HIIT Manual

High Intensity Interval Training and Agile Periodization

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To my son Nikša

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HIT vs HIIT

When referring to **H**igh **I**ntensity **I**nterval **T**raining, coaches and researchers usually use the **HIT** acronym, although **HIIT** is used interchangeably. The original title of this manual was “HIT Manual”, but together with the editors and publisher, we have decided to use “HIIT Manual” instead. The main reason is to differentiate this manual from books on *High-Intensity Training* (HIT), which is a form of strength training popularized in the 1970s by Arthur Jones, the founder of Nautilus (Source: Wikipedia).

The acronym HIIT is used only in the title of this manual, and everywhere else in the text, the acronym HIT is used to refer to High Intensity Interval Training.

Introduction

You have probably been struggling with finding a one-stop-shop guide on HIT conditioning for your athletes. I know I have. For this reason, I decided to create a simple, no BS manual that you can easily reference and quickly come up with HIT running drills without the unnecessary scientific fuss; Something that is pragmatic as hell. The HIT drills in this manual will mostly be useful for coaches and sport scientists working in team sports (such as soccer, rugby or basketball), or individual sports that utilize running-based HIT conditioning (e.g. combat sports). Track & Field coaches (especially short and middle distance running coaches) may find some HIT variations interesting and I think the models explained here could be very useful in their coaching.

HIT stands for High Intensity Interval Training and, as with any other training construct, it is hard to precisely define. I want this manual to be more actionable and less precise, or to *satisfice*, as Herbert A. Simon, father of artificial intelligence, would call it (Christian & Griffiths, 2016; Phillips et al., 2017; Gigerenzer, 2004; 2008; 2014; Gigerenzer & Gaissmaier, 2011; Klein, 2017; Mousavi & Gigerenzer, 2014; Neth & Gigerenzer, 2015). In other words, I want the approach to HIT in this manual to be good enough to be easily applied in practical settings and understandable by coaches. Having said this, I consider all training intensities above velocity at lactate threshold (vLT) or velocity at gas exchange threshold (vGET) to be High Intensity Interval Training (Buchheit & Laursen, 2013b; 2013a; Poole & Jones, 2011).

I am pretty certain that some lab coats will complain and point to the facts that the numbers in this manual are not precise, or that the planning strategies outlined are not *optimal*. These are all fair critiques, but most lab coats reason from an *unbounded* position, where they try to find idealistic or optimal training (conditional on the model assumptions). It bears mentioning Yogi Berra's saying: "*In theory there is no difference between theory and practice. In practice there is.*" In real life, coaches are struggling with a lot of uncertainties (several of which will be covered in this manual): time pressures and constraints, equipment, and very weird and unpredictable complex beings called athletes. So finding the 'optimal' solution is most likely waste of time, or even worse, impossible. Hence, in practical and complex settings, such as real life coaching and training, it's futile to try to find the optimal solution, but rather to utilize a few simple ***rules of thumb*** (or ***heuristics***) that help in finding the solutions that ***satisfice*** (Christian & Griffiths, 2016; Phillips et al., 2017; Gigerenzer, 2004; 2008; 2014; Gigerenzer & Gaissmaier, 2011; Klein, 2017; Mousavi & Gigerenzer, 2014; Neth & Gigerenzer, 2015). That is exactly my aim with this HIT Manual.

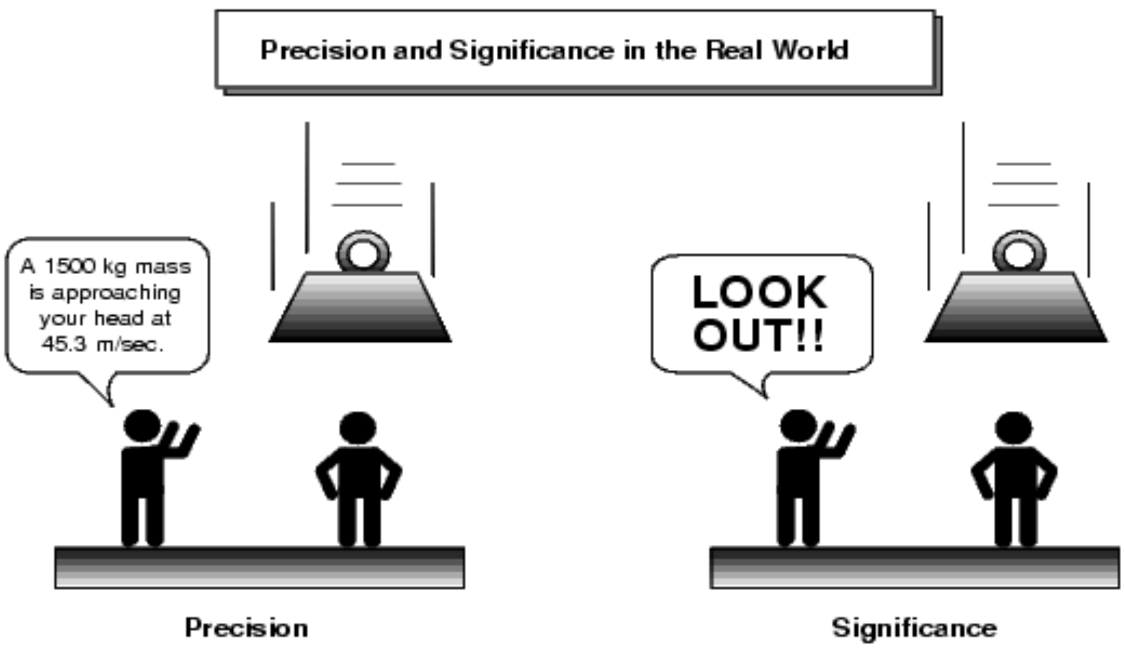

Figure 1. Difference between precision and significance. Image taken from Fuzzy Logic Toolbox™ User's Guide, available at https://www.mathworks.com/help/pdf_doc/fuzzy/fuzzy.pdf

Overview of the HIT Manual

The HIT Manual is organized in two main sections: HIT basics and HIT planning. HIT basics covers the following major points:

- Understanding the "Endurance Map" and terminology
- Equipment that is needed to test and prescribe HIT conditioning
- Understanding the "Velocity Profile"
- Estimations of key HIT parameters, that are needed for prescription and profiling
- Prescription of the HIT conditioning, corrections using start loss and COD loss, as well as grouping of athletes
- Different HIT drills - long intervals, short intervals and tempo, sprint interval training, repeat sprint training, and intermittent recovery

The planning part of the HIT manual outlines the basis of **Agile Periodization**, which is a framework of approaching planning from an uncertainty perspective. HIT planning covers:

- Understanding uncertainties involved in training planning and realization
- Three levels and types of analysis: phenomenological, mechanistical, and physiological
- Answering "what should be done" and "when should it be done" using simple heuristics
- Top-up approach to planning HIT conditioning

Understanding the above will empower you in selecting, designing and planning HIT conditioning for both individual and team sports. But before we jump into the material, it is important to have a big picture overview of the endurance methods and energy systems.

The "Endurance Map"

"The map is not the territory" - Alfred Korzybski

"All models are wrong, but some are useful" - George Box

The real world is very complex and uncertain. To help in orienting ourselves in it, we create maps and models. These are representations of reality, or representations of the real world. In the outstanding statistics book "Statistical Rethinking" (McElreath, 2016), Richard McElreath uses an analogy, originally coined by Leonard Savage (Savage, 1962), that differentiates between a **Large World** and **Small World**:

> *The **small world** is the self-contained, logical world of the model. Within the small world, all possibilities are nominated. There are no pure surprises, like the existence of a huge continent between Europe and Asia. Within the small world of the model, it is important to be able to verify the model's logic, making sure that it performs as expected under favorable assumptions. Bayesian models have some advantages in this regard, as they have reasonable claims to optimality: No alternative model could make better use of the information in the data and support better decisions, assuming the small world is an accurate description of the real world.*
>
> *The **large world** is the broader context in which one deploys a model. In the large world, there may be events that were not imagined in the small world. Moreover, the model is always an incomplete representation of the large world and so will make mistakes, even if all kinds of events have been properly nominated. The logical consistency of a model in the small world is no guarantee that it will be optimal in the large world. But it is certainly a warm comfort.*

--- taken from "Statistical Rethinking", page 19 (McElreath, 2016)

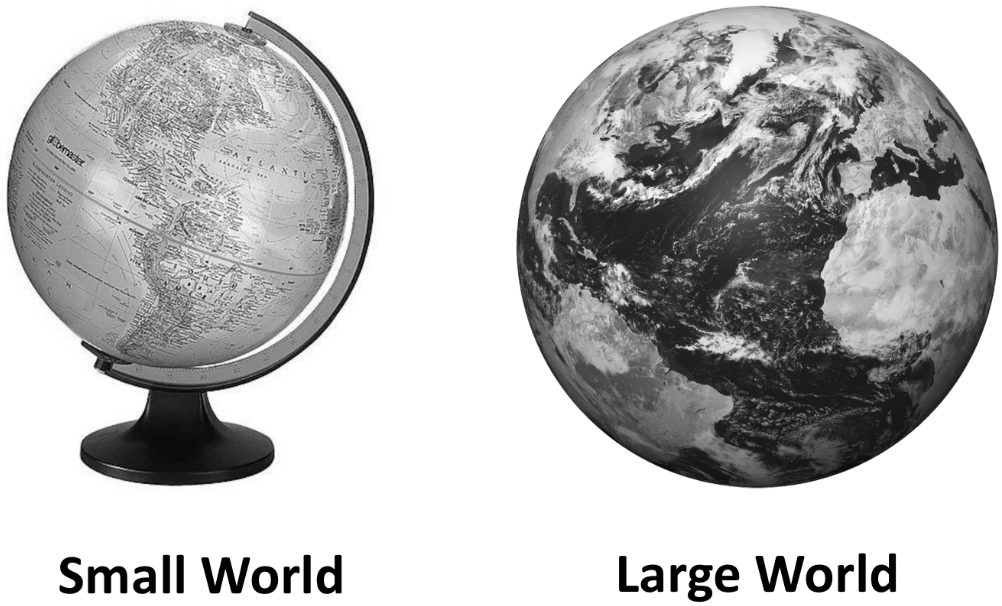

Figure 2. Small World is a simplification of the complex Large World. It is important not to forget the distinction.

The key takeaway to keep in mind is not to confuse the two. The models presented in this HIT manual are the "small worlds," which we hope to deploy in the "large world." They are all wrong - the question is how useful they are. All physiological models as well as planning strategies are the 'small world' entities. The problem is that many coaches and lab coats confuse them for the 'large world.' In this HIT manual I will provide my rationale for using ***satisficing***, ***phenomenological*** and ***heuristics*** approaches for decision making in uncertainty (i.e. large world), while avoiding confusing the small world for reality.

One such model (or a map) is the "Endurance Map." I've created the Endurance Map for a rough outline of the common "endurance small worlds" (maps and models used in endurance circles). There are numerous things that are wrong in this model and even more assumptions behind it, but it is pretty good at giving the big picture overview of the endurance world. Yes, a lot of things depend on the particular individual and his characteristic, but the general overview still holds true.

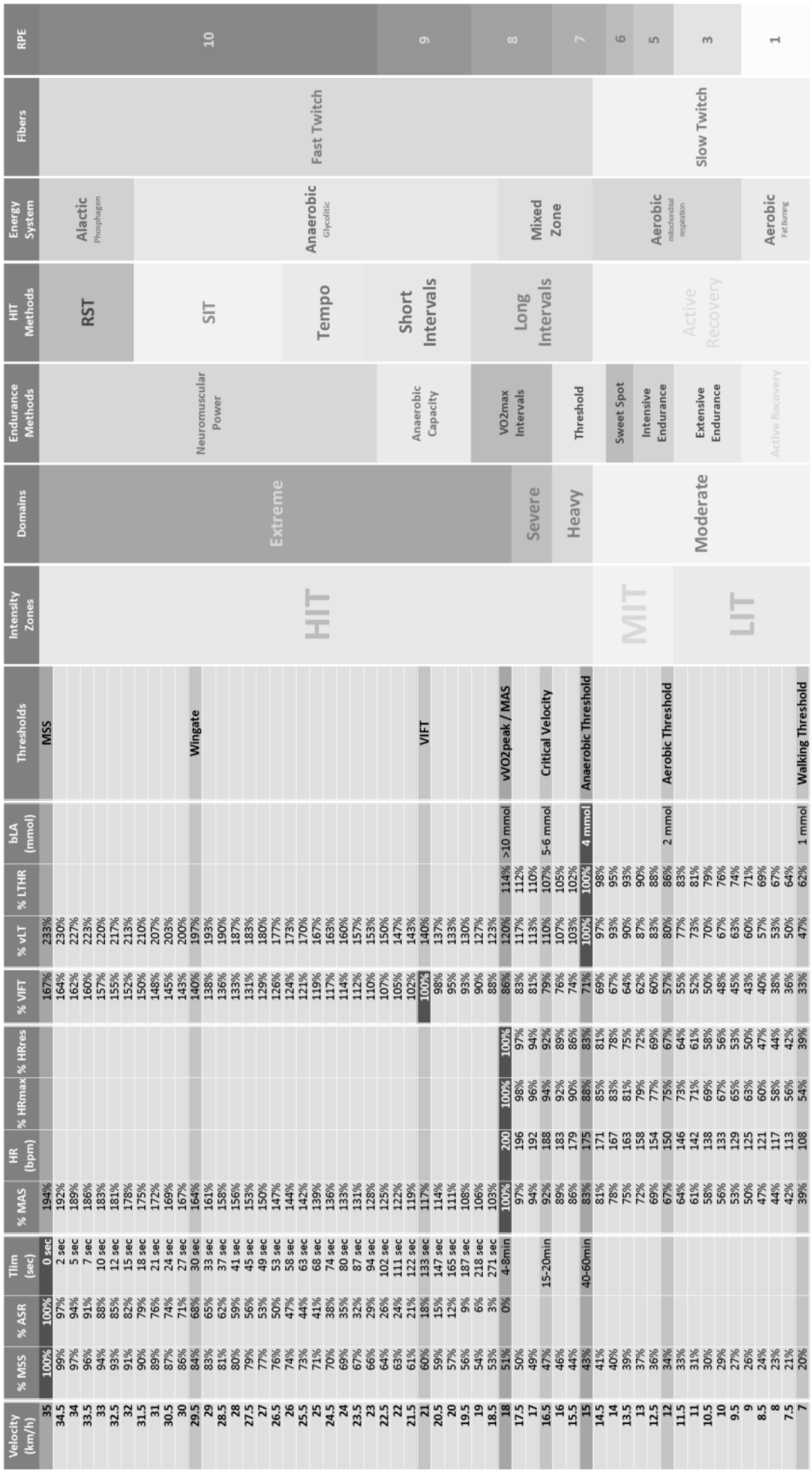

Figure 3. The "Endurance Map" – a very simplistic map of the endurance Large World.

The Endurance Map assumes flat surface continuous running. It represents a velocity continuum from **Maximum Sprinting Speed (MSS)** to zero, or in this case, the walking threshold (a velocity where one is unable to walk any faster and one needs to switch to running), which is around 7km/h (depending on the individual).

The major constructs used in the Endurance Map, as well as in this HIT manual, are **Maximum Sprinting Speed (MSS)** and **Maximum Aerobic Speed (MAS)**. Maximum Aerobic Speed is the minimal velocity associated with maximal oxygen uptake (VO_2peak) during a graded exercise test (GXT). The velocity zone between MSS and MAS is usually termed **Anaerobic Speed Reserve (ASR)**. The concept of ASR will be explained in much more detail later in this manual.

Other important constructs in the endurance world (although not in this HIT manual) are **Critical Velocity (CV)**, **Anaerobic Threshold (AnT)**, and **Aerobic Threshold (AT)**. With these three it is very easy to enter the rabbit hole of physiological models, so I will keep it simple. If you are interested in more details, please see the references.

Critical Velocity (CV) is mathematically defined as the velocity-asymptote of the hyperbolic relationship between velocity and time-to-exhaustion (Clarke & Skiba, 2013; Poole & Jones, 2011; Vanhatalo, Jones, & Burnley, 2011). To estimate it, one needs at least 4 time trials of different durations (e.g. 2min to 20min). The idea is, at least in theory, that above CV, one will start utilizing their ***anaerobic capacity*** and work on borrowed time. Critical Velocity is somewhere right in the middle between MAS and Anaerobic Threshold (AnT). The duration of work at CV is around 15-20min (although in theory it is unlimited). There are numerous ways to establish critical velocity (Clarke & Skiba, 2013; Maturana, Fontana, Pogliaghi, Passfield, & Murias, 2017).

Anaerobic Threshold (AnT) is tricky to define. Lab coats fight about it all the time. Historically, it has been identified using the maximum lactate steady state (MLSS), a threshold of 4 mmol of lactate in the blood (vLT), using gas exchange threshold (vGET), or second ventilatory threshold (vVT2), among many others. It seems that one starts recruiting more fast twitch fibers as they pass the anaerobic threshold, which results in work on borrowed time (similar to Critical Velocity). The duration that can be run at anaerobic threshold is around 20-40minutes. In this manual, everything over anaerobic threshold is considered HIT.

Aerobic Threshold (AT) is even harder to define. It usually represents the initial rise in resting blood lactate levels during a graded exercise test (GXT), which is around 2mmol, or first ventilatory threshold (vVT1).

For the sake of completeness, I've included Martin Buchheit's **Intermittent Fitness Test velocity (VIFT)**, which is going to be covered extensively in the text, as well as a Wingate Test (or a 30sec sprint test).

When it comes to the endurance world, getting lost in the details is very easy. So for this very reason, I have created this small world representation that is helpful in getting the big picture. The above five constructs are used in defining other important constructs in the endurance world, but are also used to express speed (or intensity) in a relative way. In the Endurance Map, speed is expressed in absolute terms (i.e. km/h), but also as a percentage of important constructs - %MSS, %ASR, %MAS, %vLT, and %VIFT. Expressed as such, it makes it more generalizable across athletes.

Using heart rate (HR) is possible only for sub-MAS velocities. The Endurance Map assumes maximum heart rate (HRmax) to be 200 bpm and resting heart rate to be 50 bpm. For sub-MAS velocities, intensity can be also expressed as %HRmax, %HRres (heart rate reserve, which is the difference between HRmax and resting heart rate), or %LTHR (heart rate associated with lactate threshold). Using relative intensity, rather than beats per minute, makes this model more generalizable across athletes.

Using the above constructs and relative velocities and heart rates, it is easier to map the endurance territory for the sake of the big picture overview. Let's explore some of those regions.

Using aerobic and anaerobic thresholds, Seiler (Seiler & Tønnessen, 2009) and authors from Norwegian group (Solli, Tønnessen, & Sandbakk, 2017) differentiated between three intensity zones:

1. High Intensity Training (HIT)
2. Medium Intensity Training (MIT)
3. Low Intensity Training (LIT)

As alluded to already, everything over the velocity associated with lactate threshold (e.g. around 80% MAS) is considered HIT.

The separation into different intensity domains (Poole & Jones, 2011) is really helpful to distinguish what is steady state (see Figure 4). In the Moderate domain, once steady state is achieved (e.g. after 2 minutes), heart rate (HR) and oxygen consumption (VO_2) tend to stay stable. In the Heavy domain, which is between lactate threshold and critical velocity, heart rate and oxygen consumption show a ***drift***. In other words, they tend to increase over time, but will not reach maximal values.

In the Severe domain (which is over critical velocity, but less than MAS), not only will there be a drift, but HR and VO_2 will reach maximal values.

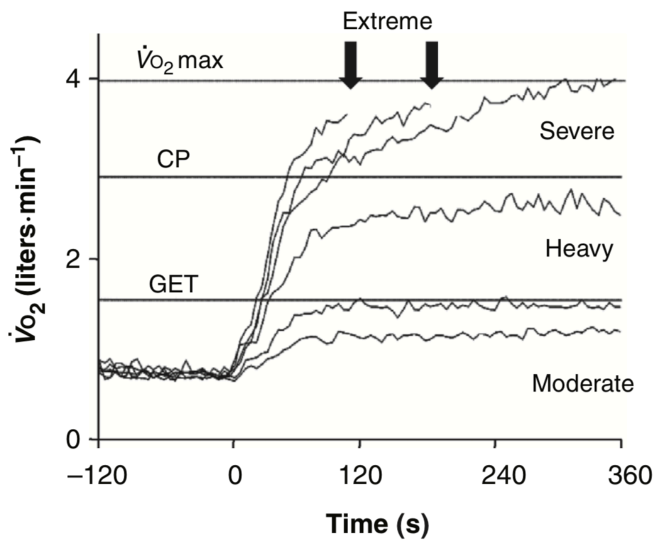

Figure 4. Poole & Jones model differentiating between four intensity zones. Taken from Poole, D. C., & Jones, A. M. (2011). Oxygen Uptake Kinetics (Vol. 72, pp. 1810–65).

The endurance methods column lists common endurance training methods that are based on %HRmax as well as %MAS and %vLT. Since this is a HIT manual, these are not going to be covered in detail. Interested readers are encouraged to check out Lyle McDonald's article series on Methods of Endurance Training (McDonald, 2009).

In the HIT method column, you will find the HIT methods (without visualizing overlap between them) that will be covered in much more detail later in the text.

The Energy System column oversimplifies the energy systems used (this is a huge rabbit hole for those interested). The Fibers column also represents an oversimplification of motor-unit recruitment. The RPE column oversimplifies rate-of-perceived effort at the beginning of the interval.

Overall, the Endurance Map is a gross oversimplification of the endurance world, but it is useful in making some sense and in orienting oneself. Besides, it provides a general idea of how things fit together.

Having this covered, the next thing to discuss is the needed tools for HIT conditioning.

Tools you will need

To apply the approach presented in this HIT Manual, you will need a few basic tools or pieces of equipment. Some will be easier to acquire while some will be more costly; for that reason I will provide a few alternatives. But by providing multiple alternatives, I run the risk of making this manual more complex and hence less understandable. I do want to make HIT prescription as simple as possible, but not so much so that it becomes too rigid. So, in a way, I had to *satisfice* and provide something that is precise enough, but also flexible enough for coaches in different situations to apply.

Cones

You will need a simple set of cones to set up the running tracks. Having them in multiple colors (or sizes) might be helpful in distinguishing different groups.

Figure 5. Cones

Stopwatch and whistle

Hopefully, as a coach, you already have a stopwatch and a whistle. If you don't, make sure to get them ASAP and make sure to get a stopwatch with a timer function. Having a timer function helps you time the intervals, especially the short intervals such as

15:15. Using a whistle, you can give 'beeps' to athletes or yell out the time left. For example, "to the cone in 3... 2... 1... stop!"

Figure 6. Stopwatch and whistle

Distance measuring wheel

Having a distance measuring wheel is a must. Since you will be estimating distances to be covered in a given time frame, you will be needing a tool that allows you to do that.

Figure 7. Distance measuring wheel. You will need this tool to measure distances

Beeper

In the case where you do not want to look at your stopwatch and give 'beeps' using a whistle, you can use an outdoor timer with a loud beeper. It does need to be loud. It is also great for playing pranks on your fellow coaches when in the office.

Timing gates

With some HIT drills, to improve prescription precision (and hence individualize better), it is important to know athletes' **MSS** (Maximum Sprinting Speed). I will provide a few alternatives for assessing MSS, but ideally you would want to have proper timing gates.

Figure 8. Timing gates. These are needed to proper estimation of Maximum Sprinting Speed

Shuttle Run Beep Test

The special version of the 20m Shuttle Run Beep Test (**SRBT**), that implements beep corrections for changes of direction (COD) can be downloaded at hitbuilder.net. This way, results from the 20m shuttle version beep test are in higher agreement with straight line beep tests (VamEval, Leger-Bucher or UMTT), while also being training-specific and sport-specific (Buchheit, 2010). You will use the velocity reached in this test as an estimate of **MAS** (Maximum Aerobic Speed).

To perform this test, you will need a loud stereo system and an MP3 player. Your smart phone or tablet connected to a speaker system will suffice. You will find the accompanying collecting sheet at the end of this manual.

I will also provide a few alternatives to this test, but stating this right upfront, Yo-Yo Intermittent tests are not good substitutes for shuttle-run beep test (SRBT) (Dupont et al., 2010; Heaney, Williams, Lorenzen, & Kemp, 2009).

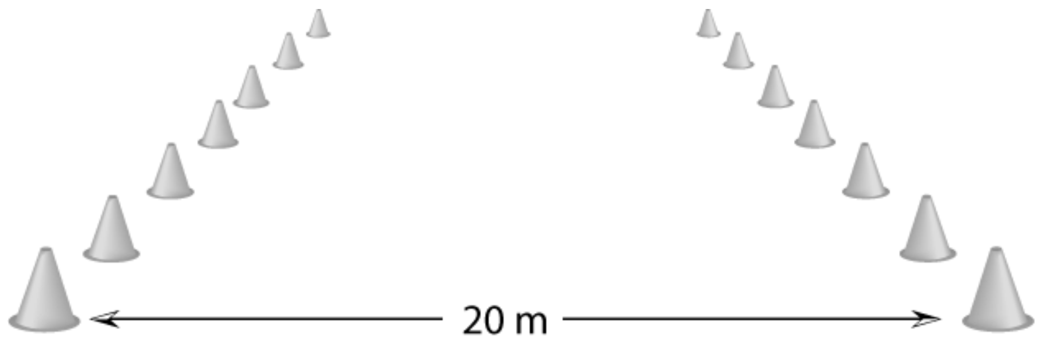

Figure 9. Shuttle Run Beep Test setup

Buchheit's 30:15 Intermittent Fitness Test (IFT)

Buchheit's IFT is a great alternative and/or addition to the shuttle-run beep test (SRBT), which also takes into account multiple other qualities (such as MSS, COD efficiency, intra-set recovery and so forth) that makes it an outstanding testing choice (Buchheit, 2010). Deciding between MSS, MAS and IFT for prescribing HIT drills is an important discussion that will soon be covered. If you wish to perform Buchheit's IFT, it can be downloaded here: https://3015ift.wordpress.com/2013/07/10/audio-files/

HIT Builder

HIT Builder is an accompanying spreadsheet that can be downloaded at hitbuilder.net. It allows for the creation of quick HIT drills for up to 200 athletes. The HIT Builder will be referenced on multiple occasions in this manual.

To wrap this up, the bare bones minimum of the tools you will need is the following:

1. Cones
2. Stopwatch and whistle
3. Distance measuring wheel
4. Shuttle Run Beep Test (and speaker system)

HIT Drills

Here is the classification of HIT drills used in this manual, mostly influenced by the outstanding work of Martin Buchheit *et al.* (Buchheit & Laursen, 2013a; 2013b) and Dan Baker (Baker, 2011):

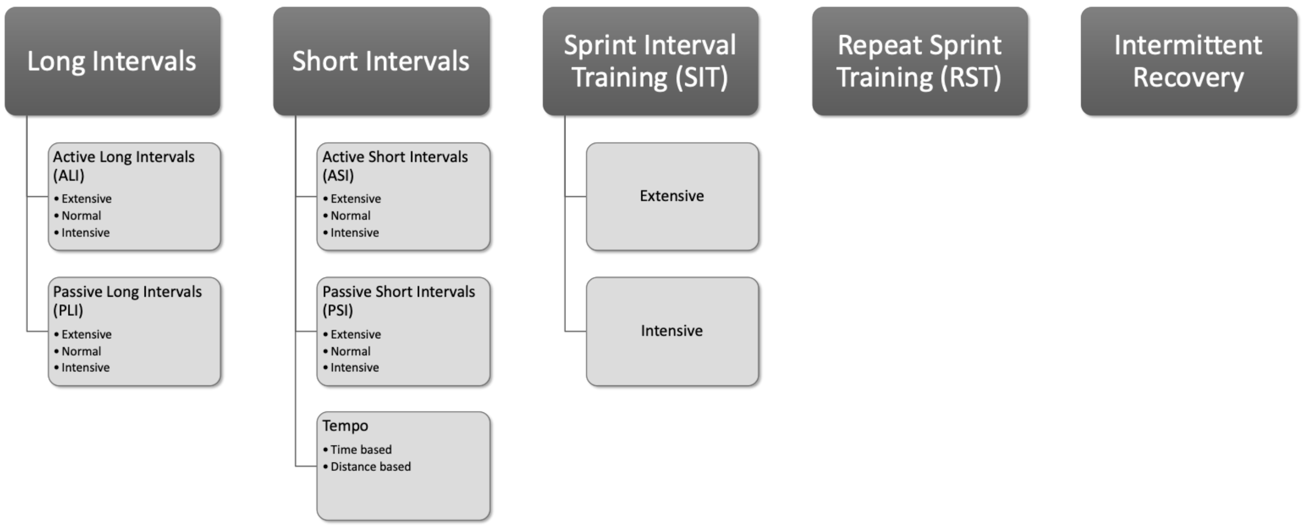

Figure 24. Classification of HIT drills

Each of these will be covered in more detail, but for the sake of a ***big picture*** overview, here is the Velocity Profile for Athlete A (MAS 4.44 m/s, MSS 9 m/s) with the distribution of HIT Drills (right side):

Velocity	%MSS	%ASR	Tlim	Dist	%VIFT	%MAS		REC	ALI	PLI	ASI	PSI	Tempo	SIT	RST
9.00	100%	100%	0 sec	0 m	177%	203%	MSS								
8.77	97%	95%	4 sec	35 m	173%	198%									95%
8.54	95%	90%	8 sec	69 m	168%	192%									90%
8.32	92%	85%	13 sec	104 m	164%	187%									
8.09	90%	80%	17 sec	139 m	159%	182%								80%	
7.86	87%	75%	22 sec	174 m	155%	177%								75%	
7.63	85%	70%	27 sec	209 m	150%	172%								70%	
7.40	82%	65%	33 sec	245 m	146%	167%								65%	
7.18	80%	60%	39 sec	282 m	141%	162%								60%	
6.95	77%	55%	46 sec	320 m	137%	156%							55%	55%	
6.72	75%	50%	53 sec	358 m	132%	151%							50%		
6.49	72%	45%	61 sec	399 m	128%	146%							45%		
6.26	70%	40%	70 sec	442 m	123%	141%							40%		
6.04	67%	35%	81 sec	487 m	119%	136%							35%		
5.81	65%	30%	93 sec	538 m	114%	131%						30%	30%		
5.58	62%	25%	107 sec	595 m	110%	126%						25%	25%		
5.35	59%	20%	124 sec	663 m	105%	121%					121%	20%	20%		
5.12	**57%**	15%	**146 sec**	**748 m**	**101%**	115%	VIFT				115%	15%			
4.90	54%	10%	177 sec	867 m	96%	110%				110%	110%	10%			
4.67	52%	5%	230 sec	1076 m	92%	105%				105%	105%	5%			
4.44	49%	0%	4-8min		88%	100%	MAS		100%	100%	100%	0%			
4.22	47%				83%	95%			95%	95%	95%				
4.00	44%				79%	90%			90%	90%	90%				
3.77	42%				74%	85%			85%						
3.55	39%				70%	80%			80%						
3.33	37%				66%	75%									
3.11	35%				61%	70%		70%							
2.89	32%				57%	65%		65%							
2.66	30%				53%	60%		60%							
2.44	27%				48%	55%		55%							
2.22	25%				44%	50%		50%							
2.00	22%				39%	45%									
1.78	20%				35%	40%									
1.55	17%				31%	35%									
1.33	15%				26%	30%									
1.11	12%				22%	25%									
0.89	10%				18%	20%									
0.67	7%				13%	15%									
0.44	5%				9%	10%									
0.22	2%				4%	5%									
0	0%				0%	0%		MAS	MAS	MAS	All	IFT/ASR	ASR	ASR	ASR

Figure 25. Example Velocity Profile and HIT drills distribution for Athlete A (MAS 4.44 m/s, MSS 9 m/s)

Here REC stands for recovery interval, performed in ***active*** variations of HIT drills, which is around 50-70% MAS. These two images provide a big picture of the HIT drills. Let's now cover each category in more detail.

Planning Strategies

All contemporary planning strategies are based on the assumption of *predictability* (certainty) and a simplistic causal network.

For an example, assume that your Government gave you a huge budget to create a new factory in addition to promising 200 skilled workers and 10 MBA experts, a safe market for the product and tax deduction. You have 5 years to finish the project. You will certainly approach this project in a *waterfall* manner:

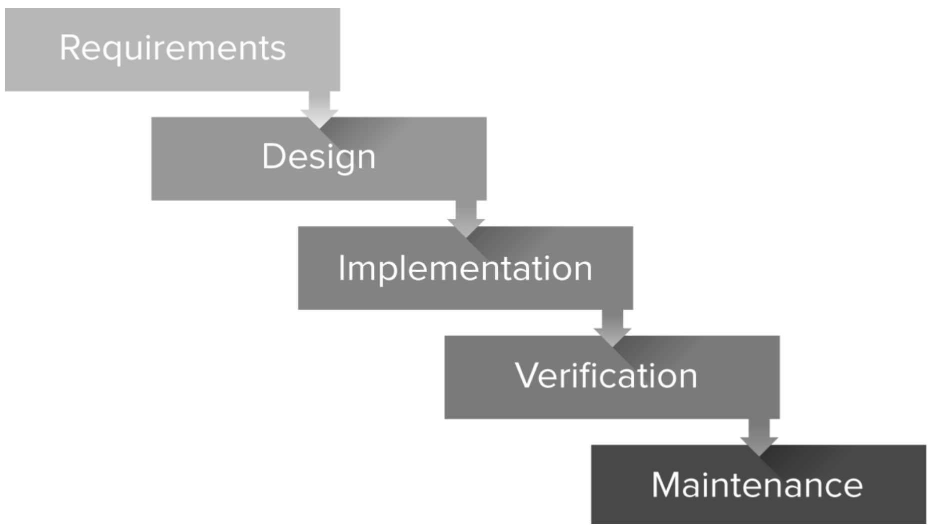

Figure 38. Waterfall project management. Image taken from SmartSheet website. Available here: https://www.smartsheet.com/agile-vs-scrum-vs-waterfall-vs-kanban

You will spend a few months making plans, acquiring all the needed licenses, creating budgets, and recruiting engineers, and then you will proceed to build things. Later you would equip them and create monitoring tools for workers. Everything in a very discreet, serialized manner.

Let's imagine another scenario. You were recently fired from your job, you have a family to sustain and house mortgage to pay off. You've acquired some life savings and you are willing to invest that into a great new app that you had in mind. How would you approach this project? Will you risk spending all your savings on developing an app for two years that no one will buy or use? Or should you put something on the market as soon as possible, minimize the risk and maximize learning what seems to be interesting to the market? You would develop ***MVP*** (Ries, 2011), minimum viable product, that you would launch and see if your project has any future to start with. This process is outlined in the ***Lean Startup*** methodology (Ries, 2011):

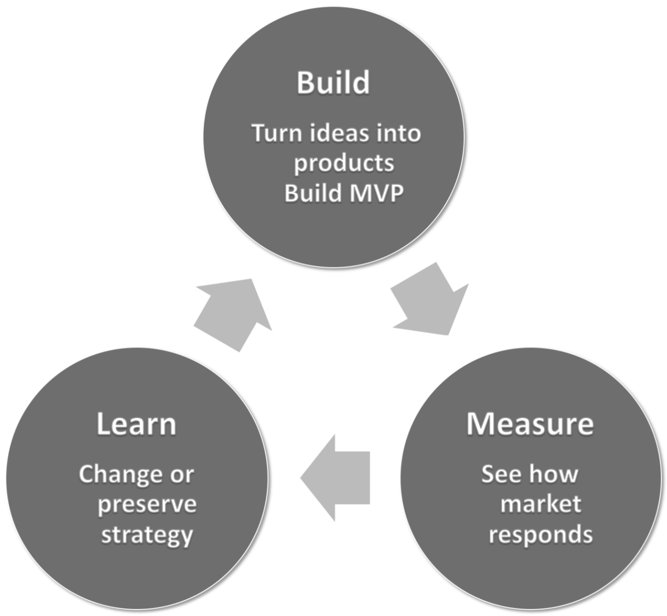

Figure 39. Lean Startup Methodology

What is the difference between the two scenarios above? It is the uncertainty of the second and bounded (constrained) resources. All contemporary planning strategies approach training as it is a factory to be built in a perfectly predictable scenario. The **Agile Periodization** paradigm I have been developing over the years (and still am) approaches training planning via understanding and embracing the uncertainties and constraints involved (Kiely, 2017; Layton & Ostermiller, 2017; Ries, 2011; Rubin, 2012; Sutherland & Sutherland, 2014).

What uncertainties you might ask? They are plentiful and they all propagate to your day to day decision making as a coach. Luckily, there is huge body of knowledge regarding the most robust decision making within uncertainty (Christian & Griffiths, 2016; Phillips et al., 2017; Gigerenzer, 2004; 2008; 2014; Gigerenzer & Gaissmaier, 2011; Klein, 2017; Mousavi & Gigerenzer, 2014; Neth & Gigerenzer, 2015). But let's quickly cover the involved uncertainties (at least the known ones):

Measurement uncertainties

All performance measures have measurement error issues, which make some more reliable and some less. In plain English, some measure more noise than signal (e.g. RSA measures are not good).

Model uncertainties

Our training models are based on outdated factor analysis models (which are also not exact) and anecdotal evidence that created a ***latent structure*** of motor abilities (constructs). This is very simplistic and needs to be understood as ***satisficing*** heuristics, rather than ontological realities. The underlying causal model of "what causes what" might be very complex and our simplistic reasoning might be especially flawed when working with elite athletes.

The general goal of such an analytic approach is to identify ***limiting factors***, ***rate limiters***, or ***determinants of performance***. But these things are not as easily identifiable in complex human organisms and environments.

For this reason, I believe the way to go is to embrace both the reductionist, analytical approaches as well as the complex, phenomenological approaches. In other words, accept Apollonian and Dionysian approaches, or rational and intuitive, objective and subjective. Complementary.

Top-Up Approach

Why would you do HIT in the first place? That's a fair question. The usual answer is very reductionistic and based on the dichotomistic form/substance model:

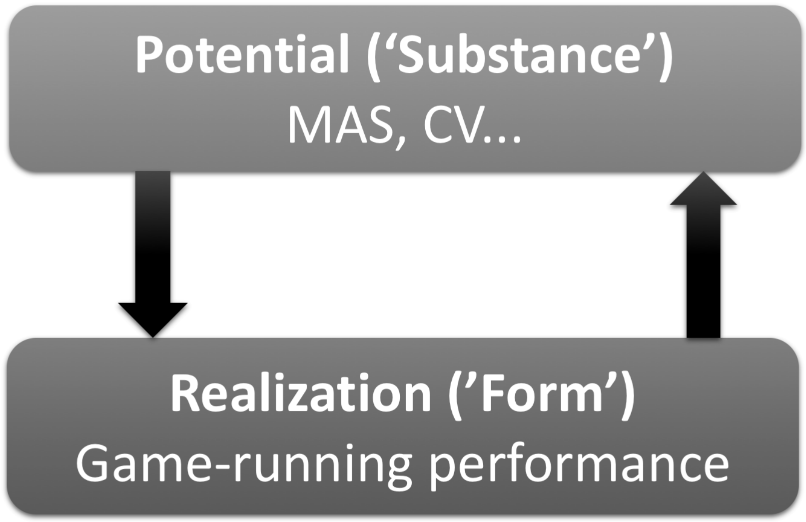

Figure 68. Substance ~ Form model applied to performance.

In this model, the goal of HIT is to increase ***latent qualities*** (substance, biomotor abilities), such as MAS, VO_2peak, vLT and so forth and then the realization (form) will follow in improved game-running performance or work capacity.

This model is also very well depicted in the works of Yuri Verkhoshansky (Y. Verkhoshansky & Verkhoshansky, 2011):

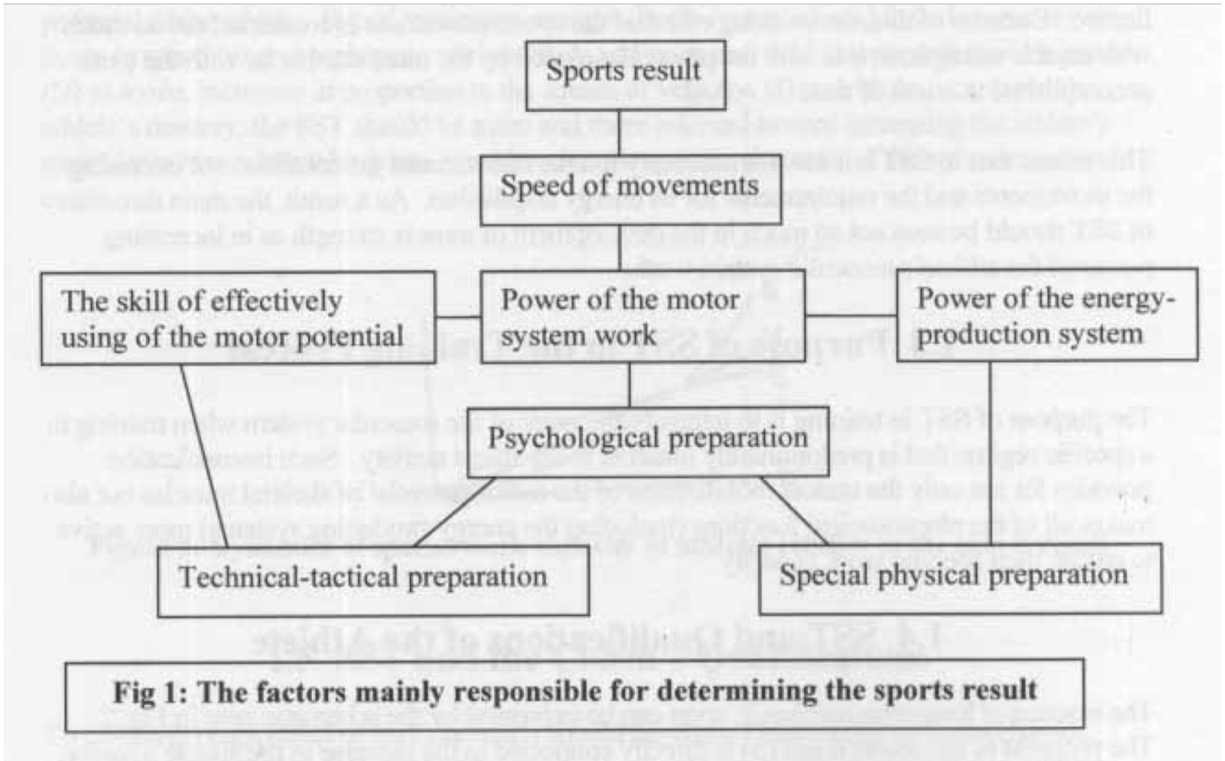

Figure 69. Constructs affecting sports results (substance ~ form model). Courtesy of Yuri Verkhoshansky. Taken from "Special Strength Training. A Practical Manual for Coaches. Moscow 2006"

If we use the car analogy, substance would be the car characteristics while form would be the driver's skill levels. Pretty much everything revolves around potential (substance, or special physical preparation in the above image) and realization of that potential (form, skill or technical-tactical preparation in the above image). This model is so ingrained in us that we are usually not aware of it. This is a very satisficing model, but sometimes it is flawed, especially when *scientism* tries to enforce their analytics-based constructs, rather than allowing for flexible, fractal-like and emergent qualities to be established continuously. This is the reason why I have introduced the Substance/Form element in my qualities model.

According to Yuri Verkhoshansky, as one's performance improves, the limiting factor becomes potential (Y. Verkhoshansky & Verkhoshansky, 2011):

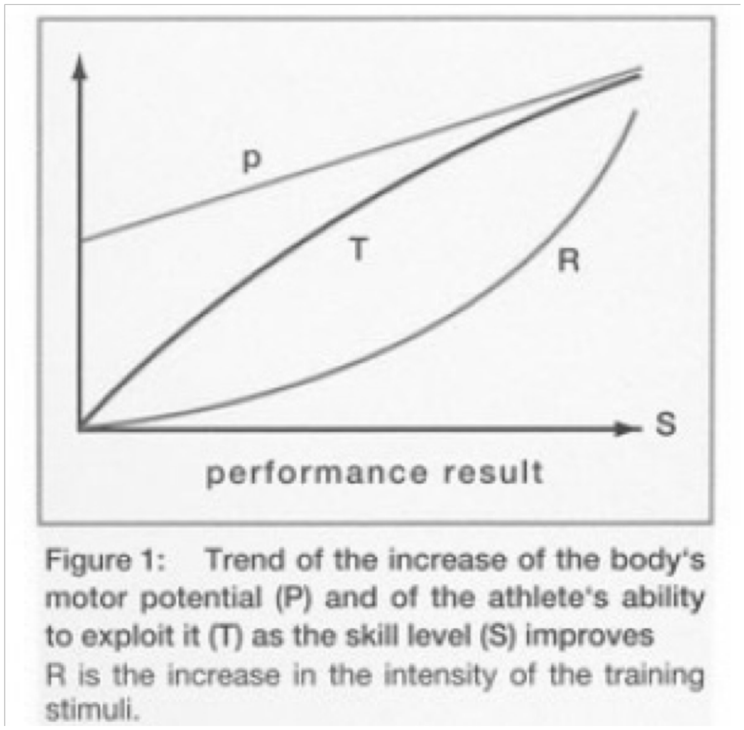

Figure 70. Relationship between potential and ability to utilize potential as performance improves. Courtesy of Yuri Verkhoshansky. Taken from "Main Features of a Modern Scientific Sports Training Theory". Available at http://www.verkhoshansky.com/)

So according to this model, the bottle neck in performance is not the skill (or coordination, or form, or ability to use potential), but potential itself. But even being satisficing, this model is too simplistic and makes lab coats conclude that in order to increase performance one must improve the underlying, analytics-based constructs. And that is one of the reasons why coaches such as Raymond Verheijen (Verheijen, 2014) flipped out and started bitching at sport scientists. As I alluded to before, I believe that a phenomenological approach in determining the qualities and substance/form relationship is more important than analytical ones (performance and physiology based). Besides, one needs to realize that limiting factors are very hard to pinpoint and they are not as simple as *A causes B* (Pearl et al., 2016; Rohrer, 2018).

For example, even if you improve MAS or VO_2max, the running performance in a game might not improve. Even if it improves, it doesn't mean that the team will play better.

There might also be a plateau phenomenon, where increasing potential costs too much (in terms of time and energy), without too much benefit in the realization (performance). Besides, maybe the needed level of potential can be achieved without doing HIT at all. Maybe the athletes can play their way into shape and that may be more than good enough.

These are all fair questions that introduce even more uncertainty. But we can't wait for the research to give us an answer so we need to rely on heuristics. In this case, the solution is again 1/N heuristic. To avoid being a sucker, some volume of HIT should be performed, even if you believe that playing your sport is more than enough to improve the levels of (specific) endurance.

But maybe the main reason to introduce HIT is not in increasing underlying potential, but increasing variety in the training program and achieving a higher level of robustness in the athletes as well as to correct for the loading fluctuations. Because playing small sided games (SSG) or medium, or large ones, creates a highly variable training load, HIT can be used to *top-up* and control for such fluctuations.

Let's assume that you follow Raymond Verheijen’s (Verheijen, 2014) periodization for a soccer team. Raymond's approach calls for iterations between three phases that utilize different soccer games. At the same time, you might track external load over GPS for every individual player (for example, High Speed Distance - HSD and PlayerLoad2D, which are measures of high speed running and CODs). On the following picture there is a hypothetical scenario that happened over 6 weeks (3x2 weeks) for a single athlete:

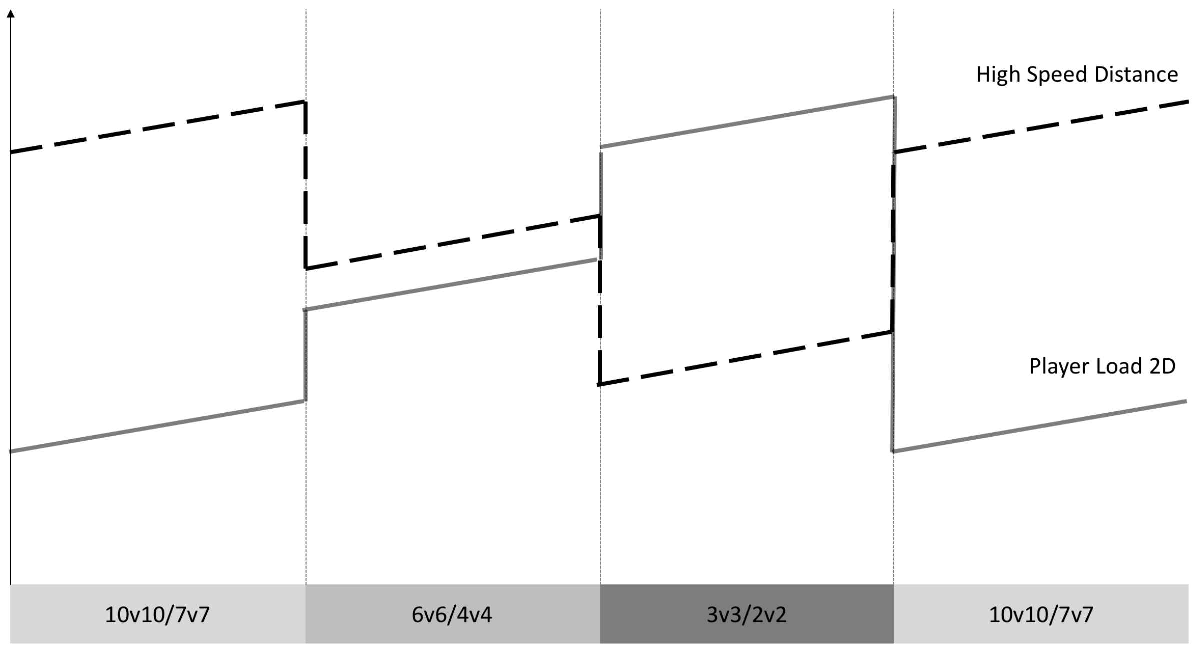

Figure 71. Rotating emphasis on large-, medium-, and small-sided games across weeks might result in fluctuations of high-speed and change-of-direction GPS metrics.

The sources of fluctuations in HSD and PlayerLoad2D might be due to variability in SSGs or, what is the case here, the switch in emphasis. Raymond introduced a concept of ***unload***, where the next phase is introduced in the previous phase using 50% of the planned load. This helps alleviate the load swings, but they still might happen (for example, an athlete might miss the SSG session). According to the research, one of the main reasons why injuries happen are huge swings in training load, especially from phase to phase (e.g. when you repeat the above cycle).

For this reason, a HIT workouts can serve two top-up purposes:

1. Top-Up Phase
2. Complement Top-Up

Example HIT programs

Providing program examples is always tricky since there are a lot of assumptions involved and it is hard to make it usable in multiple scenarios with different objectives. But, as an avid reader of strength and conditioning literature, I always appreciated a sample program, regardless of its limited applicability in multiple scenarios. For this reason, I will provide a few generic examples (or should I call them *minimum viable programs* - MVP) for team sport athletes (mostly having soccer athletes in mind) that could be done during the off-season, pre-season and in-season. This will give you a starting point that you can use and modify to suit your objectives and context.

It is important to keep in mind that these programs should be put in context with other training components (skill and practices, strength, speed, power training and so forth) and these can vary a lot from case to case. It is beyond this HIT Manual to go too deep into overall program design and periodization that takes all training components into consideration.

Off-Season HIT Program

Playing your sport (in this case soccer) and SSGs (Small Sided Games) are always preferred methods of getting in game-shape. Unfortunately, sometimes that is not possible, nor preferable. For example, being a free-agent and wanting to get in shape, coming back from injury (although soccer practices are a key element of a good **RTP** – return to play – program), or during the off-season, where one wants to have a mental break from the ball and so forth.

For these reasons, I've designed a simple running program for running-based sports; something that you can use with your athletes during a break or to have in your toolbox and apply it, if needed, in the RTP protocols or as extra conditioning.

The program is based on four 2 to 3 week long training phases:

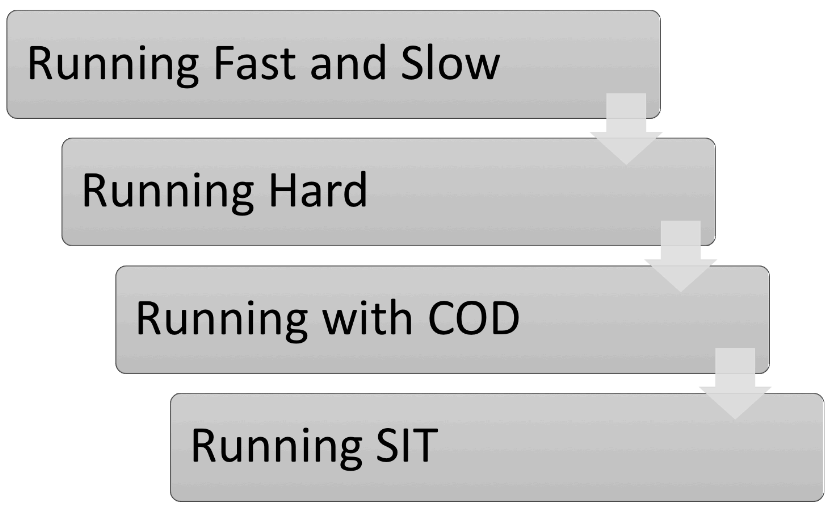

Figure 75. Phases of the Off-Season HIT Conditioning Program

Each training phase consists of 2 HIT workouts and 2 extensive runs, which are usually performed on Monday, Tuesday, Thursday and Friday, although the specific schedule depends on your context. During the off-season, where there are no team sport practices, it is important to accumulate volume of lower-intensity running together with

HIT conditioning, ideally achieving a **polarized training distribution** (Fitzgerald, 2014; Seiler & Tønnessen, 2009; Solli, Tønnessen, & Sandbakk, 2017).

The following table contains the weekly workout content of each training phase.

Phase	Duration	Monday	Tuesday	Thursday	Friday
Running Fast and Slow	2-3 weeks	Tempo	Extensive Run	Tempo	Extensive Run
Running Hard	2-3 weeks	Intensive PLI	Extensive Run	Extensive ALI	Extensive Run
Running with COD	2-3 weeks	Extensive Run	Extensive ASI	Extensive Run	Intensive PSI
Running SIT	2-3 weeks	Extensive Run	SIT	Extensive Run	RST

Table 23. Weekly workout content of Off-Season HIT Conditioning program

Using this program will make sure that your athletes are coming ready-to-train from the off-season (or RTP), while providing individually tailored workouts that are not too boring to be performed.

Phase #1: Running Fast and Slow

If the name of this phase reminds you of Daniel Kahneman's book "Thinking Fast and Slow," you are right. The goal is to perform workouts from two opposite intensity extremes: slow and fast, achieving a strategy very similar to what Steve Magness described as *funnel periodization* (Magness, 2013).

Monday	Tempo
Tuesday	Extensive Run
Wednesday	
Thursday	Tempo
Friday	Extensive Run
Saturday	
Sunday	

Figure 76. Running Fast and Slow phase workouts

Tempo workouts will prepare you for the HIT workouts of the subsequent phase, while extensive runs will represent the bread and butter of your off-season conditioning program. You can look at this phase as *base building*; something that will prepare you for the more strenuous, upcoming HIT conditioning.

Tempo workouts

Tempo runs are fast, quality runs done at a speed faster than 130% MAS (see the chapter on Tempo runs for more details). Repetition durations for these workouts are around 15-20sec with a rest period of 40-60sec.

The goal of this workout is to accumulate volume of faster, quality runs without draining your body. By using tempo runs you will be able to work on your running form and prepare your body for the hard runs to follow.

You can organize tempo runs by using time or distance. If you plan using time for running, you should stick to 15-20sec and if you plan on using distance, 80-120m will be fine (see chapter on Tempo runs for more details).

I will provide tempo workouts based on time, but you can quickly adjust by using distance instead (using HIT Builder). Here is the progression you can use:

Workout #1	3 sets of 6 reps of 15sec runs with 40sec rest
Workout #2	3 sets of 8 reps of 15sec runs with 40sec rest
Workout #3	3 sets of 10 reps of 15sec runs with 40sec rest
Workout #4	4 sets of 6 reps of 15sec runs with 30sec rest
Workout #5	4 sets of 8 reps of 15sec runs with 30sec rest
Workout #6	4 sets of 10 reps of 15sec runs with 30sec rest

Table 24. Tempo progression

During the recovery period, you can alternate between a core movement (15–20 reps) and push-ups (10–15 reps) if your shape allows you. Recovery between sets will be a little longer, around 2-3 minutes, during which you can perform basic stretching for the hip flexors, adductors, calves and hip rotators.

So the tempo workout might look like this:

10-15min Warm-up

15 sec Tempo run
Rest 40 sec and perform ab curl-ups for 20 reps
15 sec Tempo run
Rest 40 sec and perform push-ups for 10 reps
15 sec Tempo run
Rest 40 sec and perform side bridge for 20 reps
15 sec Tempo run
Rest 40 sec and perform push-ups for 10 reps
15 sec Tempo run
Rest 40 sec and perform low abs (scissors) for 20 reps
15 sec Tempo run
Rest 40 sec and perform push-ups for 10 reps
15 sec Tempo run
Rest 40 sec and perform dead bugs for 20 reps
15 sec Tempo run
Rest 40 sec and perform push-ups for 10 reps
End of set #1

Longer rest for 2-3 minutes *(perform a couple of stretches and/or dynamic moves like leg swings)*
Repeat 2 more times

Extensive Runs

To improve your endurance you need both intensive and extensive running (Fitzgerald, 2014; Magness, 2013; Seiler & Tønnessen, 2009; Solli Et Al., 2017). Extensive runs are going to be your bread and butter that we are going to keep doing through all training phases. You are also going to be able to modify this run to suit your preferences, but more on this later.

You are going to perform extensive runs in an interval fashion as well (which will make them a bit faster and on the border between LIT and MIT; see Endurance Map). Usually your extensive runs are performed at pace slower than 60-70% MAS. You can also go by feel or use a heart rate monitor (in this case, running at a heart rate lower than 80% HRmax or less than 140-160bpm). **When in doubt - go slower**. The goal is to polarize the running volume distribution and avoid the *middle zone* (see MIT in Endurance Map). Otherwise, the extensive runs will make you too tired for more intense HIT workouts. Having extensive runs in interval format makes this harder to achieve, so it bears repeating one more time: **when in doubt - go slower**.

In the following table you can find the progression for the first training phase:

Workout #1	3 reps of 8 minutes
Workout #2	3 reps of 9 minutes
Workout #3	3 reps of 10 minutes
Workout #4	3 reps of 11 minutes
Workout #5	3 reps of 12 minutes
Workout #6	3 reps of 13 minutes

Table 25. Extensive Run progression

During the recovery period between runs in the Running Fast and Slow training phase, you are going to perform the following bodyweight (BW) exercises:

- BW Squats
- BW Split squats
- BW Single Leg Dead Lifts
- Calf Raises

You are going to progress on these exercises as well during the workouts:

Workout #1	1 circuit of 8 reps each
Workout #2	1 circuit of 10 reps each
Workout #3	1 circuit of 12 reps each
Workout #4	2 circuits of 8 reps each
Workout #5	2 circuits of 10 reps each
Workout #6	2 circuits of 12 reps each

Table 26. Bodyweight circuit progression

You should be able to perform these back-to-back with no rest in under 3-4 minutes.

Thus, the workout looks like this:

10-15min Warm-up

8 minute run *at a pace less than 60-70% MAS or less than 70-80% HRmax*

1 circuit of BW exercises

8 minute run

1 circuit of BW exercises

8 minute run

1 circuit of BW exercises

Stretch and cool-down

Pre-Season and In-Season Program

When it comes to team sports planning strategies, I like to utilize two concepts: (1) functional groups and (2) mini-blocks (Jovanović, 2017a; 2017b). It is beyond this manual to go into details regarding planning strategies and the mentioned concepts, but for the sake of example I will provide some clarification.

Functional groups represent ***teams within a team*** that a coach needs to take into account and create separate plans for. Functional groups are mostly related to game availability:

Figure 80. Functional Groups

In an ideal world, coaches should provide individual plans, but in real life these four groups are more than enough. The **Playing Squad** is related to athletes who are starting the game and who play more than 60 minutes (which is the usual threshold in soccer to be considered in the Playing Squad functional group). **Reserves** are players who traveled for the game and who are on the official match list (in soccer, that is usually 7 athletes - 6 players and 1 goal keeper). **Non-travel** are athletes who didn't travel for the game and are available for extra training. **Injured** are athletes who are in a *return-to-play* (RTP) protocol and demand special attention. An extra group that is usually added is **Other**, which might include athletes who are away on a break or leave, borrowed to another club or have national team obligations.

These groups are dynamic and athletes move from these functional groups from game to game.

Mini-blocks represent building blocks of the microcycle (which is the period between two games):

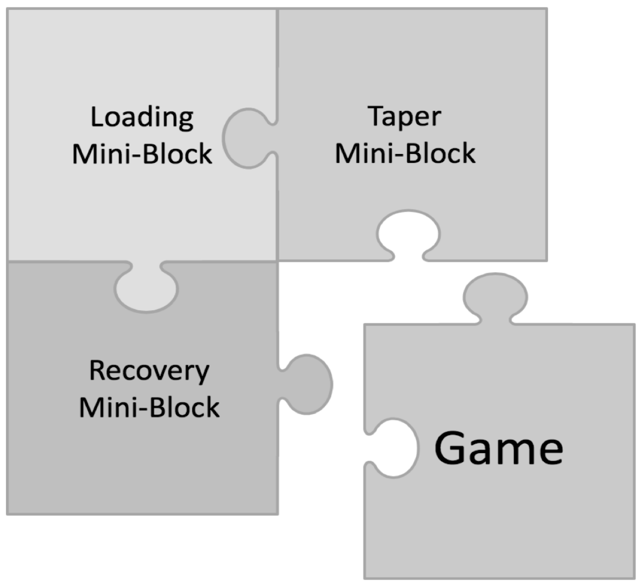

Figure 81. Mini-Blocks

These mini-blocks are laid in order: (1) recovery mini-block, (2) taper mini-block and, if there is some time left, (3) loading mini-block. These are planned for separately for the above functional groups. As already stated, it is beyond this manual to go into more details regarding planning strategies for team sports and interested readers are directed to the following references: (Jovanović, 2017a; 2017b; Mallo & Sanz, 2014; Verheijen, 2014).

The following figure contains implementation of functional groups and mini-blocks for one ordinary microcycle (Sunday-Sunday game). The outlined Thursday represents a day where the likelihood of the most strenuous conditioning will take place.

Last Game	G+0	G+1	G+2	G+3	G+4	G+5	G+6	G+7
Next Game	G-7	G-6	G-5	G-4	G-3	G-2	G-1	G-0
	Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
Playing Squad	Game	Recovery	Recovery	Loading	Loading	Taper	Taper	Game
Reserves	Game	Loading	Recovery	Loading	Loading	Taper	Taper	Game
Non-Travel	Loading	Loading	Recovery	Loading	Loading	Loading	Taper	Loading
Injured	Loading	Loading	Recovery	Loading	Loading	Recovery	Loading	Loading

Legend

Game	
Loading Mini-Block	
Taper Mini-Block	
Recovery Mini-Block	

Figure 82. One ordinary microcycle plan using functional groups and mini-blocks

When it comes to conditioning, the aim is to do most of it with the ball using large-sided, medium-sided and small-sided games. HIT conditioning is complementary to these, and if one is equipped with GPS devices, a Top-up approach (complement and phase) to conditioning can be utilized instead.

The example program in this manual is modified from Raymond Verheijen's program (Verheijen, 2014). Raymond uses an iterative, three-phase plan, in which he rotates large-sided, medium-sided and small-sided games. He also utilizes an ***unload*** (which is around 50% of load) of the upcoming phase. As stated previously, this helps in smoothing out potential spikes in load. Although soccer-specific conditioning is the primary mean for conditioning, complementary HIT conditioning is added to make sure all important boxes are ticked off all the time:

About

Mladen Jovanović is a Serbian Strength and Conditioning Coach and Sport Scientist. Mladen was involved in the physical preparation of professional, amateur and recreational athletes of various ages in sports, such as basketball, soccer, volleyball, martial arts, tennis and Australian rules football. In 2010, Mladen started the Complementary Training website and in 2017, developed the scheduling and monitoring application, AthleteSR. He is currently pursuing his PhD at the Faculty of Sports and Physical Education in Belgrade, Serbia.

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Glossary

AI - Artificial Intelligence

AnT – Anaerobic Threshold

ASR - Anaerobic Speed Reserve

AT – Aerobic Threshold

BW - Bodyweight

COD - Change Of Direction

CV - Critical Velocity (usually at the halfway between vGET/vLT/vLT2 and MAS, or around 90% MAS)

GET - Gas Exchange Threshold

GXT - Graded Exercise Test

HR – Heart Rate

HRmax - maximum heart rate

IFT - Intermittent Fitness Test

Leger-Bucher – Straight-line version of the beep test

LT - Lactate Threshold

LTHR – Lactate Threshold Hear Rate

MAS - Maximum Aerobic Speed

MSS - Maximum Sprinting Speed

MVP - Minimum Viable Product

RSA - Repeat Sprint Ability

RSS - Repeat Sprint Sequence

RST - Repeat Sprint Training

RTP - Return to Play

SIT - Sprint Interval Training

SJW - social justice warrior

SRBT - Shuttle Run Beep Test

SSG - Small Sided Games

T@MAS - time spent at MAS running velocity

T@VO_2peak - time spend at VO_2peak

UMTT – Straight-line version of the beep test

VamEval – Straight-line version of the beep test

vGET - velocity at GET (usually around 80% of MAS and 90% HRmax)

vLT - velocity at Lactate Threshold (usually around 80% of MAS and 90% HRmax)

VO_2peak - Maximal oxygen uptake one achieves in GXT

vVT1 - velocity at first ventilatory threshold

vVT2 - velocity at second ventilatory threshold

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