ) versus the ET (6500 kJ) and nearly a fifth of the time commitment. Omitting the recovery intervals, the actual exercise time for the ET (630 minutes) was 42 times greater than for the SIT (15 minutes). Despite the large disparity in the time commitment of the two training protocols, both groups had similar improvements in two self-paced cycling time trials that required approximately two and 60 minutes to complete. Additionally, similar increases were seen in muscle oxidative capacity, buffering capacity (ability to process lactic acid) and glycogen content (muscle fuel). While it is impressive that similar physiological and performance adaptations took place; despite a large difference in the training volume, I suspect that a time trial lasting only one minute may well have produced a better performance from the SIT group than the ET group because of the greater anaerobic contribution in an activity lasting one minute as compared to two minutes. Either way, the study clearly demonstrates, again, the superior time efficiency of SIT to LMICT and that SIT is effective at improving the ability to perform LMICT when required. In a previous study from the same research group, it had been shown that a very similar SIT protocol elicited a twofold increase in cycle endurance capacity, measured as time to fatigue at 80% VO_2 max (an average of 26 minutes pre training to an average of 51 minutes post training)[18]. This study by Burgomaster et al. further demonstrated that muscle oxidative potential, as measured by an increase in citrate synthase (CS) maximal activity (a marker for oxidative metabolism) increased 38% and resting muscle glycogen content increased by 26%, another benefit for improving performance. But the ability to double one's endurance capacity in just two weeks utilizing only 16 minutes of SIT is worthy of some major publicity. While the results of the study did reach the media, the news was typically lost in the vast sea of "cardio" dogma. The study also brought to light a very important principle when it comes to SIT. Para et al. had previously shown an increase in muscle oxidative potential with daily SIT but without an improvement in anaerobic work capacity[19]. It was concluded that chronic fatigue may have contributed to the lack of an improvement in this important physiological parameter; however, the study by Burgomaster et al. was able to demonstrate an improvement in peak power output, a marker of anaerobic performance, while simultaneously improving endurance capacity using less training days and more rest days. So, when it comes to SIT, less can be more; so, focus on quality not quantity. I have long said, "inactivity is a bad thing but rest is a good thing and there is a big difference between the two." It is during rest that the body adapts to the stress of exercise and it is particularly relevant when resting from SIT or HIIT where it has been shown that very short time periods of activity can have a significant physiological effect.

There are a vast number of studies that lend considerable support to the argument that SIT, compared to

LMICT, has an equal or greater cardiovascular training affect while simultaneously improving anaerobic capacity. A study that examined the anaerobic capacity of untrained, endurance-trained, and sprint-trained young men, showed that there was no difference in anaerobic capacity between the untrained and endurance-trained subjects; whereas, the anaerobic capacity of the sprinters was 30% greater[20]. This study demonstrated that the endurance training utilized by the endurance-trained subjects (namely, LMICT) had little impact on their anaerobic capacity while, SIT, the training employed by the sprint-trained men, significantly elevated it. Because of the LMICT dogma that exists within the medical field and fitness community, many people are often surprised to learn of the positive physiological effect SIT has on the cardiovascular system and aerobic capacity of an individual. But, studies examining the kinetics of oxygen uptake during short-term intense exercise reveal that the contribution of oxidative metabolism is early and significant. This very important finding has been classically misunderstood by the medical and fitness industries and is perhaps one of the main reasons for such a bias toward long-duration "cardio" exercise. As early as the late 1980s, studies had demonstrated oxidative energy contributions as high as 40% in intense exercise lasting 30 seconds and 50% for exercise lasting a minute[21,22]. More recent studies have shown an even greater contribution. It has been discovered that a threefold increase in muscle oxygen uptake can take place within only six seconds of intense activity (peaking at 50 seconds)[23] and that oxidative metabolism can contribute as much as 40% within 15 seconds of short-term exhaustive running (peaking as soon as 25 seconds at 79% of VO_2 max)[24]. Further, a comparison of the 30-second Wingate anaerobic power test and a graded VO_2 max cycle ergometer test, showed a significant difference in muscle deoxygenation[25]. During the Wingate test, deoxygenation reached 80% of the established maximum value, whereas, in the VO_2 max test, it reached only 36%. Significantly, there was no delay in the onset of deoxygenation in the Wingate test, while it did not occur under low intensity work in the VO_2 max test. Another study that examined 10, 6-second maximal sprints with 30 seconds of recovery between sprints, showed a slow decline in power output without a change in muscle lactate indicating a large contribution from oxidative (aerobic) metabolism[26].

So what does all this research actually demonstrate? Well, it shows that when you exercise with a maximal effort, your cardiovascular system and aerobic metabolism go on "full burner" to provide you as much energy as quickly as it can – it actually cannot provide all the energy needed (this is where your anaerobic metabolism comes into play), but it will give you everything it has. This is actually easy to appreciate when examined from the perspective of an example. If you were to go hiking up a mountain trail that you anticipated would take approximately one hour to get to the top, you would pace yourself so as to not get fatigued too quickly even if it was your goal to make it as fast as you could. On the other hand, if a mountain lion arrived on the scene, you had better hope that you can find some form of cover pretty quickly. Let us say you were able to sprint to a tree in approximately one minute and climb out of harm's way (we are assuming, of course, this lion's climbing ability is not that good!). Now, a simple question. Are you breathing harder after escaping the lion or after reaching the summit of the trail? I know you know the answer to this and common sense should tell you that escaping that lion would place an immediate stress on your cardiovascular system and aerobic metabolism, which is one reason why you are breathing so hard. A very basic physiological principle is that the human body adapts to stress; so, if you escape mountain lions on a regular basis or, better still, mimic the running part of it in a more controlled environment, your body is going to change for the better. The study by Tabata et al., discussed earlier, is a good example. Another reason you would be breathing very hard (and harder than after the reaching the trail summit) is that you are now needing additional oxygen to replenish significant energy stores that were hastily utilized, via non-oxidative metabolic pathways, to save your life. You would also be needing to deal with the large amounts of lactic acid that accumulated in your muscles as a result of this anaerobic effort. This additional oxygen consumption following exercise is termed "oxygen debt" or "excess post-exercise oxygen consumption" (EPOC). EPOC is a particularly important issue when addressing fat loss and it is important to remember from this example that the intensity of an exercise, as opposed to the duration, has the greatest influence on the magnitude of this elevated oxygen consumption. And, this elevated oxygen consumption continues to have a training effect on the body, as well as to simply continue burning calories, even after the actual activity has ceased.

HIIT for the Deconditioned Individual

An objection, or perhaps a concern, I frequently hear from health care professionals, as well as the general populous, is that HIIT or SIT might be applicable for an athletic population but that it has no place in the protocols for individuals that are deconditioned, obese or have cardiovascular disease. Interestingly, however, it is the general public who is often more accepting of this approach to exercise; of course, it is often easier to educate those with a blank slate than those with a partially completed scroll. While I can certainly appreciate why many people would think that HIIT might be dangerous for a deconditioned individual, it could not be farther from the truth. First, Albert et al. reported, in the New England Journal of Medicine, that the absolute risk of sudden death from vigorous exercise is less than one in 1.5 million and, importantly, this very small risk is actually attenuated with habitual vigorous exercise[27]. Also, this finding did not take into account that some sudden deaths due to vigorous exercise were as a result of non controlled vigorous exercise – meaning, there would have been external pressures to engage in the activity. Again, a basic physiological principle is that the body adapts to stress. If you ask a very deconditioned individual to ride a bike or go for a run for 20 to 60 minutes, the intensity they will be able to maintain for that length of time will be about a nano-calorie above sitting on the couch eating ice cream. However, if they are told to exercise for just 20 to 60 seconds, even the most deconditioned individual can attain an intensity that will be both challenging and safe. I would argue that the thought process that high-intensity exercise is unsafe for unfit individuals and that one should only prescribe LMICT to this population is, although perhaps counter intuitive, a dangerous one. This is because, at some point in time, life will require a burst of high-intensity exercise without much of a thought going into the decision of whether or not one is fit enough to do so. If someone is trying to haul two heavy bags to catch their connecting flight or they are clearing snow to allow them to make it to an important meeting, the pressure of making that plane or meeting will typically override any concern for whether they have the necessary conditioning to safely accomplish that level of exertion. But when you ask that same deconditioned individual to give it all they have without the pressure of an external goal, they will stay within their comfort level. In fact, it is more common that they will leave plenty in the tank when they are first beginning with HIIT and, so long as there is a modicum of exertion, this is just fine as they can progress over time. I am always telling people that they do not have to become an Olympic athlete overnight and taking it relatively easily in the first couple of weeks is a great approach. But, as they start to see improvements in their level of cardiorespiratory conditioning, they need to go harder not longer. This is key, upon seeing improvements, too many people look to increase the length of the exercise interval. As soon as they do this, the most important ingredient for initiating a physiological change, the intensity of the exercise, will have been significantly diminished. Remember that it is about quality not quantity.

Well, apart from my own clinical experience, what other evidence do I have to argue that HIIT is an appropriate method of exercise for the deconditioned? Although it surprises many people, there is actually a significant body of research supporting HIIT for a deconditioned population. Because of the damage that a myocardial infarction (MI) has on heart muscle, a population of stable, post-infarction heart failure patients is about as deconditioned as you are going to see. In this population, it is quite typical to see VO_2 max values (expressed as $ml \cdot kg^{-1} \cdot min^{-1}$) below 15, which is extremely low. For comparison purposes, a typical college-aged male would be about 45 and a typical college-aged female would be about 35. While elite endurance athletes do have the highest values (Males - 70 to 80+; Females - 60 to 70+), there is no health benefit to having these extremely high numbers; rather, one simply needs to not reside in the gutter, so to speak, and aerobic capacities in the 50s, commonly seen in sprint and interval athletes (and primitive humans), are very healthy numbers. The measurement of VO_2 max has recently been found to be the single best predictor of both cardiac and all-cause deaths among patients with established cardiovascular disease (CVD).[28,29] So, improving it would obviously be prudent. We have so far clearly established that HIIT can improve VO_2 max in normal subjects, the question is, can HIIT improve VO_2 max in the severely deconditioned? A number of studies have indicated that high-intensity exercise is key to aerobic and cardiovascular adaptations in patients with coronary artery disease (CAD),[30] chronic heart failure (CHF),[31,32] or left ventricular (LV) dysfunction[33]; as well as, reducing the risk of coronary heart disease (CHD) in healthy subjects.[34] Warburton et al. also showed that HIIT provided an effective tool to improve the cardiovascular fitness and health status of patients with CAD.[35] Further, compared to a traditional exercise training model (LMICT), it was also shown that HIIT improved anaerobic tolerance to a greater extent without increasing the risk to the patient. So, much like normal subjects then. And, as we have seen before, with HIIT, less can be more based on the fact that it has been shown that a single weekly bout of exercise, so long as it is of a high intensity, can reduce the risk of cardiovascular death in both men and women.[36] Interestingly, in this latter study, no additional benefit was found from increasing either the duration or frequency of the weekly exercise. Who cannot find the time for just one bout of HIIT per week?

In last year's June issue of the American Heart Association journal, Circulation, Wisløff et al. showed some dramatic benefits of "aerobic" interval training, as compared to moderate continuous training, in heart failure patients.[37] Aside from these dramatic benefits, a very important point to make about this study was the age of the subjects because chronic heart failure is a disease of the elderly; in fact 49% of patients with a first diagnosis are older than 80 years of age.[38] The majority of previous studies have excluded patients older than 70 years; yet, this study enrolled 27 patients, all with post-infarction heart failure, with an average age of 75.5 years and 12 of the subjects were older than 80 years of age. The patients had an impaired LV ejection fraction of, on average, 29% and an average VO_2 max of only 13 $ml \cdot kg^{-1} \cdot min^{-1}$. They were randomized to one of three exercise training protocols for 12 weeks, aerobic interval training (AIT), moderate continuous training (MCT), or to a control group that received standard advice, regarding physical activity, from their family doctor. The AIT and MCT groups met for supervised training twice weekly and performed one weekly session at home, which was designed to mimic the supervised training utilizing uphill walking. Every three weeks, the control group also met for supervised treadmill walking at 70% of maximal heart rate (MHR), lasting 47 minutes. The AIT consisted of inclined treadmill walking at 95% of MHR for four, 4-minute intervals with 3-minute active recoveries at 50-70% of maximal heart rate; total exercise time (including a 10 minute warm-up and a three minute cool down) was 38 minutes. The MCT also consisted of inclined treadmill walking but at an intensity equivalent to 70-75% of MHR for 47 minutes to make the training protocols isocaloric (i.e., of equal energy expenditure). The difference in the increase in VO_2 max, the single best predictor of deaths in patients with CVD, as a result of the two training protocols was striking, 14% for the MCT group and 46% for the AIT group. Anaerobic threshold, from an absolute perspective, also increased more in the AIT group compared to the MCT group. While MCT showed no change in work economy, AIT provided an improved work economy as demonstrated by a 15% reduced oxygen cost, an 8-bpm lower heart rate, and a 59% lower blood lactate at a given submaximal walking speed. An improved anaerobic threshold and work economy makes a huge difference in the day-to-day functional capacity of anyone, but particularly for individuals that are severely deconditioned. AIT also had dramatic improvements in heart morphology and performance, essential factors for individuals with heart failure. Of particular interest were increases in the LV ejection fraction (35%) and stroke volume (17%). Interestingly, it was also shown that AIT, but not MCT, reduced the plasma levels of oxidized LDL by 9% and increased the patients' antioxidant status by 15%. This latter increase correlated with the greater increase observed, by the AIT group, in flow mediated arterial dilation. Further, the patients' quality of life, established via a questionnaire, increased more with AIT than MCT. It is also interesting to note that informal comments from the patients found the varied procedure of AIT motivating, whereas, MCT was described as "quite boring." So, at the end of the day, in patients with post-infarction heart failure, AIT was superior to MCT in improving LV remodeling, aerobic and anaerobic capacity, arterial function, and quality of life. But I guarantee, a nationwide survey of health care professionals at this point in time, would yield the opposite prediction which, emphasizes again, the importance of research awareness. Now, the alert reader will have recognized a difference in the interval training employed by the Wisløff research team compared to much of the research referenced in this manuscript, it was HIIT but not SIT. The 4-minute work intervals employed by the Wisløff protocol are longer than the suggested 60-second maximum I have promoted throughout this discussion. As I described earlier, when one is exercising at an intensity that allows for a 4-minute effort, it is not an "all-out" effort; so one may think that a true "all-out" effort, lasting from 20-60 seconds, would create a much greater stress on the heart and, in turn, be less safe. However, by now, you will hopefully have grasped the fact that giving an "all-out" burst of effort has a similar stress to the heart, and cardiovascular system, to a "maximal" aerobic effort; the remainder of the energy required to go "all-out" comes from one's anaerobic system. The interval training utilized by the Wisløff group elicited a 95% peak heart rate; one does not get to their maximum heart rate in 20-60 seconds. Consequently, it is my contention that HIIT, utilizing intervals of 20-60 seconds, would produce results to an equal or even greater extent than found by Wisløff et al. An interesting case-study from a colleague, Robert Mottram, PT., who employed a 12-minute per week SIT protocol with his clients, lends support to my contention; as well as, of course, all the research already discussed in individuals without heart failure. A patient that had been cleared to exercise by his physician, following multiple bypass surgery, undertook the 12-minute per week SIT protocol (using a portable stepping device called The X-iser® Machine that will be discussed later in more detail) and returned to his cardiovascular specialist for a follow-up after about eight weeks of training. After numerous tests, he was given a clean bill of health and his physician was particularly pleased with the improvements he had made with respect to his cardiovascular condition. His physician's first assumption was that the medication he had prescribed was having its desired effect. Upon learning that the prescription had not been fulfilled, the physician, next, assumed that the prescribed diet was the reason for his successful outcome. Finally, after learning that his discipline to change his diet was nonexistent, the physician eventually realized that the only factor that could have caused the improvements in his patient's cardiovascular condition was the 12-minute per week SIT program. His recommendation upon obtaining this information . . . continue what you are doing!

Numerous other studies also support the benefit of HIIT for deconditioned individuals. HIIT has been shown as an effective protocol for improving respiratory muscle strength and endurance in patients with chronic obstructive pulmonary disease (COPD)[39]. Sturdy et al. assessed the feasibility of high-intensity respiratory muscle training utilizing eight weeks of interval training that consisted of three 20-minute training sessions per week. Each 20-minute session comprised seven 2-minute bouts of breathing against a constant inspiratory threshold load with each bout separated by one minute of unloaded recovery. The inspiratory load was progressively incremented throughout the eight weeks of training. This protocol was used because it had been previously shown that improvement in respiratory muscle function from respiratory muscle training was dependent upon the magnitude of the training load and an interval training protocol would allow for higher training loads. At the end of the study significant improvements were observed in respiratory muscle strength (32%) and endurance (56%) demonstrating that high-intensity, interval-based respiratory muscle training is feasible in patients with moderate-to-severe COPD. Subsequent studies have also shown a benefit of HIIT to COPD patients[40-42] and it has also been demonstrated that HIIT is an effective protocol for, and can be well tolerated by patients with peripheral arterial disease[43]. So, again, HIIT provides great benefit to the participant even in cases of severely compromised levels of conditioning.

HIIT for All Age Groups

In a similar vein to thinking that HIIT would be inappropriate for deconditioned individuals, many people assume it would not be the work out choice for the elderly or young children. Of course, one should not be surprised by now that a quick review of the scientific literature reveals that HIIT works for all ages. The study by Wisløff, discussed earlier, demonstrated the effectiveness of HIIT in heart failure patients with an average age of 75.5 years. Broman et al. showed that HIIT in healthy, elderly women, with an average age of 69 years, lowered resting heart rate by 8 percent, lowered submaximal exercise heart rate by 3 percent, increased maximal oxygen uptake by 10 percent and increased maximal ventilation by 14 percent[44]. In another study, women more than 65 years of age, took part in a high-frequency, high-intensity exercise program with no risk to their health while experiencing improvements to their quality of life, cognitive function, degree of independence and physical fitness[45].

It has also been shown that, in the elderly, leg power has the strongest correlation to self-reported functional independence[46] and that lower limb explosive power is the most important factor in fall prevention[47,48]. Further, power has also been shown to be the neuromuscular parameter that shows the greatest decline with aging[49]. The sarcopenia (decrease in cross-sectional area of muscle fibers) that occurs with aging is due to the atrophy of both type I (slow-twitch) and type II (fast-twitch) muscle fibers, but with a preferential atrophy of the type II fibers[50]. As it is often said about much of our physiology, “if you don’t use it, you will lose it”; so, if you adopt the philosophy that we should handle the elderly with “kid gloves” and only engage them in light to moderate exercise, you may well be doing your clients more harm than good. More than any other population, the elderly need vigorous exercise. This is best accomplished with HIIT since this approach will allow them to significantly increase the intensity of exercise and, in turn, target the very muscle fibers that show this preferential, age-related, atrophy.

McManus et al., examined the change in aerobic power of young boys (i.e., 10.25 ± 0.5 years) in response to a HIIT protocol or a moderate-intensity continuous training protocol[51]. As seen with other age groups, this population also demonstrated a greater improvement in parameters of cardiovascular fitness with the HIIT protocol as opposed to the continuous training protocol. It has further been shown that HIIT improves both resting and exercise lung function in prepubescent children[52]. Consequently, HIIT is also a more effective protocol for improving parameters of fitness in the young and elderly and should; therefore, be at least included in a conditioning program design or, better yet, comprise the majority component.

Weight Loss, Fat Metabolism and High-intensity Intermittent Training

It may well be that the majority of the population is motivated to exercise more by trying to lose weight than to improve their cardiovascular fitness; however, I feel as, health care professionals, our first focus should be toward decreasing cardiovascular disease, which affects nearly 80 million U.S. adults and carries with it an estimated price tag of nearly $432 billion for 2007[53]. That is why I discussed cardiovascular fitness first; rather than weight loss; although, in reality, the two are often related and both respond more favorably to HIIT than LMICT. So, because of this, it does not matter which of the two parameters your client wishes to focus upon when designing an exercise program. Note, however, that this is not what most individuals believe about weight loss, which further exacerbates the participation in LMICT versus HIIT. The main reason for this thinking is that it has long been established that when one increases the intensity of exercise, one has to increase carbohydrate metabolism and, therefore, decrease fat metabolism. While this statement is indeed correct, too many individuals overlook the fact that when one increases the intensity of exercise, the caloric expenditure increases exponentially as already discussed at length within this paper. Consequently, even though one may utilize a higher percentage of calories from fat with exercise at low intensities, the total number of calories from fat is actually lower because of the lower total energy expenditure. Further, while carbohydrate metabolism is relatively straightforward, fat metabolism is far more complex and is affected by numerous hormonal events both at rest and during exercise. Before addressing some of the research to better explain and understand this area of metabolism, it helps to again, look at this topic from a common sense perspective. In the sport of track and field, we have the opportunity to look at the extremes of the intensity-duration spectrum. Marathon runners are at one end of the spectrum with an event that lasts a little more than two hours for elite competitors, while sprinters are at the other end of the spectrum with the longest events lasting less than 45 seconds for elite competitors. The training programs of these athletes also have a similarly large difference with respect to training volume and intensity. While both groups of athletes can be considered very lean, the sprinters have a higher lean body mass despite burning far fewer calories while engaging in their athletic event[54,55]. Sprinters also possess a physique that I am confident the majority of people would be happier to develop. The picture on the cover page of this article perhaps conveys this better than words. Also, when looking at that picture, ask yourself intuitively which body would be the healthiest and most successful for overall human performance?

Now to me, it almost seems like an insult to one's intelligence to have to address the research on fat loss when the sporting world is full of examples such as the marathon runner and sprinter. However, as health care professionals, we need research examples at our fingertips to combat the objections that will undoubtedly come your way because of, again, the indoctrinated dogma that the best way to burn fat is LMICT. First, it is, again, irrelevant as to how much research has demonstrated that LMICT can lead to a positive benefit – in this case, the benefit being fat loss. So, I will concede, as you should to your clients, that there is a significant body of research showing that one can lose fat by partaking in LMICT; however, there is also a significant amount showing it to be unsuccessful. The most relevant research at this point is to assess studies that compare SIT and HIIT to LMICT and determine the most effective fat loss method factoring in, again, the issue of time commitment.

In 1990, Tremblay et al., published the findings of a study that showed, for a given level of energy expenditure, individuals engaging in vigorous activities are leaner than those participating in less intense activities[56]. To help understand this finding, they followed the report with a study that compared the effect of a 20-week LMICT program upon body fatness and muscle metabolism with a 15-week HIIT program[57]. Despite the fact that the energy expenditure of exercise was twice as high in the LMICT (with a mean estimated energy cost of 120.4 MJ) as in the HIIT program (with a mean estimated energy cost of 57.9 MJ), there was a more pronounced reduction in subcutaneous fat (measured as the sum of six skinfolds) with the HIIT program compared with the LMICT program. When the difference in the total energy cost of the two training programs was taken into account, the reduction induced by the HIIT program was actually ninefold greater than the LMICT program. Muscle biopsies were also taken before and after the training programs to examine the effect of the two training programs upon muscle metabolism. It was shown that the HIIT program significantly increased the activity of an enzyme (3-hydroxyacyl coenzyme A dehydrogenase [HADH]) of the β-oxidation pathway (fat metabolism), whereas, the LMICT did not. This greater increase in lipid utilization is attributed to a greater increase in the post-exercise period since it is well established that oxygen debt, as it was once called (note: I still recommend using this term when speaking to clients as I believe it helps with the understanding of the physiological process), or excess post-exercise oxygen consumption (EPOC) is influenced more by the intensity of exercise rather than the duration[58-63]. So, in summary, for a given level of energy expenditure, vigorous exercise favors negative energy and lipid balance to a greater extent than exercise of low to moderate intensity and the metabolic adaptations in skeletal muscle in response to HIIT favored lipid oxidation. These findings have been validated with subsequent studies[64,65]. It has also been found that only during high intensity exercise is triglyceride within the muscle hydrolyzed to release fatty acids for subsequent direct oxidation[66,67]. This may account for the observation that many individuals engaging in LMICT have some moderate early success when it comes to fat loss but often hit a plateau with their weight loss goals.

Oxygen debt or EPOC, the post-exercise elevated oxygen consumption above resting levels, as a factor affecting weight loss is too often overlooked. I like to think of it as free training time because the body has ended the exercise but the metabolism continues to work to repair and replenish as a result of the exercise. While glycogen and other high-energy compounds can be metabolized anaerobically (without oxygen; fat cannot), I equate it to borrowing money from the bank – one has to pay it back and an increase in oxygen consumption above normal resting levels is needed to do so. When it comes to replenishing the energy stores of the body, it makes sense that if one were to predominantly burn glycogen as a fuel during a work out (a HIIT work out would accomplish this), the body would need to put back those glycogen stores to be ready for a subsequent similar activity. Consequently, it would further make sense for the body to utilize fat while it is accomplishing the glycogen "top-up." This is exactly what happens and, in a similar fashion, when the body burns predominantly fat during a work out (a LMICT work out would accomplish this, but with a low total caloric expenditure), the body replenishes the fat while burning glycogen during the recovery. Because EPOC can often last longer than the actual work out time, one would want to be utilizing fat as the fuel of choice during this period to stay lean; SIT and HIIT accomplishes this very well. It is interesting to note that, for a single bout of maximal exercise, it has been shown that sixty seconds is optimal to maximize EPOC[68]. The reason for this finding is fairly straightforward. It is at the 60-second mark of an all out effort that humans accumulate the highest levels of lactic acid, which, in turn, inhibits further high-intensity muscle contraction and the anaerobic production of more lactic acid. And, the amount of lactic acid produced during exercise is highly correlated with the magnitude of EPOC because much of the elevated oxygen consumption is for the processing of the lactic acid. It has also been shown that compared to one continuous bout of exercise, the magnitude of EPOC is significantly elevated by splitting the equivalent exercise into two sessions[69], supporting the benefits of interval training when the aim is to increase overall energy expenditure. Based upon this finding, it perhaps should not be surprising that prescribing exercise in several short bouts versus one long-bout per day produced similar changes in cardiorespiratory fitness and had a trend toward greater weight loss[70]. It has further been demonstrated that following high-intensity exercise, but not low-intensity exercise, oxygen consumption remains elevated above resting levels at three hours post-exercise; further, at this 3-hour time point, the rate of fat oxidation was higher after high-intensity exercise as compared to low-intensity exercise[71].

As it turns out, the lactic acid produced from high-intensity anaerobic exercise is more than the waste product it was once thought to be. It is used as a fuel, a buffering aid and, of immense importance, a likely signaling molecule[72-74]. At high levels, lactic acid is correlated with powerful anabolic metabolites such as testosterone and human growth hormone (HGH)[75-77], which further direct metabolism toward a strong and lean physiology. Both EPOC and these hormonal messengers persist long after the exercise has ended, which helps explain why SIT is more effective for fat loss than LMICT, despite when sometimes having a lower caloric expenditure than a LMICT session[78-80]. When considering the effect of exercise on body composition, one also has to realize how hormones work when alone or in the presence of other hormones. Both HIIT and LMICT produce cortisol which, when alone, can be catabolic to the body as well as decrease lipolysis and, along with insulin, facilitate lipid accumulation by expressing lipoprotein lipase (LPL)[81, 82]. However, unlike with LMICT, the increases in testosterone and HGH from HIIT inhibit LPL and stimulate lipolysis which leads to decreased body fat[81]. So, when one factors in the hormonal regulation of fat metabolism along with the fact that HIIT versus LMICT produces a greater energy expenditure at rest, during exercise, or over a 24-hour period (despite equalizing the work output of both protocols)[83], it really should be an obvious choice as to which mode of exercise we recommend when trying to address the current obesity epidemic we are currently facing.

High-intensity Intermittent Training and Improved Lactate Tolerance

Of paramount importance to nearly all athletes, but particularly to athletes whose sports require a high anaerobic capacity, is the ability to tolerate lactate. Thus, the effect that different training methods have on the ability to tolerate lactate has important implications to both athlete and coach. Now with most things in life, if you want to get good at something, practice it! So, if one wants to be able to metabolize high levels of lactate, common sense would tell us to produce a lot of it and the body will figure out the best way to handle its production. Well HIIT, as we have already discussed, produces high lactate levels, and the current research supports the above common sense approach.

Regulation of skeletal muscle internal pH (pHi) depends on the continuous activity of membrane transport systems that mediate an outflux of hydrogen ions (H+, (or bicarbonate influx)), whereby, the acid load is counterbalanced. The dominant acid extruding system associated with intense exercise is the lactate/H+ transporter which has been shown to be up-regulated with training[84]. The oxidative fibers of skeletal muscle use lactic acid as a respiratory fuel. It has now been shown that skeletal muscle contains proton-linked monocarboxylate transporters (MCTs) that transport lactic acid across the muscle fiber plasma membrane. It has further been established that two isoforms exist in skeletal muscle, MCT1 and MCT4, and that the distribution of these isoforms is fiber dependent. MCT1 is primarily found in type I oxidative fibers, whereas, MCT4 is primarily found in type II glycolytic fibers[85]. Studies are now emerging on the effect of training intensity upon these transporters. Three weeks of moderate-intensity training did not increase MCT1 or skeletal muscle lactate uptake, whereas, three weeks of high-intensity training did increase both MCT1 and lactate uptake[86]. Further research supports this finding as well as demonstrating that intense exercise increases MCT4 in addition to MCT1[87]. Again, as a general rule of human physiology, we adapt to stress. Accordingly, it makes sense that, if athletes need to develop lactate tolerance, they should produce high amounts of lactate in their training which means they should utilize a significant volume of SIT. Burgomaster et al., has recently shown that just two weeks of SIT can significantly reduce the accumulation of lactate in the vastus lateralis muscle following high-intensity cycling[88].

Other Physiological Benefits of High-intensity Intermittent Training

So far, this article has essentially covered two main areas pertaining to health and performance, cardiovascular conditioning and fat loss. There are, however, a number of other important benefits gained from SIT and HIIT that are not seen with LMICT.

It has been shown that increases in high-density lipoprotein cholesterol levels (the "good cholesterol") have occurred as a result of intermittent exercise, but not as a result of continuous exercise[89]. Beta-endorphin levels, which are associated with positive changes in mood state, have been shown to increase following incremental graded and short term anaerobic exercise, the extent correlating with the lactate concentration[90,91]. However, in endurance exercise performed at a steady-state between lactate production and elimination, blood beta-endorphin levels do not increase until exercise duration exceeds approximately 1 hour – with the increase being exponential thereafter[91]. So not very time-efficient. Plasma glutamine, an essential amino acid for the normal functioning of the immune system, was decreased in overtrained athletes and after prolonged exercise (intermittent and continuous) but increased after short-term, high intensity exercise[92,93]. The total antioxidant capacity of marathon runners cannot prevent exercise-induced lipid peroxidation following a half-marathon run, and, at rest, have demonstrated significantly elevated levels of conjugated dienes (an index of lipid peroxidation) as compared to sprint-trained athletes and controls[94,95].

Respected colleagues, Drs. Jade and Keoni Teta, who run a HIIT program called Metabolic Effect, brought to light a benefit of HIIT that I had seen clinically but one that I had not researched to identify the physiological mechanism. The benefit is the anti-inflammatory effect of HIIT. Since it is being argued more and more that inflammation is at the root cause of nearly all disease, a whole new consideration comes into play when deciding between HIIT and LMICT. I recommend you read their article “Exercise is Medicine,” which you can access at xiser.com/downloads.php or metaboliceffect.com. As a summary, there are a few major points to make as to why HIIT becomes a form of anti-inflammatory medicine. First, there have been a number of studies reporting the endocrine properties of both muscle and fat[96-98]. Muscles release myokines (which are chemical messengers and a subcategory of cytokines), the most important of which is interleukin-6 (IL-6). When muscles contract, IL-6 is released. IL-6 is a well-known cytokine that is one element of a well documented inflammatory triad: tumor necrosis factor-alpha (TNF-α), interleukin-1 (IL-1), and IL-6. When released from muscle in high concentrations, however, and without the presence of TNF-α and IL-1, IL-6 is anti-inflammatory[99,100]. Further, IL-6 reduces the concentrations of TNF-α and IL-1 via increased mediation of their respective cytokine inhibitors[101-103], and also increases the release of an important anti-inflammatory cytokine IL-10[102,103]. The large rise in IL-6, relative to TNF-α, resulting from exercise is very different from the TNF-α mediated release of IL-6, as seen with infection or sepsis, which causes an exponential rise in both cytokines. It is interesting to note that studies on genetic polymorphisms of these cytokines, have shown an increased risk of diabetes with an increase in the ratio of TNF-α to IL-6[104]. As well as the interaction with other cytokines, IL-6 plays a major mediating role in fuel metabolism and has also been shown to communicate with numerous tissues including the brain and liver[105]. Now, in relation to HIIT and SIT versus LMICT, the key point is that the amount of IL-6 released from muscle is directly proportional to the amount of muscle being contracted[101,102,106,107]. In addition to the amount of muscle mass involved, an increase in glycogen metabolism (as one would see with SIT) causes a further increase in IL-6[107,108]. Consequently, intensity and whole body exercise play a major role in determining the amount of IL-6 released from muscle and, in turn, obtaining the numerous health and performance benefits. These findings lend support to some benefits of HIIT and SIT that might not normally be considered but may be of major significance to the success of certain clients.

Application of Sprint Interval Training and High-intensity Intermittent Training

Hopefully, by now, the argument is over as to whether SIT and HIIT or LMICT is the most effective and time-efficient mode of exercise. If the reader is not convinced after 108 references supporting the notion that SIT and HIIT is the way to go, I am genuinely at a loss as to what to tell you and wish you all the best with LMICT. For those that now see the light or were blinded by it in the first place, the question usually comes up as to how to implement this kind of training.

There are numerous ways to successfully implement HIIT and SIT – some are convenient, while others are not; some require a financial investment, while others require no money at all. Sprinting up a flight of stairs or a steep hill provide an inexpensive way to train; however, the convenience factor might prevent some from maintaining compliance. An easy solution to improve this compliance problem would be for people to take advantage of the stair wells that exist within their office buildings. This would allow them to do three, 20-second sprints, eight times per week – a time investment that has been shown to significantly improve cardiovascular endurance[18]. When appropriate, holding dumbbells or wearing a weighted vest can increase the intensity and the amount of muscle recruited. I recommend accumulating 60 seconds in short intervals with a one to one work/recovery ratio. So some practical options with this approach are: (1) six, 10-second sprints with 10 seconds of recovery between each sprint; (2) three, 20-second sprints with 20 seconds of recovery; (3) two, 30-second sprints with 30 seconds of recovery; or (4) one 60-second sprint. While one could change these short recoveries to be longer or shorter, I have found that these work-to-rest intervals work well when accumulating one minute of SIT. Four to eight of these mini interval sessions in a day, repeated every second or third day, comprise a successful program. These mini intervals can be spread throughout a whole day or completed in a more traditional interval session that may last up to an hour or more. If anaerobic quality is to be maintained, a minimum of a four-minute recovery should be used between sprints that have accumulated 60 seconds of maximal effort. I do often shorten the recovery to between one and two minutes if I am alternating sprints with some other activities that might focus more on corrective exercise/movement patterns and do not maximally challenge one's metabolism. By doing this, one can increase the time efficiency of a work out while still maintaining the quality of the SIT. I do want to emphasize the need to rest at least one day between SIT sessions for the body to adapt and recover; as I often say, "inactivity is a bad thing, but rest is a good thing and there's a big difference between the two."

Burgomaster et al., showed that by decreasing the number of SIT sessions and allowing the body time to recover, the physiological benefits were improved[18]. For those wanting to really ramp up the volume, I recommend increasing the volume on a given day rather than increasing the number of days you do SIT. On the rest days, one can certainly engage in light activities such as walking, yoga or even a round of golf; but remember not to over do it; more is not necessarily better.

In lieu of the stairs or a hill, a treadmill can obviously replace the activity, which allows a more convenient program for those that like to stay at home or for those that own gym memberships or perhaps have a workplace gym. When engaging in SIT on a treadmill, it is best to set the gradient to its highest setting (usually 15%) as this allows for a safer, slower speed while still producing a high intensity; it further reduces the impact on the joints of the lower extremities. While many individuals, at first, raise their eyebrows at the 15% gradient, they are less concerned once they experience it walking at a slow speed (e.g., 1.5 mph), so increase the slope first! I also recommend a continuous 60-second interval, rather than an accumulation of one minute with smaller intervals, as this creates a high intensity with a lower speed than would be needed with, for example, 10-second sprints. The next task is to establish a speed that fatigues the subject in 60 seconds. Experience will help here; but, as a rough guide, I find for very deconditioned individuals two to 3 mph works well; for average fitness levels, four to 5 mph; and for fit individuals, 6 mph and above. It is better to use a speed that can be accomplished without holding on to the front cross bar; when the subject is then close to failure they can grasp the bar and straddle the treadmill. Another piece of exercise equipment found at your local gym that works well for SIT is the stationary bike. Being self-paced, it is a great piece of equipment to begin SIT and for those individuals that; perhaps, lack the balance to use a treadmill (caveat: make sure you work on their balance though!). I typically use the Wingate Protocol time-frame of 30 seconds when using a stationary bike and repeat it twice for an accumulation of 60 seconds, but any of the accumulated 60-second intervals would work. Of course, riding a bike up hills with a moderate incline can accomplish the same while also getting some fresh air.

One can also apply the concept of SIT to a large number of whole body exercises that recruit a large amount of muscle. The list is literally endless. Watching some of the events in the World's Strongest Man can give you some ideas; carrying a pile of any heavy weights from one point to another does the trick very well! I also very much like activities such as the Turkish Getup (Google this exercise if you are not familiar with it), which is a scrambling exercise that incorporates just about everything from strength and mobility to a significant challenge of the cardiovascular system. I have my clients repeat five repetitions with their right arm holding the dumbbell and five with their left, all in about 60 seconds. If they are well under this time frame the weight is increased and if well over, the weight is reduced. Now this type of exercise is not going to be appropriate for many individuals and clients should obviously be screened from an orthopedic perspective so as not to cause an injury. Having said that, I do feel as an industry we tend to handle some of our clients, particularly the elderly clients, like a fragile vase. In doing so, I believe many clients train and perform below their ability and fall short of their potential. Instead, I feel one should not be afraid to at least try and get them to be able to do this kind of advanced exercise – I never see anything wrong in setting the bar high.

For those who feel a Turkish Getup is not going to do the trick with some of their clients, then by all means use other modes that will accomplish the goal without any potential risk. As already discussed, an example is to use a stationary bike. Another piece of equipment, briefly discussed earlier, with which I have been involved since the mid-1990s is The X-iser® Machine. Invented by the founder of The International Society of Biomechanics in Sports, Dr. Juris Terauds, The X-iser® Machine is a unit that was specifically designed with SIT in mind. While collecting data as the official Head Biomechanist at the Montreal Olympics in 1976 (he was also appointed to this position for the Moscow Olympics in 1980 as well as the first ever World Track & Field Championships in Helsinki in 1983), Dr. Terauds and his team established that raising one's center of mass against gravity was the main contributor of energy consumption in running. Armed with this data, in 1977, while at the University of Alberta, Dr. Terauds and his team of researchers set out to design a piece of exercise equipment that could be used for SIT while simultaneously challenging and, in turn, improving balance. His team of experts included Dr. Hans J. Gros of the University of Stuttgart in Germany, Dr. Iraklis Tsarouchas of the University of Teseloniki in Greece, Dr. Anthony Bauer of Lakehead University in Thunderbay, Canada, as well as Dr. Pierre Garvais of the University of Alberta in

Canada. All stair climbing machines and steppers seen today are a result of this initial work; however, as the units were developed, they lost the critical component of being able to go at high speed for SIT. Many units also added unnecessary handles that added cost, size and weight and also encouraged leaning and poor posture. Holding on to these handles with a death grip also took away the balance challenge and, therefore, the development of proprioception (a much needed attribute for the elderly in particular). For those that need balance support, The X-iser® Machine can simply be placed next to a wall or counter top. By only touching the support when needed (as opposed to holding onto handles), balance will be improved. In fact, one of the main benefits of using The X-iser® Machine is improved balance and it develops remarkably quickly in most individuals.

After completing my Doctorate at Colorado State University, Dr. Terauds invited me to join the mission of researching SIT, educating the fitness industry about SIT, and assessing The X-iser® Machine as a means for doing SIT. It was Dr. Terauds who first emphasized to me the importance of this mode of training. He had observed through the years of collecting sports biomechanics data that, from the athletes he had come to know, the sprinters appeared healthier and seemed to live longer than their endurance counterparts. So in the capacity as an affiliate professor at Colorado State University, one of my first projects was to examine the effectiveness of The X-iser® Machine for SIT in the laboratory of Dr. Chris Melby, an expert in exercise and metabolism with a particular interest in EPOC. After some initial pilot data collection, the research group embarked on a study to compare the oxygen consumption resulting from three, 1-minute maximal effort sprint intervals on The X-iser® Machine, separated by 1-hour recoveries, with 20-minutes of LMICT, also on The X-iser® Machine[109]. It was found that just three minutes of SIT constituted 74% of the oxygen uptake of 20 minutes of LMICT (a near 7-fold increase on a per minute basis), demonstrating the effectiveness of SIT on the unit for energy expenditure. This was also at a time when we were not incorporating a more upright and effective stepping posture or the inclusion of a dumbbell curl and press, the addition of which dramatically increases the intensity, muscle recruitment, and challenge to the balance. The initial idea of extending the recoveries to an hour between maximal sprints was so that the exercise would not induce perspiration, which would then allow people to work out in their usual day-to-day attire and eliminate the need to change and shower. Having the machine in one's office or home along with the effective "extended recovery" SIT program would then provide the most time-efficient, yet effective, exercise program possible. Indeed, since that time, thousands of individuals have shown this approach to be very effective. Extending recoveries may provide for more than just convenience; it allows for maximal performance in subsequent bouts of intermittent exercise which may be useful for training anaerobic capacity. It has been shown that following 30 seconds of maximal isokinetic cycling, four minutes of recovery is sufficient to almost completely restore Adenosine Triphosphate (ATP) and mixed-muscle phosphocreatine (PCr) in type I muscle fibers, but not in type II muscle fibers[110]. It does not take someone long to realize that a true all-out effort is not repeatable with only a 4-minute recovery. Furthermore, this same study demonstrated that the restoration of ATP and PCr correlated positively with the total work production of a subsequent 30-second bout. Consequently, the inclusion of training sessions in one's overall program where recoveries are extended to allow for total restoration of type II muscle fiber ATP and PCr content may improve muscle training for high-intensity performance. A 1-hour (or more) recovery would allow for complete, or at least near complete, restoration of ATP and PCr in type II muscle fibers. The X-iser® Machine provides a convenient way to implement such an exercise protocol.

Because of its small size, it is not unusual for a strength and conditioning coach, particularly one who spends most of his or her time working with top-level athletes, to take a quick look at The X-iser® Machine and dismiss it without as much as a second thought. While many can see the unit providing benefit to a deconditioned individual, such as for use in the home, they typically think it has no place in their weight room. While I would rather that not happen, it is certainly understandable given that the compared reference is the inexpensive and poorly engineered mini steppers, "as seen on TV" and found in the isles of one's local Walmart. The size of The X-iser® Machine is where the similarity with the various mini steppers ends. First, The X-iser® Machine is constructed of aircraft-grade aluminum that can handle well in excess of 400 lbs. (in fact, strong enough to withstand the efforts of professional linemen holding 50 lb. dumbbells!). Second, the components in the unique hydraulic unit are of the highest engineered quality enabling a few critical benefits. The unit is virtually silent, extremely smooth and, of great importance, provides for a variable resistance that allows the user an unlimited pedal speed. This then equates to intensity, which, in turn, equates to physiological change for the better.

“Okay,” I hear you say, “but I can get my guys to sprint up the stadium stairs.” Yes, you can certainly do that as I have just discussed. Think, however, about bringing the stadium stairs into your gym or studio that then allows for a series of sprints between other activities while simultaneously providing for some very unique training opportunities. Now, while the unit is used for more than just high-intensity, closed-chain speed stepping (go to xiser.com and click on “Demos”), it is the ability to engage in this activity while maintaining a load on both lower limbs that sets the unit apart from anything else available. It is an activity that few have ever likely experienced with ANY exercise, let alone using a piece of exercise equipment. The nature of the hydraulics of the unit allows for a form that produces a "static equilibrium,” high-frequency stepping action that challenges anyone like nothing I have ever seen or felt. What actually happens is the body's center of mass stays level (imagine balancing a glass of water on your head) while the legs are stepping at as high a frequency as the user can produce (which can be in excess of 300 steps per minute for an elite athlete). In order to prevent the body's center of mass from moving up and down (as seen with all other stepping activities), both legs have to work equally on both the up and down strokes of the stepping action. Consequently, the quads are working concentrically on the down stroke and eccentrically on the up stroke, simultaneously while in opposition. Compared to actually sprinting on a track, the stepping form focuses purely on the ground reaction force that propels the center of mass upward and forward. So unlike sprinting on the ground, where there is a 50 percent recovery phase for each leg with respect to ground reaction force, this "no recovery" protocol leads to tremendous strength gains and the rapid gait change leads to neuromuscular development to enhance power, speed and agility (training an elite athlete’s hip flexors for a high knee lift is therefore worked separately). Once an individual’s form is polished on the X-iser® Machine, a 20 to 60 second sprint induces significant fatigue, which is magnified considerably when one has the ability to add a dumbbell curl and press. Consequently, the unit is also a great addition to any circuit or interval work out for both conditioning and rehabilitation. Proprioception, agility, coordination, and balance can be further challenged by moving the feet farther back on the pedals and by adding other activities into the modality, such as the dumbbell curl and press or medicine ball drills. The ability to be able to incorporate the dumbbell curl and press while using The X-iser® Machine is particularly useful and effective given the research discussed on recruiting large amounts of muscle to ignite myokine mediated health and performance benefits. It is important to emphasize that because the unit responds to the force generated by the user, it is effective for anyone – an Olympic athlete, a child or a deconditioned individual looking to lose weight. For those that might be concerned about getting a deconditioned individual to engage in SIT, The X-iser® Machine works particularly well because it is both self-paced and self-limiting. By self-limiting, I mean that because of the unique challenge that the "static equilibrium" stepping form brings, deconditioned individuals typically fatigue in their legs prior to maximizing their cardiovascular system. Consequently, it allows for a progressive challenge to the cardiovascular system as one develops the necessary muscular strength and endurance over time.

While I have focused this article on the superior benefits of SIT and HIIT over LMICT, there is the recognition that there are athletes that need to do some endurance work. There are also individuals that like LMICT to simply get a good sweat going. So, while The X-iser® Machine is superb for SIT, it should also be noted that, because of the variable resistance, it does work well for a nonimpact endurance work out; while simultaneously challenging and developing the user's balance and proprioception. The unit is also great to use for a warm-up to simply get one's day going or for use prior to a sporting event such as a round of golf. Further, the unit can be used in a backward position for working dorsi flexion range of motion and tibialis anterior development (any shin splints out there?) and for working side flexion of the thoraco-lumbar junction and lumbar spine (accomplished by stepping without bending the knees). This latter movement can also be done while flexing at the hip which then works lumbar spine rotation and further helps stretch the hamstrings, glutes, and piriformis. Scapular and core stabilization are accomplished in a forward prone position and hamstrings, glutes, and core stabilization in a backward supine bridge position. It is also possible to introduce a variety of additional exercises due to the unit's size, portability, and uniquely connected hydraulic system. Once you have experienced the high-speed X-iser® Burst Training with proper form, you will quickly realize how the X-iser® Machine makes for a fantastic addition to any home, gym or studio.

Case Studies of Sprint Interval Training and High-intensity Intermittent Training

I discussed earlier in this article the gentleman, who, following bypass surgery, employed a 12-minute per week SIT protocol using The X-iser® Machine and improved his cardiovascular health to the point of surprising his physician. This is only one of many case studies that have been reported by the many practitioners and clients with whom I have had the pleasure to either consult, work or simply share the research. There are a few other reports that are worth discussing in this article.

In 2005, at the studio of Robert Mottram, PT., in Palm Desert, California, I conducted a 12-week pilot study to examine the effect of a 12-minute per week SIT protocol (using The X-iser® Machine) upon cardiovascular work economy and body composition. Twenty-seven healthy subjects (aged 52.8 ± 2.2 years; range 34 - 77) completed the program. In response to a modified Harvard Step Test (step height was adjusted as ability allowed but was consistent for pre and post measures), the subjects were tested pre and post training for their rate of perceived exertion (RPE) and heart rate (HR). The RPE used a simple scale of one to 10, with 10 being the hardest and one being the easiest. Subjects were also measured for girth measurements (13 sites) and body weight. The 12-week SIT protocol consisted of the subjects completing four sets of three, 20-second sprints with 20-second recoveries, separated by 4-minute intervals, three days per week (Monday, Wednesday, and Friday). This, then, amounted to just 12-minutes per week of actual sprint time – the protocol being based upon the initial work at Colorado State University and subsequent research that had confirmed our findings[18]. After the 12-week study, the subjects had reduced their body weight by 3.8 ± 0.8 lb. ($p < 0.001$) and the sum of their girth measurements by 13.1 ± 1.6 in. ($p < 0.001$). The relatively small decrease in weight accompanied with the large decrease in the sum of the girth measurements is a clear indication that the subjects lost fat and gained lean muscle mass. This also matched with the study exit interviews when the subjects discussed their impressions of the study; all subjects reported a decrease in dress or waist size. In response to the step test, RPE was reduced by 3.7 ± 0.3 scale points ($p < 0.001$) and post training HR was 12.5 ± 1.0 bpm ($p < 0.001$) lower than pre training values. This improvement in work economy was dramatic given the low training volume (i.e.,12 minutes per week) and relatively short training period (i.e., 12 weeks). The subjects also reported a marked improvement in strength and endurance while going about their day-to-day activities. So, this pilot study demonstrated that using The X-iser® Machine, just 12 minutes per week for 12 weeks, can have a significant effect on health and performance.

Drs. Jade and Keoni Teta, who, like me, are proponents of HIIT, reported the case of a 43-year-old female diagnosed with congestive heart failure secondary to an infection that occurred in September 2006. The patient was a candidate for a heart transplant and was told not to exercise at all. Upon consultation with Dr. Keoni Teta in November of 2006, her ejection fraction was only 15%. Along with a holistic approach to healing, their HIIT program increased the patient's ejection fraction from just 15% to 35% in only eight months. With the increased ejection fraction and an additional improvement in the heart size (specifically, a reduction in both the left atrium and left ventricle), the patient was no longer a candidate for a heart transplant and now reports living a normal life with plenty of energy.

Another colleague, Dr. Oscar Coetzee, had developed a successful weight loss program without a clear exercise component in place and was looking for a simple program that he could provide to his clients. Dr. Coetzee met me at one of the "Weight Loss Resistance" seminars of renowned weight loss expert, JJ Virgin, Ph.D., where I was speaking on the exercise component of the program as a result of the success JJ Virgin had seen with her own clients using SIT and subsequently The X-iser® Machine. Dr. Coetzee obtained his own X-iser® Machine and began the program on himself to assess if he would use our SIT protocol for his clinic. It did not take long for Dr. Coetzee to realize he had found the program he was looking for and began its implementation. The results of his program are quite outstanding. While he was having some success without the protocol, Dr. Coetzee is the first to convey that the addition of The X-iser® Machine and SIT protocol has made a huge difference, particularly with respect to improving the blood lipids. One client dropped their total cholesterol 78 mg/dL from 249 on Lipitor to 171 off medication in as little as four months with a corresponding 14% reduction in body fat. Another lowered their triglycerides 480 mg/dL from 588 to 108. A mother of two reduced her body fat by 22% in just six months. More information, as well as additional case studies, is available at Dr. Coetzee's website, ocphd.net, where the subject data results are within the iTRIM Smart Program™ link.

Dan Swinscoe, MPT, CSCS, (peaksportsandspinept.com) consulted with me regarding one of his clients after he heard me speak at last year's World Golf Fitness Summit hosted by the Titleist Performance Institute where I was speaking on SIT. He had been presented with a 70-year-old male patient (weight 200 lb.), who had reported an approximate three-year history of lightheadedness when climbing stairs. On several occasions the sensation was so strong he thought he was going to black out. This could occur with only one flight of stairs such as in his home. The patient was “very fit” and rode his bike at least two days per week for about 60 miles at a time. He further participated in a 1-hour “spin” stationary cycling class one to two days per week. When he first consulted with his physician in 2004, he was given a treadmill echocardiogram. The test was stopped after 13 minutes because he reached 104% of the target heart rate. He presented no symptoms. The report showed no ST abnormalities at rest and no ischemic ECG changes. Echo images showed left ventricular size and wall thickness to be normal and ejection fraction at 63%. Later in 2005, lab test results showed Hct: 42, platelet 237, white blood count 5.0, total cholesterol 202, triglycerides 64, HDL cholesterol 56, LDL cholesterol 133, sodium 135, potassium 4.3, creatine 1.1, BUN 21, glucose 88. Blood pressure was 142/86 with a heart rate of 78. At this time, he was diagnosed with “Exertional presyncope and chest discomfort with symptoms suggesting exertional hypotension at maximal exercise level.” He was, then, scheduled for a nuclear treadmill stress test. Thereafter, the cardiologist wrote to his PCP, “I suspect his symptoms relate to difficulty maintaining his left ventricular filling pressure in the setting of his diastolic function and high heart rates.” He was advised to maintain hydration and it was suggested he takes a beta blocker for hypertension and borderline concentric left ventricular hypertrophy. He chose not to take the beta blocker. Per the patient, he has had “every blood test” they have imaged for his brain and his heart and keep finding him to be without a problem and in good health, particularly for his age and despite the condition persisting. He consulted with his physical therapist, Mr. Swinscoe, about the problem in July 2007 since he had helped him through various other problems in the past. He knew Mr. Swinscoe treated benign paroxysmal positional vertigo (BPPV), a condition that includes dizziness or vertigo, lightheadedness, imbalance, and nausea, and he requested Mr. Swinscoe to try that treatment with him. After the initial examination, Mr. Swinscoe could not tell him what was wrong, only that it was not consistent with BPPV. So, Mr. Swinscoe did not treat him, but became extremely intrigued by his situation and, at that point, contacted me. My first reaction was to suggest that the volume of LMICT that the patient was engaging in was too much and it had potentially weakened the contractility of his heart which, in turn, could lead to his lightheadedness. I suggested that the patient may respond well to SIT. They began the same SIT protocol with The X-iser® Machine described in the above pilot study on August 10, 2007. The first four sessions were on full resistance to decrease the intensity in the early stages, it was then lowered to increase the intensity once the patient was comfortable. With session 11, he began using 8 lb. dumbbells to add the bilateral curl and press motion while stepping. By session six, his symptoms were noticeably less frequent; they now only occurred if the patient bound upstairs after eating a meal. By session 10, they were gone entirely. The patient took a 6-week vacation out of the country after session 10. The symptoms were nonexistent during that time and he reportedly "sprinted up steps all over the cruise ship and all over Europe." Upon his return, he continued only because he liked the training and went on to purchase his own X-iser® for home use. Three months later, the patient was still without symptoms. The patient had a followup treadmill test on October 19, 2007. He exercised 13 minutes and 20 seconds on the Bruce protocol stopping only because of fatigue. The cardiologist wrote, "He is off the scale in terms of exercise tolerance for his age and gender. He had no chest pain. He had a normal hemodynamic response to exercise with a peak systolic pressure of 172. There are no ECG changes diagnostic for myocardial ischemia and no arrhythmias. Normal resting left and right ventricular systolic function with no echo evidence for inducible ischemia." Interestingly, his initial treadmill test and his final treadmill test were both 13 minutes in duration; however, the first one, in 2005, was stopped because his heart rate got too high. In 2007, after SIT on The X-iser® Machine, his test was stopped because of fatigue rather than his heart rate being too high. Schultz et al., recently examined the effect of excessive long-term exercise on cardiac function and myocyte remodeling in hypertensive heart failure rats to see if it attenuated the pathological remodeling under hypertensive conditions[111]. Compared with sedentary hypertensive rats, excessive exercise resulted in a 21% increase in left ventricular diastolic dimension ($p < 0.001$), a 24% increase in heart to body weight ratio ($p < 0.05$), a 27% increase in left ventricular myocyte volume ($p < 0.01$), a 13% reduction in ejection fraction ($p < 0.001$), and a 22% reduction in fractional shortening ($p < 0.01$). Excessive exercise also resulted in greater fibrosis and did not prevent activation of the fetal gene program in hypertensive rats. It was concluded that excessive exercise, in the untreated hypertensive state can have deleterious effects on cardiac remodeling and may actually accelerate the progression to heart failure. It is worth noting that Mr. Swinscoe's patient had a blood pressure of 142/86 mmHg at his initial stress test in 2005 and had been recommended to take a beta blocker to control hypertension; given the results of Schultz et al.[111], the patient may well have been cycling himself into a serious problem with his excessive endurance exercise. Thankfully it appears SIT has corrected the problem.

I have recently had an obese, hypertensive client reduce her blood pressure to just 110/72 mmHg as a result of only one month of SIT. This finding is supported by a study by Baker et al.[112] Further, a SIT protocol had dramatic improvements in an already very fit individual who works in the fitness industry. A 52-year-old female subject underwent 12 weeks of SIT. Her heart rate for the 3-minute Harvard Step Test was reduced by 12.5 bpm, demonstrating an improved work economy. Her predicted aerobic capacity, from the Astrand-Ryhming Stationary Bike Test, increased from 38.4 to 44.7 ml/kg/min, an increase of 16.4%. Her power production during the Wingate Power Test improved from 305 Watts to 429 Watts, a 40% increase. The subject also lowered her percent body fat from 15.6 to 14.6 and increased her lean body mass by 2.6 lb. Again, these results show how effective SIT and HIIT can be on parameters of health and performance in a short time period.

Closing Comments

Hippocrates first advised us more than two thousand years ago that exercise – **though not too much of it** – was good for health. It seems that message is still true today. I believe the research referenced within this article provides a strong argument that SIT or HIIT, and not LMICT, should be the first choice when it comes to choosing a mode of exercise for the vast majority of individuals. This is in spite of the fact that the latest 2007 updated recommendations from the American College of Sports Medicine and American Heart Association[113] makes no mention of SIT! While it makes sense that endurance athletes likely need a certain volume of LMICT, the recent heart attack and near death of 49-year-old Alberto Salazer on June 30, 2007, one of the best American marathon runners of all time, and the corresponding research by Schultz et al.,[111] may make some distance runners question their volume of training and add more SIT. The evidence of the benefits of SIT has been around a long time as has been discussed in this article. Whenever I return back to Britain and see one of the few remaining double-decker buses, I am frequently reminded of the research of Jeremy N Morris, DSc, DPH, FRCP, who showed, back in 1949, that simply climbing the stairs of a double-decker bus, intermittently throughout a day, afforded the bus conductors protection against coronary heart disease not afforded to the sedentary drivers[114]. I knew of this research when Dr. Terauds suggested I work with him on the X-iser® Machine project and I remember thinking that the unit simply represented those double-decker bus stairs but with the benefit of providing more stairs! So, it is with this thought that I ask everyone to simply engage in a little bus-conductor work to help their health. Whether you chose to add the convenience of an X-iser® Machine or choose one of the many other methods, I sincerely hope that you and your clients (if you are a practitioner) incorporate SIT into your life and reap the significant benefits that will lie ahead.

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Author's Biography

Dr. Mark J. Smith graduated from Loughborough University of Technology, England, with a Bachelor of Science in PE & Sports Science and then obtained his teaching certificate in PE & Mathematics. As a top-level rugby player, he then moved to the United States and played for the Boston Rugby Club in 1987-1988 while searching the American college system for an opportunity to commence his Master's degree. That search led him to Fort Collins, Colorado, where Dr. Smith completed his Masters degree in Exercise and Sport Science at Colorado State University. He continued his studies in the Department of Physiology, where he obtained his Doctorate. His research focused on the prevention of atherosclerosis (the build up of plaque in arteries that leads to cardiovascular disease), in particular, using low-dose aspirin and antioxidant supplementation.

As an affiliate faculty member in the Department of Exercise and Sport Science at Colorado State University, Dr. Smith worked extensively with Dr. Loren Cordain, the renowned author of the book, "The Paleo Diet." As a result of this collaboration, Dr. Smith has had significant experience in helping autoimmune patients improve their condition through diet manipulation. This same diet has also helped individuals lose weight and athletes improve performance. Dr. Smith has also worked extensively as a personal trainer and health consultant and has lectured extensively on the benefits of high-intensity intermittent exercise and Paleolithic nutrition.

Dr. Smith began his work with X-iser® Industries in February 1995 as the Director of Research & Program Development and now holds the same position at Corrective Wellness, which runs xiser.com, the research, marketing and sales company for the X-iser® Machine. In the aforementioned positions, Dr. Smith has researched and developed innovative high-intensity, short-duration training protocols that are now becoming increasingly recognized as an effective training method. He has become a leading authority on the health benefits of this type of training and these training programs are now implemented at thousands of health and conditioning centers around the world.

Dr. Smith's main interest today is in the prevention of disease and the optimization of one's health by lifestyle modification. Consequently, he emphasizes education as a means to bridge what he feels is a large gap between health-related research and the general public's awareness of health-related issues. In addition to his position at Corrective Wellness, Dr. Smith works as a consultant and as a clinician, along side 11-year PGA Tour Physical Therapist, Rob Mottram, at The Heath & Performance Center at Mission Hills in Rancho Mirage, California.

As well as playing first-grade rugby in the UK, Dr. Smith played for both the Denver Barbarians and the Boston Rugby Club in the U.S. Rugby Super League. He was also a member of the American Eagle 50 player pool and captained the Denver Barbarians to a National Championship in 1990. He further captained the Western United States Territory. He is also an accomplished calligrapher, skier, and tennis player, and would like to be playing more golf!

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