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Prevention and Rehabilitation

Part 3-developmental stage: The cornerstone of training

Nicole Rodriguez [a, *], D.C. Craig Liebenson [b], Fred Duncan [c]

[a] BVB Academy Im. Łukasza Piszczeka, Goczałkowice-Zdroj, Poland
[b] L.A. Sport and Spine, Los Angeles, CA, USA
[c] Fred Duncan Performance Training, Buffalo, NY, USA

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ABSTRACT

This article highlights the second stage of athletic development, the Developmental Stage. In this article we build awareness in growth and maturation, highlighting a 3-stage process through the use of the Khamis-Roche protocol. We covered an introduction to Strength Development for athletes in the developmental stage. Speed Development was addressed in a progressive way to teach critical positions and we introduced ways to assess a developing athlete from ages 12–15.

1. Introduction

Guiding young athletes is a gradual process that should lead to continuous improvements while also minimizing injury risks. Coaching youth athletes is about teaching how to develop motor literacies and to find enjoyment with activity. Creating environments that provide a positive experience with movement is necessary for long term injury risk reduction and enhanced performance in sport. (Article 1 Link). (see Tables 1 and 2, Fig. 1)

The developmental stage is the cornerstone of athletic development, which is when the body and mind are transitioning into the mature state. Ideally, youth athletes would transition into this phase after experiencing the foundational stage from ages 9 through 12 (Article Two Link). If the athlete was not exposed to these foundational competencies and just played their sport, for example, now is the perfect time to take action through structured and guided discovery. The goals are to identify growth and maturation, assess movement quality, learn to train in the weight room, and experience developmental speed principles.

2. Growth and maturation: Targeting PHV

Biological maturation refers to the progress towards a mature state. Identifying the phases of growth can be estimated using invasive and non-invasive testing means. To assist coaches that work with youth, we will discuss the non-invasive means using a predictive model called the Khamis-Roche Method. Protocols for the prediction of mature height include current age, height, weight and mid-parent height (the average of both biological parent's height) in boys and girls (Khamis and Roche, 1994). Using a percentage of predicted mature height was shown to be a reasonably valid estimate of biological maturity status (Malina et al., 2004). The percentages are as follows:

Identification of Peak Height Velocity (PHV) can reflect a developing athlete's maturation (Malina et al., 2004) and one method of categorizing the different stages of development in youth players is pre pubertal growth spurt, pubertal growth spurt and post pubertal growth spurt (Lloyd et al., 2014 and Balyi and Hamilton, 2004). The development in muscle mass and quick increases in anthropometric measurements can affect movement proficiency, therefore, the frequent assessment or in-training assessments of movement proficiency and fitness capacity should be a key factor in youth physical development programs.

Athletes grow and develop at different rates and strength and conditioning (S&C) coaches need to take this into consideration when designing training programs (Lloyd et al., 2014). This variability in biological maturity exists between athletes of the same chronological age and is highlighted around the developing athlete's growth spurt (Malina et al., 2004). So, it's important to identify the time period called “adolescent awkwardness”, which is the increase in stature during the pubertal growth spurt (Philippaerts et al., 2006).

* Corresponding author.
E-mail addresses: Nicole@coachnicolerodriguez.com (N. Rodriguez), craigliebensondc@gmail.com (D.C. Craig Liebenson), fredduncantraining@gmail.com (F. Duncan).

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Table 1
Khamis and Roche Predictive Model.

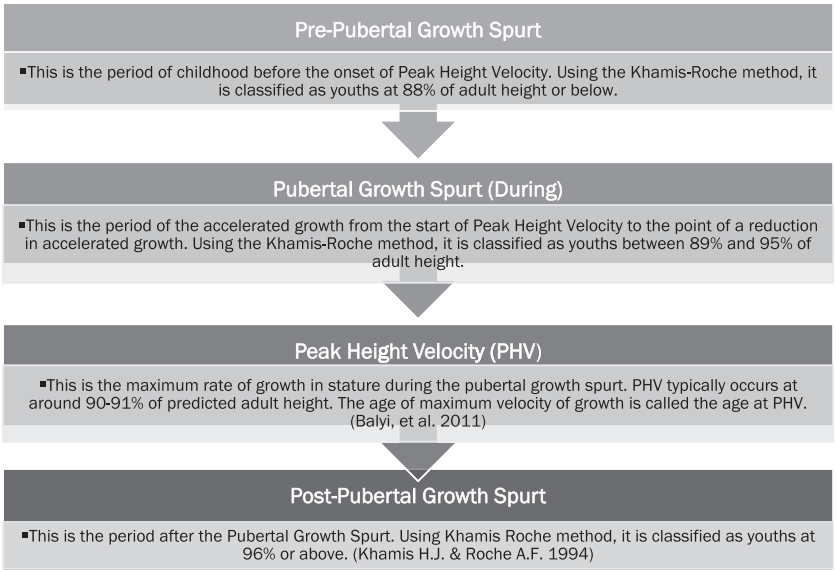

Table 2
Sample two day program.

Day 1 (U12-13)	Day 2 (U12-13)
*Total Body Warm Up	*Total Body Warm-up
Intro Power Prep Drills	Intro Power Prep Drills
Partner Race (10–15yds) - 2 × 5	Mirror drill - 6–8 s or Game of Tag x 4-6
MB Chest Throw x 10	MB Scoop Throw x 10
NCM/CM vertical jump + stick 2 × 5	Lateral Bound 2 × 5/e
Bodyweight Squat - 2 × 12-15	Split Squat - 2 × 10-12
Day 1 (U14–15) *Total Body Warm Up	**Day 2 (U14–15)** *Total Body Warm Up
Progress Power Speed Drills (distance + repetitions)	Progress Power Speed Drills (distance + repetitions)
Push-up start (10yds) 1 × 10, falling start (15–20yds), 1 × 5	Band Resisted or Hill Sprint - 2 × 5 × 10yds
MB Vertical Chest Throw + Jump x 6	MB Vertical Behind the Head x 6
Multi-response Vertical Jump - 4 × 3	Horizontal Jump (Broad) - 3 × 5
Squat (3 s lower, 3 s hold) - 3 × 8	Bodyweight Reverse Lunge - 3 × 8/e
Single Leg Bridge - 2 × 10	Push-up to shoulder touch - 3 × 10

*Total Body Warm up.

3. Strength development for the youth athlete U12–U15

Developing general and relative strength should be a priority in every program – regardless of sport, age, or gender. The adaptations from strength training flow into other qualities like power, flexibility, and even stamina. This particular age group will undergo an extensive general preparation phase ((GPP link 3)) where strength, coordination, and general fitness are prioritized. Assuming the athlete has undergone previous trainings and demonstrated physical competency per our outline in Article Two (link 2), more progressive strength training can begin by using both strength training in the weight room and on-field methods.

Step one is competence of the movement, demonstrating how well the young athlete can perform the prescribed movement. S&C coaches must determine a movement standard to simply decide if the movement performed is acceptable or not acceptable. In step two, we look at volume and capacity, identifying how many times (how long) the athletes can perform this movement well (as many good reps as possible). Finally, in step three, we look at intensity using load, speed or a combination of both.

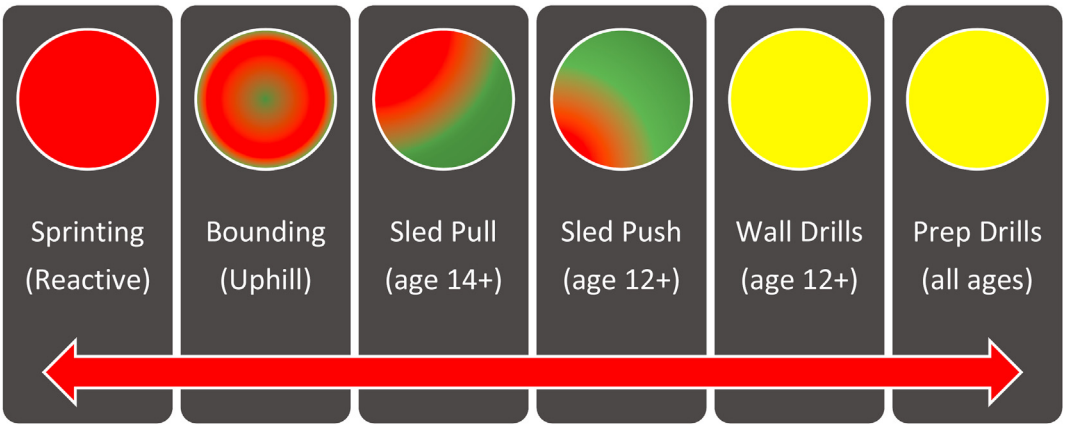

Fig. 1. High velocity to low velocity continuum.

The goal is to build competence, capacity and to learn intensity in the three universal buckets: Triple Flexion, Triple Extension and Rotation.

4. Why develop strength?

Strength training is merely the interaction between physics (forces) and biology (our body). In order to constitute "strength training" there must be forces generated and an overload provided. Over time, this leads to positive adaptations like increased force production/absorption or increased stiffness of tendons (source). This is not solely weight training as sprinting, jumping, and throwing medicine balls can all provide an overload stimulus. Therefore, strength training is a broad term that needs to be placed in context to have meaning.

5. Means to build strength

Even if your team does not have access to a weight room, you can still find plenty of ways to strength train your athletes.

- *Bodyweight exercises* can be progressed by manipulating the tempo (slow eccentrics, adding isometric holds, or increasing total time under tension), adding volume, or including more challenging exercises (pistol squat, pull-ups, lunge matrix). For example, a bodyweight squat with a 3–5 s lower or a split squat with a 3–5 s hold at the bottom of each rep. You can also develop bodyweight circuits to develop general strength and work capacity.
- *Medicine ball (MB) exercises* are perfect for athletes as they can increase strength and speed given the high velocity they can be performed at. There are endless variation to choose from – MB chest throw, overhead behind the head throws, forward scoop throws, rotational throws, or even a MB throw directly into a sprint. These are progressed by using heavier medicine balls, increasing the total number of throws, or introducing new throws.
- *Sprinting* is inherently plyometric and can have a positive effect on strength. Aside from traditional sprints or accelerations, the coach can include the use of weighted sleds, band-resisted sprints, push-up starts, or MB throws into sprints.
- *Plyometrics* are generally used to develop power, though they also have an influence on strength. Youth athletes should begin with lower intensive, single response jumps (jump and stick) before progressing to more intense, multi-response variations (hurdle hops).

6. Sample two day program (U12–U15)

The sample below is made to serve as a basic, plug and play strength program for teams that do not have access to a weight room. The volume is intentionally low, this is because there is no need to rush development. With this age group, general strength will likely be low, hormonal changes will be high, and the stress of school/social/sports must be considered. The goal is to provide positive stressors (eustress) in the appropriate doses to slow cook athletic and cognitive development.

Upper Body Push/Pull.
Lower Body Push/Pull.
Trunk Strength (Pillar).
Locomotion (Run, Skip).
Power.

7. Speed development basics

The term 'speed' varies in the context of different activities and sports. Reaction and acceleration and the ability to reproduce these speed qualities are important for young athletes in sports such as basketball, tennis and soccer. In general, training programs should seek to improve reaction and acceleration in virtually all explosive sports (Jeffreys, 2009).

At this stage, our goal is to pick the best movements that can be performed at low velocities and/or high velocities. Low velocity movements are programmed to teach positional awareness, with an option of adding load to train positional strength. Low velocity movement are designed to provide context to the critical positions of the movement skill as these movements are performed in a controlled manner, eliminating the high levels of coordination seen in faster drill selections. High velocity movements will be movements that are executed with minimal decrease in velocity both in loaded and unloaded movements. High velocity movements help athlete's learn intent and the expression of the force. Here's a continuum, moving fast to slow.

When teaching the developmental speed principles our goal is to relate the movements to a feeling and provide an expert demonstration, so the drill selection can do the work for us. For example, take an incline (uphill) bound. When providing the 15–30 s instruction, we want to challenge the athlete to get uphill in 7 steps, followed by an exact visual to serve as the challenge. For this age range, 12–15, our main goal is building positional awareness, positional strength and provide opportunities to express the force they currently have.

Here is a simplified, global look into the critical positions you want to see across speed development.

Table 3
Triple flexion position assessment.

Low Velocity	OH Squat	Wall Squat	Split Squat	SL Squat	Lateral Squat
Med Velocity	Drop Squat	Drop Hop	Loaded Squat		Lateral Lunge
High Velocity	Pogo to Split Drop	Split Squat to Switch	Catch Position (Clean)		

Linear Short (Acceleration): Teaching the ability to start.

1. Critical Position: Leg Separation is learning hip extension and hip flexion at toe off. This can be taught through intent, using high velocity movements and through sled pushing (low velocity), which increases ground contact time (GCT).
2. Learn front side mechanics: Forward lean with hip and knee flexion at 80–90°. This is felt with Prep Drills, Wall Drills, and Sled Pulls, Incline bounding.
3. Feel back side mechanics: Provide opportunities for long GCT. This is felt through Prep Drills (Skip for Height, Distance), Sled Pushing, Sled Pulling, Bounding Drills.

Linear Long (Absolute Speed): Teaching the ability to sustain speed.

1 (see Table 3).Critical Position: Table 4 Position is when the backside leg is under the COM and the front side leg is flexed at the hip and knee creating a 4 shape. This is observed when the down foot is in full weight bearing (see Table 5).
2. Front Side Mechanics: Leg Recovery is teaching how to snap the shoe under the hip. This is performed to help match hip flexion and knee flexion. This taught through prep drills like the Pop-Float Skip.
3. Back Side Mechanics: Leg Drive is feeling how to snap down and make contact under the COM. This is felt through full speed runs and straight leg skips, shuffles and bounds.

Lateral Re-Acceleration: Teaching the ability to stop and change direction.

1. Critical Position: Low COM, Angles of Attack (trunk, shin, feet)
2. Lead Leg in Shuffle/Cut: Directs and prepares for first step back to acceleration. This is taught through moving with intent under reactive conditions.
3. Trail Leg in Shuffle/Cut: Helps decelerate the body and re-accelerate to change the direction of the COM. This is felt through cutting movements, rotational movements and through learning how to push off the inside edge of the shoe.

8. Physical assessment for U12–U15

The purpose of functional assessment is to identify the developing athlete's competency, tolerance, and capacity. This is crucial to create a precise program that bridges the gap from what an athlete has (current capacity shortfall) to what they need (required capacity or demands).

Although the specific “functional” needs of individuals vary, the fundamental patterns and movement literacies are logical starting point for movement assessment. Three universal buckets are:

- Triple flexion
- Triple extension
- Rotation

Triple flexion is best assessed in a squat pattern with the goal of understanding how the young athlete lowers the center of mass (COM), both bilateral and unilateral. There are numerous options ranging from slow to fast.

The key for any of these is to identify pain, apprehension or protective patterns, quality of movement sequencing, balance and strength.

Triple extension is best assessed in jumping and locomotion. Functional competency plays an important role in the player's acceleration and speed (Clark, 2004), and the appropriate length tension relationship is crucial in the sprinting action. The primary actions in sprinting are extension of the hips and legs and plantar flexion of the ankles (Jeffreys, 2009). Probably the greatest action contributing to speed is hip extension. Powerful hip extensors are vital in driving the thigh down and back as the athlete is propelled forward. The major muscle groups involved are the gluteal and hamstring muscles. These muscles need to be trained hard and specific to their function in sprinting. Whether you are testing or training, these extension movements can be recorded and measured. You can also track the results of jump test and expect improvements when movement quality improves.

The key, as for flexion, is to assess pain, self-efficacy, coordination, and strength. In addition, landing ability and ankle stiffness mechanism can be appreciated in this assessment.

Table 4
Triple extension assessment.

Static	Wall Drills	Loaded Carry	Reverse Hyper	
Rhythmic	Tempo Skip	Skip (Height)	Skip (Distance)	Load and Lift
Dynamic (Sagittal)	NCM Jump	CM Jump	Broad Jump	Single Leg Hop
Dynamic (Frontal)	X-Under Skip	X-Under/Over	Lateral Bound	Sled Pull

Table 5
Rotation assessment.

Dissociation	[a]Upper Segment (control)	[a]Lower Segment (control)	Rotary Squat
Anti-Rotation	Front Pillar Bridge (w/Lift)	TSPU (FMS)	Stir the Pot
Segmental	Tall Kneeling Lift (low to high)	½ Kneeling Lift (low to high)	NCM Medicine Ball Throw
Explosive	Rotational Row	Parallel Med Ball Throw	Perpendicular Throw

[a] Adopted by Titleist Performance Institute.

Rotation and it's mirror anti-rotation are essential parts of movement integrity and performance. We want to assess how the athletes transfers force and how the athlete dissociates.

Additional characteristic functions to be assessed include:

1. Landing ability

If a person can't decelerate efficiently, they can't use whatever speed (acceleration) they have. To “stop on a dime” while keeping one's center of mass (COM) over their base of support (BOS) demonstrates great landing ability. Depth jumps are an excellent example of this skill. The athlete would drop from a low box and then spring back up so that their feet are at least the same height as the box. The ground time would reflect landing ability and should be as short as possible. Landing ability is closely associated with ankle stiffness as well.

2. Mobility

After an injury or going through puberty, mobility can become compromised. Normally, people compensate for mobility deficits in one region by shifting their centers of rotation to neighboring regions. The body functions beautifully as a kinetic chain linkage system demonstrating regional interdependence. However, “tipping points” can be reached for instance when mobility deficits overload under-prepared areas of compensation. For instance, restricted ankle or hip mobility can lead to lower back issues if the spinal erector spinae are not sufficiently prepared for the load.

9. Conclusion

The opportunities provided in the developmental stage prepare the athletes for the increase in volume and intensity they will soon experience as they enter the performance stage. The demands of the modern game will continue to evolve, and psychological demands of the adolescence years will always present challenges. The goal is to experience principles of movement in the developmental stage so we can progress towards an empowering and autonomous model in the performance stage. Ultimately, we can best guide our athletes through a difficult stage in their career by creating standards, building awareness of the changes they will experience during their pubescent stage, assessing current anthropometrics measurements (PHV) and by performing physical and performance assessments.

CRediT authorship contribution statement

Nicole Rodriguez: Conceptualization, Methodology, Writing - original draft. **D.C. Craig Liebenson:** Writing - review & editing, Visualization, Supervision. **Fred Duncan:** Writing - review & editing.

Declaration of competing interest

The authors whose names are listed immediately below certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

References

Article 1 Link 1. https://www.bodyworkmovementtherapies.com/article/S1360-8592(19)30323-7/fulltext.
Article 2 Link 2. https://www.bodyworkmovementtherapies.com/article/S1360-8592(19)30217-7/fulltext.
Balyi, I., Hamilton, A., 2004. Long-Term Athlete Development: Trainability in Childhood and Adolescence - Windows of Opportunity - Optimal Trainability. National Coaching Institute British Columbia & Advanced Training and Performance Ltd, Victoria.
Clark, M.A., 2004. Optimum performance training for the health and fitness professional. Calabasas. NASM.
GPP Article Link 3. https://www.bodyworkmovementtherapies.com/article/S1360-8592(19)30094-4/fulltext.
Jeffreys, I., 2009. Game Speed: Movement Training for Superior Sports Performance. Coaches Choice, Monterey CA.
Khamis, H.J., Roche, A.F., 1994. Predicting adult stature without using skeletal age: the Khamis-Roche method. Pediatrics 94 (4 Pt 1), 504–507 (erratum Pediatrics 1995; 95:457 for corrected tables).
Lloyd, R.S., Faigenbaum, A.D., Stone, M.H., et al., 2014. Position statement on youth resistance training: the 2014 International Consensus. Br. J. Sports Med. 48, 498–505.
Malina, R.M., Bouchard, C., Bar-Or, O., 2004. Growth, Maturation and Physical Activity, second ed. Human Kinetics, Champaign, IL.
Philippaerts, R.M., Vaeyens, R., Janssens, M., Van Renterghem, B., Matthys, D., Craen, R., Malina, R.M., 2006. The relationship between peak height velocity and physical performance in youth soccer players. J. Sports Sci. 24, 221–230.