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LTPD, Maturation and Training Modalities - The State of Play

Introduction

Over the past 10 to 15 years a lot of study has been done regarding the role of specific training and sport specific training in Youth. A lot of this data was summarised last year in a massive review done by Lloyd et al.

The review brought together research on a host of different training related areas such as speed, strength, endurance training - to name a few. This has helped us answer many questions about the safety and effectiveness of different types of training in pre adolescent, adolescent and post adolescent youth athletes and swimmers.

Basically, for you the coach to be able to prescribe the most effective program with the greatest impact on the physical aspects of your young swimmers there needs to be an understanding of the age and sex specific differences in body composition, performance variables, the kids' potential to adapt positively to training stimulus - as well as specific developmental growth factors. That last point - developmental growth factors - is of particular interest to me. There are actually things you can, and cannot do, to certain age groups of swimmers.

Today I will basically present the best practice model for coaching according to LTPD principles. The LTPD document has in large part been given the backing of research (and proven correct), and therefore globally we as coaches are in a position to better understand how to develop an appropriate training plan that will mature with the young swimmer and provide them with the appropriate training at the appropriate stage of their development.

I will be looking at three areas. Firstly, we will briefly consider how the different energy systems mature and develop from birth through to adulthood. This information will give you good insight into what type of fitness training is appropriate for what age of swimmer.

Secondly, we will visit that topic that interests us all - speed development.

Lastly, I will present for your consideration guidelines as to best practice in developing Training Plans aligned with scientifically sound LTPD principles.

Training the energy systems

Let me begin by saying that kids are not just small adults. A 7 year old is not just a smaller version of a 10 year old. A 13 year old is not just a small 18 year old.

On the face of it those statements are clearly true and should be obvious. However we all know that the realities of running swimming businesses, and the availability of kids in the afternoon, does mean that from time to time 7 year old's do swim with 10 year old's and 13 year old's do swim with 18 year old's. While that is practically unavoidable in terms of running your swim squads, what you can do is you can make sure that each of those age groups are receiving the correct training stimuli at the correct stage of their development even in a group or squad environment.

So, a quick update on terminology for you, when we talk about aerobic or anaerobic conditioning or training the aerobic or anaerobic systems, we are talking about metabolic conditioning. You're talking about manipulating metabolic processes that give energy to the body so that we can swim longer, faster, further - whatever.

It doesn't take much to understand that physiological and hormone changes during growth and maturation will have a massive impact on that person's capacity for training the aerobic or anaerobic systems, as well as basic things like their neuromuscular coordinating - their ability to complete an acceptable swimming stroke.

The research into this particular question has been done, back in 2008, and so now we know - amazingly - that 7 year old's can't do what 10 year old's can do. More importantly we know why.

Also of interest is the fact that the particular system/s in the human being that will adapt as a result of the training stimulus is determined by what stage of development the kid is in.

In 2008 research done by Gamble showed that the 'metabolic response of younger athletes during a bout of endurance exercise differs between age and maturation stage'.

Basically, the adenosine triphosphate (ATP) and phosphocreatine (PC) content in muscles of young athletes has been reported to be compatible to that of Senior athletes - but before adolescence they have a less developed glycolytic energy system.

What this means is they cannot work anaerobically, they don't make massive amounts of lactic acid. For example, that kid in the squad you tell to swim easy and the whole squad tells you he's sprinting - and he insists he's swimming easy. All that's going on there is he's not swimming anaerobically at all - he just doesn't 'feel the burn' as much as a more mature swimmer will.

In fact pre-adolescent kids do almost everything based on lipidosis or fat-burning systems. Basically these kids are using fat and phosphocreatine only for exercise. They don't get tired, they don't get sore arms, they don't break down like senior swimmers.

However the important take home here is since the glycolytic energy systems are less well developed in pre-pubertal kids you cannot train them on lactate production and lactate tolerance work - they simply lack the energy system to derive a training benefit.

If you look at the LTPD model it advocates that your fitness training of pre-pubescent kids basically favours an aerobic environment. The research done emphasizes that due to the limited capacity for anaerobic exercise in pre-pubertal children this type of training should be avoided in this developmental phase.

So let's now consider aerobic conditioning.

You will get similar gains with pre-adolescent and adolescent children as far as aerobic training goes. Overall though, your fitness gains aerobically in response to your training with young athletes will be less than that you can get out of adult athletes.

Prior to puberty boys and girls have similar responses to aerobic training so there is little or no gender effect in that stage of development. However, post puberty aerobic conditioning is more important for your female athletes as this needs to counteract the decline of anaerobic endurance that is observed in girls after the onset of puberty.

In addition to this aerobic training will help those girls keep body composition under control - which we see in our girls as they go through this stage of development. Later on for the girls higher intensities of training may be required in order to produce the improvements in endurance that you need from your top squads.

Back to our friend anaerobic conditioning. Remember I said earlier anaerobic conditioning in pre-pubertal children is not advised because kids at that stage of development can not respond to this type of training. The research behind this comes from work done way back in 2000. Like I referenced earlier - children don't have a high tolerance for glycolytic metabolism. Children do however have well-developed high energy phosphocreatine systems. So we can say they are very good at lipidosis, and they're good at ATP-PC energy production, so they are able to recover faster from exercise bouts primarily because they have lower acidosis as a result of lowered glycolytic enzyme activity.

As children grow into puberty and adolescence they get progressively better adapted to anaerobic exercise because their capacity for glycolytic metabolism is steadily increasing.

Remember too that if you don't have a well developed glycolytic energy system, you are not going to store large amounts of glycogen in your muscles. That means that swimmers in the early development stages have lower glycogen levels relative to adults. Rather, they use fats/lipids as a fuel source during exercise which tends to offset the use of glycogen stores.

In the phases that follow puberty the amount and intensity of anaerobic conditioning you are doing can be slowly increased toward your senior swimming levels.

Metabolic Conditioning Training Guidelines

	Pre-pubertal	Pubertal	Adolescent
Training mode (in rank order)	Cross-training Running-based conditioning Conditioning games	Running-based conditioning Conditioning games Cross-training	Conditioning games Skill-based drills Running-based conditioning Cross-training
Training format	Long-aerobic intervals (90 sec-4 min bouts) Short-duration intervals (10-30 sec bouts)	Long-aerobic intervals (90sec-6 min work bouts)	Long aerobic intervals (90-120 sec) Short- and medium duration intervals (20-60 sec)
Intensity	Self-regulated work and recovery bouts	Moderate to high (65-85%)	Long intervals at 85-100% Short-/medium intervals at 90-120%
Volume, frequency	4 times per week	4 times per week	4-5 times per week alternating formats on consecutive days

Speed Development

When we are talking about improving speed as swimming coaches were talking about improving or increasing the performance of our swimmers.

A good question is whether training is the main determinant of improvement or whether their natural development - their simply growing up - is the primary determinant of improvement. Remember a person's response to training is influenced by the age of maturation status.

With speed development, there appears to be a 'window of opportunity' where accelerated adaptation occurs, but only for a certain period In that kids' life.

There is limited research to give us answers, but in 2015 a review of the effectiveness of different training programs on speed development was carried out. A number of methods have an impact on sprint performance in children.

Children who are pre-pubertal have greater benefit from plyometric training than sprint training. Children who are pubertal have a greatest benefit from plyometric training followed by strength training. Post-adolescent kids show great improvement with a combined program plyo- and speed, followed by strength.

Basically these results suggest that younger kids get more benefit from neuromuscular stimulation, whereas older kids respond better to stimulation aimed at improving muscle strength.

Giving us a little more think about is a meta-analysis of resistance training in kids done in 2010 that clearly suggested that great gains in strength and power can be achieved by your later maturing swimmers.

The most important thing in developing speed is to focus on performing the movements with quality, with proper technique. Also, if you're going to properly develop speed, you must give adequate rest between repeats. Please coaches you need to seriously consider your exercise vs. recovery periods when you are actually doing sprint training.

Speed develops as the kid grows but not in a smooth fashion. There are periods of increased speed adaptation between pre-adolescent and later adolescence. These natural spurts of increase performance have been attributed more to neural development in pre-adolescence and to hormonal development in post-adolescence.

So with your younger kids they're learning to do the movements better - with the goal of becoming autonomous swimmers. With your older kids you have the influence of testosterone in males and maturity hormones in females that will help you develop speed.

Gender differences in speed development really become clear at the onset of puberty with your girl's making limited gains in speed throughout their adolescence - while the boys simply make great gains.

Adaptations in the central nervous system have been shown to have the greatest impact on speed in children as they learn to recruit and coordinate muscles and movement patterns. This does continue through adolescence and that emphasizes the LTPD model and the 'window of opportunity' for developing speed around puberty.

Maturation also plays an important role in the development of speed as changes in limb length, muscle size, and the intrinsic properties of those muscles (the composition of the fibres) all changes during this time.

It is therefore clear that physiological changes have a great impact on speed development during childhood.

Speed is also a result of the product of stroke length and stroke frequency. If you analyse strokes you find that your stroke frequency does not influence your maximum speed as much as your stroke length. Stroke frequency does decrease as a child grows - so maximum speed increases are due to increases in stroke length.

Let's look at some practical applications of how you develop speed through the different stages of maturation.

	Early childhood	Pre-pubertal	Pubertal	Adolescent
Suggested age-range	0-7 years	Girls: 8-11 years Boys: 8-12 years	Girls: 11-15 years Boys: 12-16 years	Girls: >15 years Boys: >16 years
Sprint training	Locomotor skills	Technique	Technique and maximal sprints	Maximal sprints
Complimentary training	Physical literacy	Plyometric Coordination	Plyometric Strength Hypertrophy Coordination	Hypertrophy Strength Complex training
Primary training adaptation	Neural	Neural	Neural & physical	Physical & neural

Early Childhood (0 to 7 years for Boys and Girls)

Your main goal with young children is to use physical activity to develop movement skills and to do anything you can to further that goal. Your primary coaching goal is to develop technical skills - your physical conditioning must take a back seat.

Young kids, for example, develop the ability to run, but the focus then should be to enhance the ability of running rather than on seeing how fast they can go. Get them to run correctly.

So after you have left learn to swim, don't leave the errors in for the next 10 years. Fix them when they are 5, 6, 7 - that is the time you've got to get their movements down. Starting at 12 is going to be very difficult.

Until children reach the age of 7 the nervous system is just growing fast. Your focus needs to be on movement and not speed in the water. Coordination patterns and the natural growth of that central nervous system should be aligned and incorporated in training children, and you must keep in mind that those basic movement skills are one of the many systems that needs development in children - not only as swimmers but as developing human beings.

Your lessons must introduce clear instructions and drill sets that promote good movement skills and swimming technique.

Proper feedback and instruction is required to promote the learning of proper movement patterns. We do need to have appropriate and structured classes and training at this early age, but remember that different kinds of free play (and other sports activities) will also cause the natural development of speed. Don't only concentrate on swimming when the kids are this small - get them out there get them doing a lot and they will slowly get faster at all of it, just because they are growing up.

Pre-Pubertal Children (8 to 11 in Girls and 8 to 12 in Boys)

During this phase you are going to focus more on the technique of sprinting mechanics. You can also introduce physical training at this stage - now you can get into your early plyometric and sprint work as well as high-speed coordination training - which has also been shown to be effective during this developmental phase. That ‘window of opportunity’ philosophy suggests that there may be heightened adaptation to sprint training at this age, and your training needs to have a neural focus while integrating those more technical and physical aspects of your sprint and speed conditioning.

However, at this stage technique training should make up the largest part of your training volume. Your physical training and your swim sets will aid in the development of technique particularly if it's monitored properly and if appropriate feedback is given to your children.

Movements should start with basic instructions encompassing small movements progressing on to greater ranges of motion and longer loading time-frames of speed work.

Pubertal (11 to 15 and Girls and 12 to 16 in Boys)

In this phase we are moving from a focus on technique to concentrated physical training to complement their sprint performances. Technique and correct stroke mechanics should still be important and should still be corrected, but at this stage, the foundation should have been laid down. If that's not the case and the child does not have correct stroke technique to be able to sprint correctly, then the program should be a stepped backwards to the point that is appropriate for that kid.

Adolescent people have a lot going on in their body - body shape and composition are changing and this may cause a period of awkwardness. During this stage you need to support, you need to encourage, and you need to reinforce fundamental swimming and sprinting skills. Your physical training is basic and attention is always given to proper form and technique because you don't want injury or over-use issues.

Post-Adolescents

Now you're in a phase where the main part of training focuses on strength for sprinting, but you must still demand high quality on technique.

In this phase strength training, plyometric training and speed training have all been shown to help improve sprint performance. Your strength training should focus on maximal force production and relative strength - so we want strong individuals that can work quickly.

Training for Speed

The basic goal of sprint specific training should be that all activities are completed at maximum intensity with proper form. The amount of maximum intensity must be appropriate to the ability and development developmental stage of the kid being trained.

The Long-Term Development of Our Swimmers (LTPD)

The National Strength and Conditioning Association in America published a position statement on LTPD which addresses several areas that need to be thought about when planning conditioning programs for young swimmers. That statement gave us a list of principles that we should think about when planning (hopefully) successful long term swimming programmes.

1. Long-term athletic development should accommodate for the highly individualized and non-linear nature of youth growth and development.

> This is not so straightforward. "It is common knowledge that there are great differences in anatomy and physiology between children, adolescents, and adults. Obvious differences include muscle structure, size, activation patterns and function (Falk *et al.*, 2009). These differences have been shown to decrease force production and maintenance potential, and in turn, could increase the risk of injury (Faigenbaum, Avery D. Kramer, W. Blimkie, 2009). The differences between children of the same chronological age, in biological maturity is variable in magnitude, tempo and timing, which may influence the extent of exercise tolerance, exercise response and recovery from training (Lloyd *et al.*, 2016)."

2. Youth of all ages, abilities and with different interests should engage in long-term athletic development programmes that promote both physical fitness and psychosocial well-being.

> "The presence of external factors on the individual, such as socio-economic status, stress and other lifestyle factors, will have a dramatic influence on physical development, dietary habits, sleep patterns and psychosocial health (Biddle and Asare, 2011)."
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> Global recommendations on youth physical activity suggest that youth should aim for at least 60 minutes of moderate to vigorous physical activity per day, in different areas, such as family, school, sports and community wellness (Faigenbaum and McFarland, 2015).

3. All youth should be encouraged to enhance physical fitness from early childhood, with a primary focus on motor skill and strength development.

> "Many of the health benefits associated with adult fitness training, are achievable by youth, under the right guidance, supervision and planning. The specific needs, interests and abilities of the individual should be considered.
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> A broad spectrum of exercises and activities should be included to ensure the individual as a whole develops fully in all aspects, including fundamental

movement skills and general strength. (Faigenbaum, Avery D. Kramer, W. Blimkie, 2009).

Although the correct sequencing of fundamental movement skills require the application of coordination of multiple muscles, joints and movements, the need for a general level of strength and endurance will exist (Lloyd *et al.*,2016)."

4. Long-term athletic development pathways should encourage an early sampling approach (trying a number of physical activities or sports), which enhances the range of motor skills.

"Early childhood is dedicated to developing several neural and metabolic pathways in order to learn and execute skills, activities and movements that require strength, endurance, skill & accuracy etc. Training programmes at this time should focus less on separating these factors into individual facets, but rather on incorporating activities that combine these factors. This will ensure that the individual will be exposed to a broader range of modalities and skill- acquisition opportunities (Faigenbaum, Lloyd and Myer, 2013)."

There is a recent trend, in which children and youth are encouraged to engage in specific training toward a single sport early (this is commonly called "early specialization" and specifically refers to those children who specialize in one sport before the age of 12 or in primary school), due to the lure of higher performance standards, such as provincial and national team selection, scholarships and lucrative contracts (Ericsson *et al.*, 1993).

The early specialization approach has been made more popular by myths such as the "10,000-hour rule". This concept suggests that one does as much training in one sport as early as possible to reach 10000 hours, which will supposedly result in one being an expert. There is no scientific evidence for this rule.

The current scientific evidence actually suggests that from a performance and injury prevention perspective - one should only specialize in one sport in high school.

The trend has been a common phenomenon, where children who display natural talent in a given sport or activity, leads to parents and coaches seeking and expecting better achievement. The issue is that the overexposure to narrow ranges of movement patterns with insufficient recovery and change, may lead to higher risk of injury and decreased performance. By exposing the individual to a broader range of opportunities to develop, there is natural variability and less monotony, and less chronic stress in specific muscular-skeletal areas (Bartlett, Wheat and

Robins,2007). Programmes for youth should focus on developing a wide range of movement skills."

5. Youth should participate in physical conditioning that assists in reducing the risk of injuries and ensures ongoing participation and long-term engagement.

> "According to the International Olympic Consensus statement on youth athletic development, there is an alarming incidence amongst athletes aged 11-18 years of 35 injuries for every 100 individuals annually, which require medical attention. Lower-extremity injury and concussion accounted for more than 60% and 15 % of the injuries, respectively (Schneider *et al.*, 2012). The highest sport-specific injury rates for boys include field-hockey, rugby and wrestling. For girls, the highest injury occurrence rates are in netball, football, gymnastics, field-hockey and running (Caine, Maffulli and Caine, 2008).
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> It is impossible to eliminate all injury in sports. However, the implementation of injury prevention strategies can reduce the frequency and severity of injuries (Bergeron *et al.*, 2015). Programmes that focus on balance and proprioception (body awareness in a space), have been shown to reduce injury incidence in most sports by between 28% and 80% with specific effectiveness in reducing lower-limb, knee and ankle injuries (Caine, Maffulli and Caine, 2008; Van Der Sluis *et al.*, 2014; Bergeron *et al.*, 2015; Nauta *et al.*, 2015).
> Prevention strategies include the use of external protective equipment, such as helmets, mouth- and wrist-guards, bracing and taping (Caine, Maffulli and Caine, 2008), and the implementation of updated rules and regulations. Further strategies that could be implemented include flexibility training, correct execution of exercise biomechanics and optimal recovery between training sessions (Bergeron *et al.*, 2015; Lloyd *et al.*, 2016).
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> Current data indicates that there is an increased risk of injury, particularly to the lower extremities, around the time of the adolescent growth-spurt (Le Gall, Carling and Reilly, 2007; Caine, Maffulli and Caine, 2008). During this time, there is rapid and different growth rates between structural tissues, with bones growing earlier and quicker than both muscle and tendons, which decreases muscle flexibility and joint range-of-motion (Kerssemakers *et al.*,2009)"

6. Training programmes should provide a range of modalities to enhance both health- related and skill-related fitness components.

> "Children and youth have a greater ability to respond positively to a given training stimulus at various stages of development, than adults (Lloyd *et al.*,2016). The understanding of the responsiveness to different training modalities stems from large amounts of cross-sectional studies, and indicates that youth can make significant improvements in muscle strength,

power, agility, endurance and running speed (Behringer *et al.*, 2010). Although there is strong evidence to suggest that well-planned programmes focusing on strength and motor-skills may improve physical performance, there is little evidence to indicate a specific exercise modality that needs to be prioritized at a given developmental stage.

This further emphasizes the need for a broad spectrum of exercise modalities and training stimuli, to provide the greatest range of opportunities for full development at this developmental stage. These should include components that improve overall health, such as cardiovascular- and strength training, as well as skill-related activities such as sport-specific movements."

7. Trainers should use relevant monitoring and assessment tools as part of the development strategy.

"For the overall well-being of the youth athlete, long-term training prescription should be complimented with appropriate and simple monitoring and assessment tools. If there is a lack of monitoring, there may be increased risk of excessive demands in training loads and decreased opportunity for recovery and regeneration (Armstrong and Bull, 2006).

Trainers should try to educate youth athletes and their parents to raise awareness of the risks and symptoms of over-training, burn-out and the related injuries that stem from over-reaching during training. Athletes and their parents should also understand the role of basic self-reporting and monitoring strategies and the potential impact of appropriate recovery strategies on the long-term plan.

The rationale and goal for assessments in youth athletes may include talent identification, predicting future performance, determining strengths and weaknesses, informing coaches/selectors in the selection of teams, evaluating the effectiveness of training, evaluating current health and enhancing the athlete, coach and parents' understanding of the future training plan (Bergeron *et al.*, 2015).

Monitoring physical performance with the broad range of physical assessments available, needs careful consideration of the developmental stage the individual is currently in, the specific needs and interests of that individual and also the available testing equipment and environment. Testing includes measurement of strength, power and cardiovascular capacity (Lloyd, RS; Oliver, JL; Hughes *et al.*, 2015), as well as motor-skill competency (Cools*et al.*, 2009)."

8. Programmes should be systematically progressed and individualized for successful development.

> "The practitioners responsible for athletes in a long-term athletic development setting, should, where possible, use a progressive, individualized and integrative approach when programming the strength and conditioning activities (Lloyd *et al.*, 2016).
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> There should be clear communication on the goals of the programme, regardless of whether the individual is a high-level athlete or a young, sedentary child who has never trained before. The programme needs to have specific, measurable and realistically attainable goals, which will lead the progression process. Planning should also include the necessary plan for recovery and regeneration in the programme."

9. The health and well-being of the child should always be a primary focus of developmental programmes.

> "The impact of sedentary lifestyles during childhood and adolescence, has been shown to have lifelong impacts on overall health and associated costs of health-care (Faigenbaum, Lloyd and Myer, 2013).
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> This shows the need for management and more importantly, prevention of behaviours of inactivity in children. Although accepted guidelines of physical activity in younger individuals do exist, which include activities such as swimming, running and cycling, some individuals do have deficiencies in the necessary strength, endurance, and motor-planning, and these individuals require more individualized intervention.
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> As mentioned before, health benefits similar to those that adults may experience as a result of training are attainable by children.
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> Furthermore, these benefits have a certain carry-over and impact later in life, and this demonstrates the need for programmes that have a primary focus on long-term health-promotion. This requires specific and deliberate planning and prescription of the required "dose" of training and exercise that is developmentally appropriate, meaningful and most of all, enjoyable to the individual."

In conclusion, it is clear that long-term athlete development is a highly developed process, which leans heavily on the coach and parents, to understand that there are a number of factors that need to be addressed, to optimize the environment for the athlete to develop and mature.

The specific understanding of the individual in-terms of physical, psychological and developmental capacity, as well as the knowledge of the needs of each factor in the developmental process, is key to the appropriate programming of the conditioning process of that individual. All youth should be offered the platform to develop at their own pace, according to their own needs and goals, and provided with the best, scientific, evidence-based practice, ensuring that programmes end up being motivating, goal-driven, organised and fun.