The Principle of Ratios

The Principle of Ratios was authored by Soviet scientist M. Nabatnikova, and states that "there is an optimal relationship between different components of preparedness for a given athlete, corresponding to his or her sport, gender, age, level of mastery, and individual characteristics." Essentially, each sport, and athlete, will have an optimal ratio of development of physical qualities that will allow them to perform their best. That ratio will be dependent on a number of factors, including the sport, gender, age, level of the athlete, and individual physical and mental characteristics. Therefore, while it may be somewhat easy to discern the general makeup that one must have to succeed in certain sports, in order to maximize performance, these qualities must be more closely scrutinized. The main general physical qualities that people are likely familiar with are strength, power, hypertrophy, flexibility, and energy systems development (or conditioning). The purpose of this article will be to outline, in a general sense, how each of these can impact (positively or negatively) one's performance.

Strength and Power

When people think of strength & power in sport, sports such as sprinting, weighted throws (shot, discus, hammer), football, and weightlifting spring to mind. While strength and power are obviously huge components of those sports, they are vitally important physical traits in many other sports as well. Pavel refers to strength as the "mother quality," because it positively influences so many others.

To begin with, we must define our terms. Strength, at its most basic level, is the maximal ability of a muscle to produce force. Power is the ability of the muscle to produce force as quickly as possible. It is, literally, the amount of work done divided by the time it took to do it.

It's all well and good to worry about what's happening with the individual muscles, but more relevant to our discussion is the expression of strength and power in movement. The expression of strength, such as that seen in a squat, is the coordination of many muscles working together, at the right time, to produce the proper movement. The reason this is important, is that it is possible for the muscles to get stronger (improve their ability to generate force) without increasing the weight used, especially if your technique is not very good.

It is just as it is possible to *not* get stronger while adding more weight to the bar, by simply changing technique enough (allow the back to round, the knees to cave, stopping short of the depth you should) to allow yourself to move more weight. And in younger athletes, this added weight on the bar is enough of a stimulus for them to still improve and get stronger and faster – but it sure as heck doesn't do much to make them injury proof! I would much rather see an athlete miss a lift because their technique was a bit off than put themselves in a dangerous position just to try to hit a bigger number.

For a perfect illustration of strength not always translating into big lifting numbers, look no further than gymnasts. Gymnasts are ridiculously strong and powerful, yet rarely (if ever) train with barbells. The strength required to get into and hold some of the positions they do is tremendous. But ask them to perform a simple bench press, and results would likely not be particularly impressive, because they haven't practiced the movement at all. Does this mean they are not strong? Heck no! They simply lack the coordination necessary in that particular movement to move big weights.

But because we can't actually look at each individual muscle fiber, we generally rely on tests such as various barbell lifts, along with jumps and sprints, to demonstrate if the athlete is getting stronger or more powerful. These are certainly good indicators, but they, too, can be strongly influenced by technique. In fact, teaching an athlete proper technique can dramatically improve their performance with minimal actual training being done.

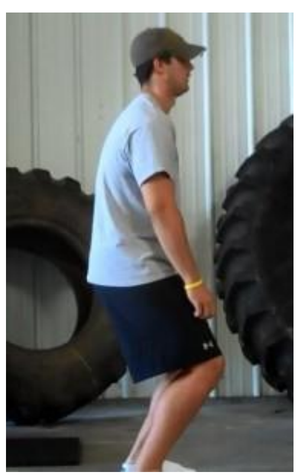
With all this talk of technique, how can we tell how much of improvement is due to improving technique, and how much is due to actual improvement in the physical capabilities of the muscles? To be honest, we can never be 100% sure, but we are always striving for technical mastery as well, because we are putting the athletes in the most advantageous position to use the strength and power capabilities they have. This also decreases the risk of injury by putting them in biomechanically sound positions.

So, now that I've spent way more time than I probably needed to define our terms, it's time to answer the question at hand: What is the role of strength and power in sport? In many sports, such as those listed earlier (sprinting, throwing, weightlifting, powerlifting), the answer is obvious. And in other sports, such as basketball, football, and baseball, the ability to be powerful and run faster and jump higher will give you a leg up on the competition, so long as your sport-specific skills are there. Again, all this, I'm sure, is obvious. So why am I droning on? Because, as always, there is even more to it than that.

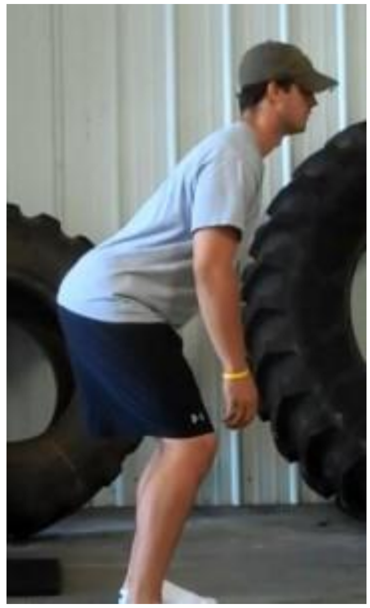
With the exception of long-duration endurance events, strength and power play at least some role in improving performance. And for that reason, nearly all athletes could improve their performance by training it. Increasing strength improves injury resistance by strengthening muscles and tendons. Increasing maximal strength and power production also gives us a bit of a "reserve" to work with. That is, rather than always having to work near the top end of our capacity, we are working at a lower relative percentage, meaning the work is easier, and we can likely sustain it for longer.

James Smith refers to these as Maximal Outputs and Operational Outputs. Maximal Outputs are what we are capable of doing, and Operational Outputs are what we need to do. Unfortunately, we all too often focus on the Operational Outputs – the level of physical qualities we need to do in our sport – rather than increasing what we *can* do. Just because a rugby player very rarely reaches top speed doesn't mean they shouldn't do some sprint work to improve top-end speed, thereby improving acceleration speed, and reducing the amount of energy needed to run at what was previously top speed. Just because a basketball player will never literally squat someone off of them, increasing the absolute strength of their legs via strength training will make it easier to bang under the boards for rebounding position.

Using another example, if a basketball player comes in that is too weak to hold a good athletic position for more than a few minutes at a time, it is unlikely they will be particularly effective, especially on the defensive end. However, by increasing the strength of the hips and back, it is much easier for the athlete to stay in that position for an extended time, improving their performance.



Poor Athletic Position – Feet flat, hips directly over the heels, shoulders behind the knees, shoulders rounded.



Good Athletic Position – Weight on the balls of the feet, bent at the knees and hips, shoulders in front of the knees, back straight

Increasing strength, up to a point, also improves the potential for power development. At a certain point, doing all the jumping and sprinting in the world won't get you any faster or more explosive. You must add strength training to improve the "ceiling," if you will, for power.

As I have also said many times, terms like stronger and more powerful are relative terms. You must determine the current level of the athlete, and what is necessary for them to improve their performance. Additionally, the means of getting them stronger will not always be "put them under a bar." For some, simple bodyweight training will be all they need for quite some time.

As the athlete moves along in their athletic career, simply improving total-body strength and power will no longer suffice. This is because each sport carries with it its own strength and power requirements. Not only is the amount of strength & power necessary sport-specific, but it is also joint and movement-specific as well. Because of this, some will argue that certain athletes don't need to be that strong. I agree with this, to an extent, but I also haven't met many athletes, particularly in high school, who would meet that threshold.

For instance, swimmers need more upper body strength and power focus, while track athletes need far more lower body work. However, among younger athletes, the goal should simply be to improve strength and power production of the total body, in a variety of directions, at the major joints. As the athlete ages and advances in ability level, it may then be prudent to specify which joints and movements should take precedence in training.

As an athlete becomes more and more trained, the effort and energy required to improve strength and power continues to increase. It is at that point that you must weigh the benefits of increased strength and power with their ability to improve sporting results. At a certain point, the maintenance of current strength and power levels is all that is necessary, and more time must be spent perfecting sport techniques and tactics. We have only so much energy and recovery ability, and especially for more advanced athletes, it is time better spent on their sport. But in younger athletes, I have yet to meet one that I would deem "strong enough." Most have done minimal strength training, or have been taught so incorrectly that they don't know what proper lifting technique is, and are spending an inordinate amount of time doing sport-specific training. Teaching them proper training in an effort to increase total-body strength and power will go a long way toward improving their performance, for the reasons outlined above.

I will readily admit I am a meathead at heart – I love trying to get bigger and stronger, and getting athletes bigger and stronger. So I may be a bit biased toward the benefits that strength and power provide to an athlete. With that said, however, we *always* take into account the individual needs of an athlete when designing their programs. What we as coaches personally want or like is irrelevant – what matters is the athletes see the results they need. Almost every athlete can benefit from getting stronger and more explosive. I will talk further about methods of acquiring strength and power elsewhere. For that reason, I won't go into too much detail on that front – the point of this article is simply to outline the why. Why do we need strength and power? And how much do we need?

What I'm trying to say is, strength and power are context specific – just as with almost any other physical quality. At their highest levels, different sports require different levels of absolute strength and power. Different joints and movements will have different needs. But measuring strength and/or power must be done within certain confines – simply saying there is more weight on the bar is not a very good gauge. And worrying about sport-specific needs at young ages is largely a waste of time. So, until an athlete has reached a high level of achievement (and no, winning their little league tournament does not qualify), "more" is probably a good guideline to follow for strength and power, provided it is performed and prescribed appropriately.

Hypertrophy

I have a feeling that many kids (much like myself) first started lifting weights as a means to emulate the look of Arnold. Any benefit for sports, while nice, was kind of incidental. It is with that in mind that I write about hypertrophy training for athletes. Hypertrophy is simply an increase in muscle size. Some athletes (especially younger ones) need to add muscle mass to their frame. The great thing about training like an athlete (with an emphasis on big, multi-joint movements, proper movement patterns, and improving strength and power potential) does a great job of putting muscle mass on kids. The simple addition of resistance training, almost regardless of load, volume, or frequency, will put at least some mass on pretty much anyone.

Where the biggest change needs to be made is in regards to the volume used. If an athlete has a specific need to pack on weight, we can up the volume of these exercises in an effort to put on size a bit more quickly. Additionally, if an athlete has areas that need to be built up (for instance, the shoulders in football players), specific hypertrophy training can be used in those areas to try to build them up a bit quicker. For this, bodybuilding-type training, utilizing higher volumes of work, with shorter rest times, is helpful. This type of training is best performed during the off-season; however, it is again going to be dependent on the training and biological age of the athlete.

Many athletes are looking to put on mass in their younger years (teenage and college mostly), and this is great, because that is also when their bodies are best suited to handle it. They possess the natural hormonal environment conducive to growth. However, an issue can arise if they are trying to put on too much mass too soon, or if they are perhaps outgrowing their optimal size for performance.

While muscle mass plays an important role as "body armor" (as Dan John calls it), too much of it can actually be a bad thing. This (among other reasons) is why training like a bodybuilder all the time is all wrong for an athlete. Some athletes need to put muscle on – especially those in collision sports like football and rugby, and to a certain extent hockey and lacrosse. Basketball players may not see the value in it, but it is useful for them as well.

This will come as a shocker and will probably take some of you aback, but hypertrophy can be quite important for females as well. Joe DeFranco once made the analogy that if you have a hamburger, and you take away the fat, what are you left with? The muscle! And this piece of muscle will be smaller than the original piece of meat. This is something to keep in mind for girls – gaining muscle in and of itself will not make you "bulky." It's a BS term thrown around by morons like Tracy Anderson who don't know their head from a hole in the ground. Fact is, the more muscle mass you have, the more calories you burn, and the bigger "engine" you have. Again, this doesn't mean that girls even need to train specifically for hypertrophy, but they needn't be afraid to put some weight on the bar, either.

I've also heard of some parents wanting their younger (pre-pubescent) kids to put on weight. While this isn't a bad thing, the fact of the matter is that A) They probably need to eat more (especially good food), and B) they simply don't have the hormonal environment to support putting on large amounts of muscle mass. No amount of training will fix this. Training at that age should be a sort of "physical education," which is touched on elsewhere. They can also use that time to ingrain perfect technique so that when they move on to using heavier loads, they don't have to spend a ton of time learning how to do things properly. Focus on keeping them active, learning proper motor patterns and eating a lot of good food.

One myth that is out there is that the larger the muscles, the stronger the athlete. However, this isn't necessarily true. It is true that, all else being equal, a larger muscle is a stronger muscle. However, if that were true, professional bodybuilders would be the strongest men in the world. Strength is largely about the nervous system creating maximal force in the muscles and coordinating that force between muscle fibers both within the same muscle and between different muscle groups. As this coordination improves, strength goes up. This type of adaptation is what weight-class sport athletes thrive on. Weightlifters and powerlifters alike will often use methods that utilize higher loads and lower volumes so that they can gain the neurological adaptations with minimal gain in muscle mass.

> *"The highest correlation between muscle mass and strength is observed in those cases when strength is maximal and the speed at which it is displayed is of secondary significance. The connection between strength and bodyweight decreases as the speed at which strength is displayed increases; it does not have vital importance for explosive types of exercises..."* -Y.V. Verkhoshansky, 1977
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> *"An increase in muscle mass is not an obligatory result of strength training."* -Y.V. Verkhoshansky, 1986

Notice in the first quote, that hypertrophy does not have vital importance for explosive exercises – this is because, we must remember that we are propelling the body, and therefore any and all weight (no matter how lean it is) must be propelled as well. This is why adding weight is not always a good idea. In many sports, relative strength (strength to bodyweight ratio) is of extreme importance – sports like gymnastics, wrestling, and MMA in particular, largely because the last two are weight class sports. The goal is to be as strong as you can be for the weight class you compete in. And if your sport requires jumping or sprinting, it is important to keep tabs and make sure that any extra weight you are adding isn't slowing you down.

The best time to add muscle mass, if necessary, is in the offseason. During the preseason and in-season, the athlete's training and recovery abilities need to be directed toward their sport. Depending on their training age, they should be focused on maintaining strength and power abilities (and if they are of a low training age, these can actually continually be improved), and recovering from their sport practice.

In the end, focusing only on hypertrophy for athletes, to the exclusion of other qualities, probably isn't the best approach. Progressively lifting heavier weights, while eating plenty of calories, and still focusing on strength, power, and movement skills will likely add the size necessary. However, if more muscle is still needed, adding some volume, particularly to smaller, single-joint exercises (which won't impede recovery as much), would be just fine, too.

Mobility and Flexibility

If asked how much flexibility one needs, the frequent answer is probably "more." However, much as with strength or hypertrophy, simply saying you need "more" flexibility or mobility may be incorrect. The necessary amount of mobility and flexibility will vary based on the sport. Not everyone needs to be as flexible as a gymnast, nor should they be. Hypermobility is great for those who need it, but for other athletes it can put them at much greater risk of injury.

Before going much further, I think it's important to point out the differences between flexibility and mobility. While there are likely many definitions floating about, I will give you the definitions I use, and you may decide for yourself how to define them. I generally think of flexibility as being passive – that is, how much range of motion (ROM) a joint has when relaxed. Think about something like a simple hamstring stretch, whatever variation you choose. The goal is to relax the hamstring and stretch it as far as you can. That is what I consider flexibility. Mobility, on the other hand, is what *usable* ROM there is about a joint. That is, the ROM of a joint while active. So for instance, while you may be able to score well on a sit and reach (which, admittedly isn't necessarily a test of only hamstring flexibility), you may not have near that ROM when performing something like a squat.

This also points to the importance of building stability through whatever ROM you have. This can be highlighted by watching those who go to the weight room and do nothing but partial ROM exercises, then go stretch.

Appropriate strength training has been shown to improve flexibility just as well, if not better, than static stretching. (Hint – use a full ROM!) In other words, to those who say weightlifting just makes you "bulky" and/or "inflexible" – please think before you speak. Improving ROM, either passive or active, does take some time though.

All that said, if someone has a heck of time even getting into basic positions, how do we get them the requisite flexibility and/or mobility?

Static stretching prior to exercise has been shown to decrease strength & power performance. I have heard and seen some coaches say they will take that decrease in performance if it keeps their athletes healthy. The problem is, there isn't any research showing that it reduces risk of injury. Now, if an athlete has a mobility restriction that places them at a greater risk of injury, then yes, it is in their best interest to stretch beforehand.

We generally improve flexibility and mobility via a few avenues. First and foremost is a dynamic warm-up prior to the workout, raising the core temperature, making muscles more pliable and increasing blood flow. All this leads to adding at least a bit of mobility. Another way we improve mobility and flexibility is targeted static stretching (the old "stretch and hold" type of stretching) post-workout. For many athletes, this will mean stretches for the hips (especially the hip flexors), and the anterior shoulder and pecs. These aren't universal, but are very common among the majority of the American population, and kids and athletes are often no different. However, if an athlete has other issues, those are addressed as well. If an athlete has the requisite flexibility/mobility, then appropriately performed resistance training should allow them to maintain the ROM they have.

As you can see, as with most aspects of training, flexibility and mobility can be a bit more involved than people think. I'm all for people thinking they simply need "more" flexibility, because most people do. But for those who already have it, more may not be the answer. So assess what you actually need, and train accordingly.

Energy Systems Development (Conditioning)

Ah, the great conditioning debate. Some coaches swear you must run until you're ragged, others feel that every drill and form of training you do must be done at a breakneck pace in order to develop the appropriate conditioning to win championships. While this probably does get the athletes ready for the rigors of practice, does it truly prepare them for sport – or perhaps, the question should be asked, do practices, as they are currently constructed, properly prepare athletes for their sport? To properly answer that question, let's once again start by defining our terms.

James Smith has noted that the word "conditioning" in and of itself does not have a specific meaning. It is no different than "training." Context must be specified. In fact, if I remember correctly, my first encounter with the idea of conditioning was in my high school psychology class, talking about Pavlov's classical conditioning experiment with his dogs. If, for some reason some of you are not familiar, let me refresh you: around 1900, Ivan Pavlov, a Russian physiologist, conducted an experiment on his dogs to test the concept of conditioned reflexes. He would ring a bell and give his dogs food. What he realized was that the dogs would salivate when he gave them food, but eventually, the simple ringing of the bell was enough to trigger the salivation response from the dogs. He had conditioned the dogs to respond in a certain way, by using inherent responses they already had.

All of this is to say, when using the word conditioning, all we really mean is "preparing our body to respond in a certain way to a certain stimulus." In other words, for instance, powerlifters and weightlifters are conditioned to lift heavy weights – it is what their bodies have been trained to do. However, when most people refer to conditioning, they are talking about energy systems development. That is, developing the appropriate energy systems of the body to produce the necessary energy and allow a high level of performance, conditioning the body to use the appropriate energy systems. By specifically training these energy systems, certain adaptations take place in the body, making those energy systems more efficient and powerful.

To start, an overview of the energy systems:

Humans have 3 energy systems which provide energy for our muscles to contract. Each vary in terms of their potential output, as well as their availability.

1. Alactic-anaerobic – Also called the ATP-PC system, ATP is what makes our muscles contract. Our muscles always have ATP in them, as well as creatine phosphate (the same creatine that you take if you ingest the supplement). This system is very powerful, and provides energy immediately, but fizzles quickly, and is usually done at about 10-12 seconds.

2. Lactic Glycolysis – Lactic acid begins accumulating, and the body uses this for energy. However, this system also is responsible for the muscles shutting down if an activity of too high intensity is sustained for too long (though the exact mechanisms are not entirely clear). This system is not as powerful as the first, and also is responsible for the "burn" you feel in the muscles. Lasts up to 2-3 minutes

3. Aerobic Glycolysis – uses oxygen to produce energy. Lasts as long as we have fuel (glycogen and/or fat) to sustain it.

It is important to note that all 3 systems are always being used, simply in different amounts. For instance, you are always producing lactic acid; it just isn't accumulating, because you're not working hard enough to make it build up.

And while it might seem like the ATP-PC and aerobic systems have little effect on one another (because they're so far apart), the aerobic system is quite important, especially in team sports! The better developed your aerobic system is, the more quickly ATP can be replenished, and the faster you can use that energy system again. Sounds like a recipe for success!

Interestingly, aerobic development and lactic acid development seem to be at odds with one another – shocker! High aerobic development produces greater mitochondrial density in the cells. Mitochondria are the "powerhouse" of the cell, where oxygen is processed and turned into ATP. More mitochondria = more ATP production. However, the frequent training with lactic acid loads destroys mitochondria, thereby dragging down aerobic capacity in the cells.

A snippet from an article by Eric Oetter sums this up much better than I:

> *"For the most part, the energy systems demands of a repeated-sprint athlete are alactic-aerobic. The alactic system is responsible for providing the immediate energy to drive high-intensity movement while the aerobic system serves as the foundation for substrate recovery between bouts of activity.*
>
> *…*
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> *Simply following the ball (or discounting the huddle, in the case of American football) might mislead onlookers into overestimating the glycolytic demands of repeated-sprint sports. However, in light of the Osgnach study and time-motion research on other sports, it's clear that the bulk of the metabolic demands lie in the other two energy systems.*
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> *This begs the question – why, if these athletes rely so heavily on the alactic and aerobic systems, is there still overwhelming support of high-intensity, glycolytic-based training methods?*
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> *One theory is that high-intensity seems to be the rule in training. The current American system thrives on running people into the ground – it's primarily the athletes possessing genetic superiority that rise to the top levels of competition and get to play. While I'm not advocating an easy way out, research points to much smarter methods in preparing our athletes for sport.*
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> *Overreliance on high-intensity techniques can produce undesirable ramifications for repeated-sprint athletes. For example, the constant sympathetic nervous system activation associated with this style of training can impair an athlete's recovery between bouts of activity and between individual training sessions.*
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> *And due to the competing adaptations present, a focus on glycolytic development ensures suboptimal aerobic development. Considering the aforementioned ATP-CP and medium-intensity demands of repeated-sprint athletes, inadequate preparation will lead them to dip into glycolysis sooner and cause them to fatigue faster."*
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> (For more on energy systems, and why the lactic energy system is probably the last thing that needs to be emphasized, read the rest of the article from 8weeksout.)

So what's the big deal? If all 3 energy systems provide energy, why does it matter which ones we're using? The most basic answer is because when we are primarily reliant on the ATP-CP system, we are our most explosive. This is the energy system that provides the energy for our best-effort sprints, jumps, and short-time explosiveness.

However, too often we see people working much more in the glycolytic-lactic zone – trying to go all-out, but doing so for upwards of 30-60 seconds, with minimal rest times. While this may not seem like a big deal – hey, we're working even harder! – the adaptations to that type of training actually make us *slower* and *weaker*. Not exactly what we're aiming for in almost any sport. Charlie Francis, one of the greatest sprint coaches of all time, notes, "Lactic training is too slow for speed development, and too fast to recover from in 24 hours." But, this is what we see a lot of from coaches. Trying to get both "fast" and "in-shape" in the same workout. It doesn't work that way.

Additionally, trying to train skills in the lactic zone is an exercise in futility. Rather than teaching and honing skills while fatigued, teach them and learn them while fresh, then work on applying them to a fatigued situation. Many will decry that this takes far too long; but when looking at it from a long-term development model, you will see that there is plenty of time – years, in fact. Unfortunately, our "win-now" culture dictates that we see results as fast as possible, long-term development be damned.

Before I go too much farther, I do want to note that this doesn't mean the lactic system should never be trained. Some sports actually do rely on it somewhat heavily. However, the lactic system is the most easily trained of the 3, and the adaptations occur the fastest. Additionally, and perhaps most importantly, because that is the system that is the most taxed during most sport practices, it is essentially pointless to work on it during other training times – they will get plenty once their practices start.

I'm sure many people are asking, "what's the big deal? Our athletes get through their games just fine the way we do things." As always, the question is not "does what we're doing work?" It's "can we make it better?" First, we have to remember that pretty much anything is going to be better than nothing. So yes, training any of the energy systems, in any haphazard manner, will give better results than if they are doing nothing. So in that context, it 'works.' But it's certainly far from optimal. And as coaches and athletes, isn't that what we're striving for?

Training energy systems is no different than training muscles – we are training it to act in the manner we want. We are training the energy systems to provide energy in as great a quantity as we can, as quickly as we can. And in order to do that, we must aim to "condition" the energy systems that are most important to the sport of the athlete. Simply aiming to get the athlete tired is not the point – quite literally any idiot can do that. Train the adaptations you want, appropriate to the sport, and if fatigue follows, so be it. Fatigue is a byproduct – not a goal!

Summary

To wrap up, as you have seen, simply saying an athlete needs to have everything may not be entirely accurate. At younger ages, training everything at a low level is desirable – they simply cannot produce the intensity necessary to become overly strong and powerful, nor do they possess the hormonal profile to put on slabs of muscle. However, flexibility can be very well developed at that age, as well as aerobic training and some sprinting. They can also lay the groundwork for strength, power, and hypertrophy work that can commence once they reach puberty. At a certain age (depending on the sport), the ratios necessary to truly excel can be examined and programmed for. However, simply aiming to improve everything eventually will get you nothing! So be cognizant of where your athlete(s) actually are – are they ready for specificity? Or is a more general program a better way to go?