SSI-NYSI CONSENSUS STATEMENT ON STRENGTH & CONDITIONING FOR YOUTH ATHLETES

Introduction

An array of benefits accompanies a well-planned and supervised strength and conditioning (S&C) session for youths. These sessions can trigger positive neuromuscular adaptations to enhance muscular strength, motor skills, and competitive fitness while reducing the risk of injury. Other important considerations when devising an S&C programme during the period of growth and maturation are the athlete's chronological, biological, and training age. These factors will guide the coach in determining the appropriate exercise variation, volume, intensity, and other training-related factors. Thus, reducing the risky effects of over-training or over-reaching. Therefore, there is a need to provide information on safe and effective S&C practices for coaches working with youth athletes to encourage sports participation, reduce injury risks, and acquire a competitive edge. To guide these objectives, the National Youth Sports Institute (NYSI) and Singapore Sport Institute (SSI) have put together recommended guidelines based on the joint consensus statement with the latest evidence-based training recommendations to share best practices and inform sports coaches on the benefits and safety of S&C for youth athletes. These guidelines will elaborate on training progressions for youth athletes for the different constituents of S&C involving strength development, speed development, agility training, plyometric training, and metabolic conditioning throughout the stages of growth and maturation.

Definition

- Strength & Conditioning (S&C) – Sport physical preparation training that includes strength development, speed development, plyometric training, agility training, and aerobic fitness
- Children – Girls and boys who have not yet developed secondary sexual characteristics (approximately up to the age of 11 years old & 13 years old respectively)
- Adolescence – Period of life between childhood and adulthood (girls 12 – 18 years old and boys 14 – 18 years old are generally considered as adolescents)
- Youth – A global term which includes both children and adolescents
- Pre-Pubescent – Period before the onset of puberty
- Circa-Pubescent – Adolescence period starting from the onset of puberty
- Post-pubescent – Period after the completion of puberty
- Growth – Measurable changes in size, physique, and body composition
- Maturation – Variable timing and tempo of progressive change within the human body

RECOMMENDED S&C GUIDELINES

Resistance Training

1. Resistance training, should be age-appropriate, follow a sensible progression pathway. Programmes should be properly supervised by a qualified adult to ensure safety for youths.
2. Programme design should take into consideration an athlete's stage of maturation, training age, fundamental movement skills (FMS) competency, technical lift proficiency, existing strength levels, and psychosocial factors.
3. Technical lift competency through a range of basic exercises should be prioritised before external load progressions are considered.
4. Bodyweight exercises introduced in the initial phases can be an excellent start point. Once proficiency has been established, the difficulty of bodyweight exercises can be progressed by altering any of these variables:
    - Movement plane
    - Gravity
    - Movement range
    - Time under tension (TUT)/Contraction speed
    - Limb leverage
    - Stability
    - Type of contraction

5. Exercise variations should be individualised depending on the athlete's proficiency in the exercise movement.
6. Other modalities such as free weights, resistance bands, medicine balls, and manual resistance may also be utilised as variations or progressions to an exercise.
7. Free weights should be prioritised to constantly provide additional stimulus once an athlete has achieved movement proficiency.
8. Exercise progressions should seek to challenge the movement coordination and rate of force development (RFD) of the youth athlete.
9. The number of repetitions prescribed should be exercise dependent and objectively driven to suit the training requirements.
10. One to three repetitions of an exercise may be performed when teaching technique to allow for real-time feedback.
11. During the period of peak height velocity (PHV), coaches can consider using alternative loading to regulate training load without exposing the youth athlete to increased injury risk.

12. Training to muscular failure for youth athletes is discouraged as similar gains in strength and hypertrophy can be elicited via other means. It is an injury risk if exercise form is compromised under fatigue.
13. Predictive equations to estimate 1RM values from submaximal loads (3-5RM strength test protocols) may be used to track strength progressions. However, strength tests should always be carried out under qualified supervision, and only prescribed after technical competency with external loading has been established.

Table 1. Recommended guidelines for resistance training progression.

Level of Development	**Beginner**	**Intermediate**	**Experienced**	**Advanced**
Repetitions	8 – 15	6 – 10	5 – 8	2 – 5
Sets	1 – 2	2 – 4	2 – 4	2 – 5
Exercise Per Session	6 – 10	3 – 6	3 – 6	2 – 5
Exercise Selection	Modified bodyweight exercise with light resistance	Introduction to simple free weights exercises where appropriate	Progression of free weights exercise with the introduction of complex lifts	Introduction of complex multi-joint movement and programme routines
Intensity (%1RM)	Bodyweight, 50 – 70%	60 - 80%	70 - 85%	85 - 100%
Repetition Velocity	Moderate – Fast	Moderate – Fast	Fast – Maximal	Maximal
Rest Intervals	1 min	1 – 2 min	2 – 3 min	2 – 5 min
Training Frequency	2 – 3	2 – 3	2 – 4	2 – 5
Recovery (between sessions)	72 – 48 h	72 – 48 h	48 h	48 – 36 h

Speed Development

1. Locomotor skill development as part of FMS should progressively include teaching proper running gait and mechanics of sprinting from childhood with simple chasing games such as tag.
2. Coaches are encouraged to include FMS, coordination, stabilisation, and proprioception training for speed development in youth athletes.
3. Coordination patterns should constantly be reinforced during the pubescent period to counter the effects of rapid changes in body structure during puberty.
4. Resistance and plyometric training together are effective methods to develop speed due to the influence of neural and structural adaptations.

Table 2. Recommended guidelines for speed training progression.

Stages of Development	**Primarily Neural Adaptations**		**Structural and Neural Adaptations**	
	Early Childhood (Neural Adaptation)	**Pre-Pubescent**	**Circa-Pubescent**	**Late Adolescence**
Objective	FMS (locomotor)	Sprint technique and resisted sprints	Sprint technique, resisted sprints and maximal sprints	Maximal sprints
Complimentary Training Selection	Physical literacy, strength training	Plyometric, strength training, coordination, FMS	Plyometric, strength training, coordination, hypertrophy	Plyometric, strength training, coordination, complex training
Repetitions	10 – 20 m	10 – 20 m	40 – 60 m	40 – 60 m
Sets	≤16	≤16	3 - 5	3 - 5
Intensity	Sub-maximal 70 - 90%	Sub-maximal 70 - 90%	Maximal 90 - 100%	Maximal 90 - 100%
Rest Intervals	1.5 – 2 min	1.5 – 2 min	5 – 7 min	5 – 7 min
Training Frequency	-	1 - 2	2 – 3	2 - 3

Plyometric Training

1. Youth plyometric training requires a sensible and individualised approach for progression based on stages of growth and maturation to enhance athletic performance while reducing injury risk.
2. The programme should begin with low-intensity drills focusing on land mechanics and force production capacity.
3. Progression to higher intensity plyometric drills can be introduced as the youth athlete demonstrates proficiency in the land and jump mechanics.
4. The principles in Figure 1 can be utilised to ensure a logical sequence to plyometric progression depending on the individual athlete's movement maturity, proficiency, and work capability.

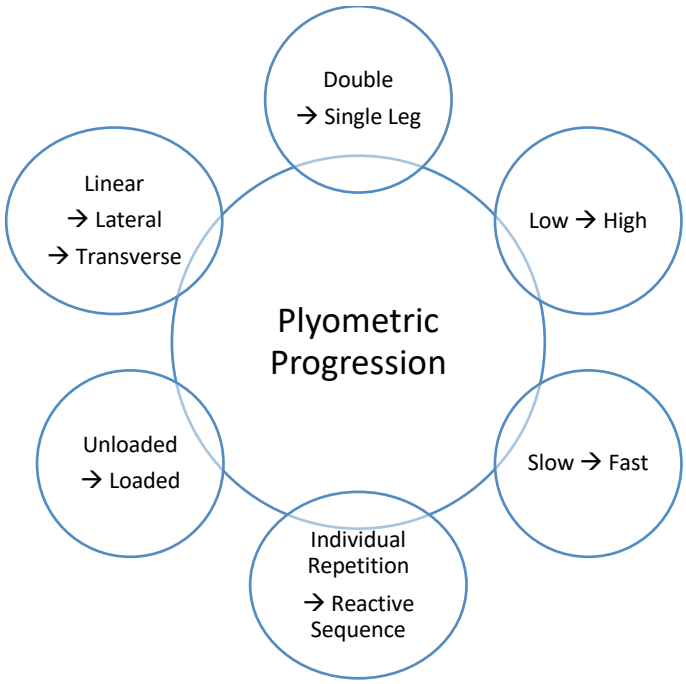

Figure 1. Plyometric progression.

5. Coaches are encouraged to ensure that the quality of plyometric takes precedence over quantity especially when done in a fatigued state.
6. Sufficient rest should be provided between plyometric training sessions to avoid the occurrence of maladaptive responses from over-training, over-reaching, and overuse injuries in youth athletes.
7. On a micro-scale, recovery between sets of plyometric exercises should be extended as the intensity increases.

Table 3. Recommended plyometric training progression.

Stages of Development	**Early Childhood (Neural Adaptation)**	**Pre-Pubertal**	**Circa-Pubertal**		**Circa-Pubertal – Late Adolescence**	
Structure	Unstructured	Low	Moderate	Moderate – high	High	High
Objectives	FMS – Locomotion (run, skip & hop)	Jumps from a standing position & jumps in place – low amplitude jump	Bilateral to unilateral hops – low amplitude plyometric	Force production & absorption – higher amplitude jump-land training	High-intensity plyometric – bounding, hurdle jump/hop combo	High-intensity plyometric – depth jump, resisted bounding
Repetitions	NA	6 – 10	6 - 10		190 – 230 Ground contact (16 years old and above)	
Sets	NA	1 – 2	2 – 3 or 185 – 205 Ground contact (13 to 16 years old)			
Intensity	Low	Low	Moderate	Moderate	High	High
Rest Intervals	1 – 3 min	1 – 3 min	2 – 4 min	2 – 4 min	3 – 5 min	3 – 5 min
Training Frequency	2 – 3/ wk (non-consecutive days)					
Recovery (between sessions)	48 – 72 h (non-consecutive days)					

Agility Training

1. Coaches should take into consideration determining factors involved in both CODS and RA when planning an agility training programme.
2. The youth athlete should be constantly challenged in their visual perception, spatial awareness, and decision-making components.
3. A variety of cross-sport and sport-specific game situations can be considered through structured and unstructured play to encourage the development of the sub-qualities of agility.
4. When working with team sports or large groups, small-sided games (SSGs) or a game of Tag can be utilised to teach specific skills or strategies emphasising on movement efficiency and effectiveness.
5. Below are four strategic aspects of Tag that coaches can use to teach tactical objectives:
    - Balance and alertness;
    - CODs in avoiding tags;
    - RA to tag targets; and
    - Spatial awareness of surroundings.
6. Stages of Agility Development
    a. FMS
        - Locomotion, exercise movement skills & jump-land mechanics
    b. CODS (Figures 2 – 4)
        - Static drills and foot placement
        - Movement Matrix
        - COD Mechanics Integration
    c. RA
        - Small-sided games (SSGs), Tag Games

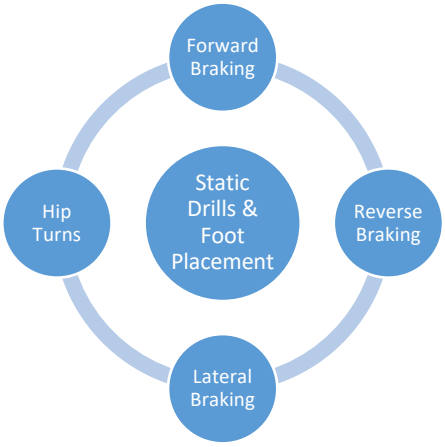

Figure 2. Static drills & foot placement matrix.

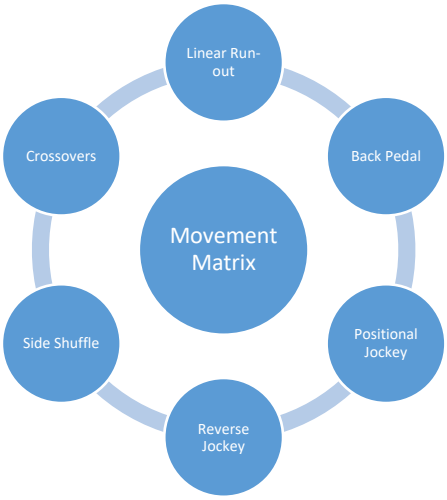

Figure 1. Movement matrix.

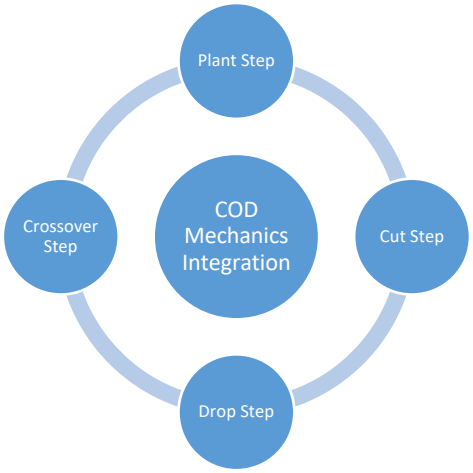

Figure 2. COD mechanics integration matrix.

Table 4. Agility training recommendation for youths.

Stages of Development	**Early Childhood (Neural Adaptation)**	**Pre-Pubertal**	**Circa-Pubertal**	**Circa-Pubertal – Late Adolescence**
Structure	Low	Low	Moderate	Highly
Main Objectives	FMS – Locomotion (run, skip & hop)	FMS – Exercise movement skills, locomotion, jump & land	COD mechanics & skills	RA
Intensity	Low	Low	Moderate	High
Rest Intervals	30 – 60 s	30 – 60 s	60 – 90 s	90 s
Training Frequency	2 – 3/ wk (non-consecutive days)			
Recovery (between sessions)	48 – 72 h (Non-consecutive days)			

Metabolic Conditioning

1. Sampling Stage

During the initial stages of learning, coaches are encouraged to expose the youth athlete to high sets of unstructured (randomised) repetitions. This methodology during sampling seeks to achieve technical proficiency and basic metabolic endurance while tapping on skill acquisition principles.

2. Specialisation Stage

As the youth athlete specialises, the conditioning programme may evolve to replicate the metabolic needs of the sport. The inclusion of sport-specific situations (e.g. SSGs in football) may be part of a metabolic conditioning plan.

3. Investment Stage

As the youth athlete progresses from proficiency to mastery in a sport, enhancing the metabolic capacity for performance to increase athletic competitiveness is an essential part of a periodised training plan.

Table 5. Metabolic endurance training recommendations.

Mode	Continuous and interval training using large muscle groups
Method	Cycling, running, swimming, circuit training & resistance training
Frequency	3 – 4/ wk
Work Duration	30 min – 1 h
Intensity	80 - 90% HR_{max}
Programme Length	Minimum of 12 weeks

Table 6. Strength-Power training recommendations.

Mode	High-intensity interval training (HIIT)
Method	Cycling, running, swimming, circuit training & resistance training
Frequency	2/ wk
Work Duration	30 s – 4 min
Rest Methods	Active (60 - 70%) or passive
Intensity	> 90% HR_{max}