Warm-ups for Youth Athletes: Making the First 15-Minutes Count

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Abstract

Warm-up procedures have been found to have a significant influence on fitness performance in youth athletes. As such, warming up before exercise and competition is encouraged and is a widely accepted practice with children and adolescents. Differences in structure, type, duration, intensity, and content of warm-up protocols have led to considerable variation in warm-up procedures. As a result, there is a lack of consensus on the ideal method for preparing youth athletes for exercise and sport. This article, therefore, aims to review current warm-up classifications and considerations of youth athletes, while providing a template of appropriate exercises that can be used safely and effectively in individuals of varying capabilities.

Introduction

A warm-up is considered essential practice by coaches and youth athletes, to optimize performance and reduce injury risk (2,8,20,23). A well-designed warm-up aims to enhance performance by facilitating physiological changes that result in increased muscle metabolism, muscle fiber performance, muscle conduction velocity, blood flow to the tissues, and postactivation potentiation (2,18). Furthermore, it affords athletes time to mentally prepare for the upcoming activity (2,8).

Traditionally, a warm-up consists of a brief period of low-intensity aerobic activity, followed by flexibility and sport-specific exercises (27). Typically, this may encompass a light jog or cycle at the start of the warm-up, followed by a period of dynamic stretching, before concluding with agility and plyometric exercises that aim to replicate movements associated with the sport in question (8,10). Many youth athletes, however, incorporate only 1 or 2 of these recommended activities in their warm-up routine, believing they are performing an appropriate and adequate warm-up (7). In addition, as the team coach is largely responsible for delivering warm-up programs to youth athletes, the prescribed exercises are often based on trial and error and personal preference (7,28). Individual differences and variation in intensity and duration of a warm-up further impacts the effect on performance in the subsequent event (i.e., training or completion); that is, greater conditioned youth athletes may require a longer and/or more intense warm-up to elicit the goal of a physiologic response (3,8). Maturity differences, most notable during adolescence, further confound program prescription and efficacy (17).

A recent investigation on the effectiveness of various warm-up strategies provided information for how alternative strategies may compliment the traditional warm-up (8). Alternative warm-up strategies differ from the traditional warm-up by viewing the warm-up as an extension of the training process and prescribing specific exercises to aid long-term physical development (8,10). The aim of this article is to use recent warm-up trends to provide a progressive warm-up structure that

can be implemented in youth populations, across sporting codes, and in accordance with individual competency levels.

Passive and active warm-ups

A warm-up can be broadly divided into 2 major categories: passive and active (2,8). A passive warm-up entails raising core temperature by external means, through the use of hot showers, baths, saunas, diathermy, and/or heating pads (2). Although not commonplace, the passive warm-up is gaining in popularity as a method to maintain elevated core and muscle temperature between an active warm-up and the actual event (18). British cycling used this method with positive results during the London Olympics, with cyclists wearing electrically heated insulated tights to maintain leg muscle temperature during the transition phase (period between completion of warm-up and start of the event) (see Loughborough University Knowledge Transfer website at http://edmgr.ovid.com/scj/accounts/ifauth.htm). Although this method increases core and muscle temperature without depleting energy substrates, it is not practical for most youth athletes due to time, equipment, and expertise constraints (i.e., lack of time, equipment, and expertise to appropriately implement) (2).

By contrast, an active warm-up is the most widely used strategy before competition, increasing core and muscle temperature with general and sport specific exercises (2,3,27). The general phase includes activities such as jogging, stretching, calisthenics, and resistance exercises, whereas the sport specific component includes stretches and movements applicable to the chosen sport (e.g., squat and lunge patterns in racket sports) (18). Recent research has examined current trends in warmup practices (8), with a number of methods looking to create a systematic structure that optimizes the contribution of each physical component (i.e., mobility, strength, power, speed, and agility) and where each component positively contributes to the next phase (9). One such method is that of the “RAMP” system (10), which is designed to eliminate the “gray areas” of current practice (10). Consisting out of 3 key phases: raise, activate and mobilize, and potentiate (RAMP), this method looks to compartmentalize and target different components of physical development, with the exercise complexity and intensity progressively increasing throughout the warmup (10).

A similar model implemented by FIFA within their youth academies is that of the 11+ warm-up (see FIFA Medical Assessment and Research Centre website at https://www.yrsa.ca/pdf/Fifa11/11plus_workbook_e.pdf). Designed to reduce injury, the 3 parts of this warm-up are performed in a specific sequence, with a progressive increase in intensity. In contrast to the “RAMP” method, the “11+” warm-up provides exercise recommendations for each of its 3 parts, with 3 levels per part. These standardized methods provide a starting point by which warm-up activities may be constructed to enhance performance and reduce injury risk in youth athletes during training and competition (10).

Components of a warm-up for youth populations

Table 1 presents a range of exercise options that can be implemented by a youth athlete when performing a warm-up. The exercise options provided look to expand upon the “RAMP” and “11+” framework, presenting additional detail for each of the 3 sections identified in these models. The prescribed exercises are tailored toward youth athletes at opposite ends of the training spectrum, the inexperienced youth athlete who is relatively new to physical training, and the experienced athlete who is physically competent with multiple years training experience. That said, with individual exposure to physical training and motor competence operating along a continuum,

individual programming choices may vary. If the suggested time frame of 5 minutes per component were adhered to, youth athletes would be exposed to 30 minutes of dedicated physical development. For ease of implementation, the recommended exercises entail minimal equipment that may be performed in a variety of settings, with the sets, reps, and load adjusted according to the capability of the individual in question. Selected exercise examples are illustrated in Figures 1–5.

Figure 1 Four-point kneeling with thoracic rotation extension.

Figure 2 Three-point cone touch.

Table 1 Example of a warm-up structure with appropriate exercise selection for an inexperienced young youth athlete and a competent, older youth athlete

RAMP Protocol			**11+**	**Physical Component**		**Allocated time**	**Inexperienced, young youth athlete**	**Competent, older youth athlete**
RAISE			PART 1	CARDIOVASCULAR ACTIVITY		5 min	Double legged skipping Structured game (e.g. Tag)	Double and single legged skipping Structured game with restrictions (i.e. catch one handed only)
	ACTIVATE			DYNAMIC MOBILITY	Full Body	5 min	Inchworms Stationary spidermans / ambulatory spidermans	Inchworms into press up Inchworm into Spiderman
					Lower Limb		Leg swings: Forward / backwards/lateral Moving over and under a hurdle A-Skips B-Skips Carioca	Incorporate the use of accessory equipment (e.g. foam roller) Trigger point mobility as needed
					Upper Limb		Jogging forwards and backwards while swinging arms Four-point kneeling with thoracic rotation (Figure 1)	Skipping while swinging arms Four-point kneeling with thread through & thoracic rotation
			PART 2	BALANCE		5 min	Balancing on a drawn line Balancing on a beam Single leg balance (for time) Single leg balance – eyes closed (for time)	3 point cone touch (Figure 2) Y-Balance Single leg medicine ball slams
				CO-ORDINATION			"Simon says" game Obstacle course with various challenges Hop scotch Balloon play Wheelbarrow walking	Throwing and catch a ball/s with a partner Obstacle course with increased complexity of challenges Target practice with a ball: footwork or hand-eye coordination
				ACTIVATIONS	Lower Limb	5 min	Bridges Clams Stationary / ambulatory lunges Duck walks (Figure 3) Stationary lateral lunges Lateral glute band walk Monster Walks	Single leg bridges Cossack squats Weighted stationary / ambulatory lunges Arabesques: with a wooden dowel / kettle bell / bar Curtsey lunge (Figure 4)
					Upper Limb		Elastic band exercise: Standing row Elastic band exercise: Chest press	Increase the resistance of the exercise band used Incorporate catching and throwing exercises with 1kg medicine ball

RAMP Protocol			11+	Physical Component		Allocated time	Inexperienced, young youth athlete	Competent, older youth athlete
					Full Kinetic Chain		Elastic band exercise: Squat to overhead press Elastic band exercise: Lunge with overhead press Elastic band exercise: Split squat with band rotations (Figure 5)	Overhead squats holding a band/dowel/bar Overhead split squat with a wooden dowel / bar Olympic lifts and/or derivatives
		POTENTIATE	PART 3	FORCE PRODUCTION	SSC-Slow	5 min	Jumping jacks Burpees Tuck Jump Countermovement jump Box jump Broad jump Lateral leap Single leg forward hop & stick Single leg lateral hop & stick Medicine ball slams (1-2kg) Medicine ball chest press (1-2kg) Medicine ball rotational throw (1-2kg)	Squat jump with upward medicine ball throw Countermovement jump with upward medicine ball throw Lateral leap and return Split squat jumps with medicine ball rotations Multiple bounds Forward hops with return Repetitive lateral hops Drop snatch Medicine ball slams / chest press / rotational throw (3-5kg) Medicine ball drills based on sport specific movements
					SSC-Fast		Pogo hops* Hurdle jumps	Pogo hops with secondary movement (either a jump/sprint) Drop jump with secondary jump (either vertical / horizontal / lateral)
				SAQ		5 min	Linear sprints with and without deceleration Diagonal/lateral speed work Diagonal/lateral speed work with turn	Linear sprints with multiple turns and breaking movements Partner drills of increasing complexity and/or challenge Reactor ball drills

Figure 3 Duck walks.

Figure 4 Curtsey lunge.

Figure 5 Split squat with band rotations.

In contrast to the components of both the RAMP and 11+ protocols, there is considerable overlap between warm-up components, with the prescribed exercises often addressing more than one component. For example, the use of A-skips, B-skips, and carioca movements (Table 1) can be used to both raise muscle temperature and mobilize joints and tissues. Incorporating exercises that address multiple parts of a warm-up assist in targeting desired physical components within a limited time frame.

Table 2 presents a warm-up that coaches and practitioners may implement given only 10–15 minutes. The grouping of exercises into various physical components enables coaches and practitioners to incorporate an exercise from each component for their youth athlete(s) that matches their ability and/or targets an area in need of development. This ensures that the youth athlete(s) are exposed to a compliment of athletic drills and skills, enabling the development of motor competence to enhance physical literacy within a constrained time frame.

Inexperienced youth athlete

The primary focus for individuals, who are new to physical training and/or are less mature, is the development of sound technique and fundamental movement skills (21). Mastering exercise technique and patterns in a safe and fun environment will help maximize their movement potential while keeping them engaged (12). Initiating the warm-up with a game creates a fun, relaxed environment to raise muscle temperature and joint fluid viscosity (10). Having a couple of variations in the warm-up for subsequent sessions provides constant challenge and aims to prevent boredom. Incorporating dynamic mobility exercises that target the kinetic chain immediately after cardiovascular activity assists with maintaining the effects of this period and are preferable to isolatory or stationary exercises. As balance and coordination are considered key to athletic development, consistent exposure to these 2 components are essential for building a strong athletic foundation.

Table 2 Example of a 15-minute warm-up, with appropriate exercise selection for an inexperienced young youth athlete and a competent, older youth athlete

	Inexperienced, young youth athlete		**Competent, older youth athlete**	
Physical Component	**Exercise**	**Sets & reps**	**Exercise**	**Sets & reps**
Cardiovascular activity	Double-legged skipping	3 min	Double- (20s) and single-legged (5s ea. foot) skipping	3 min
Dynamic mobility	Inchworms Stationary spidermans A-skips B-skips Carioca Jogging while swinging arms	1 x 5 reps 1 x 4 reps ea. leg 1 x 10m 1 x 10m 1 x 10m 1 x 10m	Inchworm into press up Inchworm into spidermans Foam roll relevant areas Trigger point mobility Skipping while swinging arms	1 x 5 reps 1 x 3 reps ea. leg 2 min As needed 1 x 10m
Balance	Single-leg balance	1 x 30s ea. Leg	3-point cone touch (Figure 2)	1 x 3 reps ea. cone
Co-ordination	Wheelbarrow walking (with partner)	1 x 10m pp.	Throwing and catching a ball with a partner	1 x 5 catches pp.
Activations	Elastic band exercise: standing row Elastic band exercise: chest press Clams Duck walks (Figure 3) Elastic band squat to overhead press	1 x 10 reps 1 x 10 reps 1 x 10 reps ea. leg 1 x 10m 1 x 8 reps	Elastic band exercise: standing row Elastic band exercise: chest press (Figure 4) Curtsey lunge Cossack squats Overhead squats with a band/dowel/bar	1 x 15 reps 1 x 15 reps 1 x 8 reps ea. side 1 x 4 ea. side 1 x 6 reps
Force production	Medicine ball slams (1-2kg) Broad jump Lateral leap and stick Pogo hops	1 x 6 reps 1 x 3 reps 1 x 3 ea. leg 1 x 10 reps	Medicine ball slams Forward hops with return Lateral leap and return 5 pogo hops with 5-m sprint	1 x 8 reps 1 x 3 ea. leg 1 x 3 ea. leg 1 x 3 reps
SAQ	15-m sprint with decelerations 5-m sprint and return	1 x 3 reps 1 x 2 reps ea. side	Zigzag sprint over 15m 5-m sprint and return reacting to a partner	1 x 2 reps ea. direction 1 x 2 reps ea. side

ea. = each; kg – kilogram; m = meter; pp. = per person; s = seconds

The association between motor coordination and physical activity is crucial, with those individuals who possess more advanced motor coordination being more likely to engage in physical activity (13). Incorporating exercises that target the development of movement patterns in a warm-up enables practitioners to address coordination with the aim of enhancing motor competence. Subsequent exercises can be used to prepare and activate muscle groups for upcoming activity and should be tailored to the demands of the sport. To provide an element of fun and maximize engagement for younger children, activations can mimic animal movements (i.e., duck walks) or appeal to their imagination (i.e., monster walks). Because movement in sport requires quick acceleration, deceleration, and change of direction, the ability to quickly produce force aids an individual's performance and insulates them from injury (26). Completing the warm-up with a combination of speed, agility, and sport-specific drills is likely to impact performance in the succeeding activity and expose athletes to regular bouts of speed and agility training at the optimal time in a workout (10).

Experienced and competent athlete

The exercises prescribed for the older, competent athlete assumes these individuals have developed a level of exercise technique that enables them to competently perform a range of exercises of increasing complexity at high intensities. As such, the exercises include more complex movement patterns that incorporate high-power outputs and are closely aligned to those performed in sport. The inclusion of multijoint, multiplane, and at times, loaded exercises, provides a constant challenge, while preparing them for the upcoming activity. For athletes in a heavy competition period, the warm-up can also provide an efficient way to provide regular exposure to progressive strength, speed, power, and agility training (10). Consistent exposure to more complex drills in the warm-up may reduce the time spent on technique during practice, while allowing additional physical sessions to focus on other aspects of physical performance (i.e., movement exploration).

Tailoring the composition, intensity, volume, and rest periods of the recommended exercises prescribed in each section should be performed according to the individual needs of the athlete or team. For example, if a particular individual is struggling with producing force, or drills that require force production, additional time can be allocated to this component (i.e., performing multiple reps/sets of said exercise), with exposure to other components reduced to a minimum threshold (e.g., 1 set for all other exercises). Furthermore, when implementing this warm-up with youth, the intensity of each drill, along with the rest between drills, can be manipulated to ensure that all athletes remain engaged and obtain an adaptive response (21).

Considerations when structuring a warm-up for youth populations

Compared with adults, youth (e.g., children through adolescence) have unique physical, psychological, and social differences, which underpin the importance of a structured, logical, and evidence-based exercise selection for a warm-up protocol. Therefore, it is important to understand an individual's training ability, age, and level of maturation when designing a warm-up. Figure 6 defines these considerations, with appropriate questions that can be asked to ensure the considerations are being met within a warm-up. The primary consideration in a warm-up is the motor competence of the youth athlete, along with their confidence in their motor competence. Additional considerations within an age group may be the maturity status of a youth athlete, their volume of exposure to physical training, as well as their level of enjoyment. To create the best environment to promote physical development, enhance fitness behaviors, and prevent injury, it is key to understand these unique characteristics of youth (17).

Understanding the motor competence level of a youth athlete is crucial because it is likely to impact other considerations It is therefore important to account for the training experience of an individual when programming the warm-up and match exercise selection accordingly (18). For an inexperienced athlete, exercises may initially favour simple, body weight exercises, with more complex progressions added as their competency increases (1). For instance, athletes looking to develop lateral hip strength may initially perform lateral band walks in the warmup, while experienced, well-trained athletes may look to include loaded Cossack squats. Figure 7 presents an example of a progressive/regressive exercise sequence that targets lateral hip strength, with exercises systematically progressing from simple and unloaded to complex and loaded.

Examples of appropriate sets, reps, and load for each exercise are provided and can be manipulated based on the youth athlete's motor competence (e.g., technique), as well as the available training time. Individuals can also regress in the sequence, either in load (sets, reps, or weight), or in exercise selection, if they are unable to competently perform the selected exercise. This often occurs if an

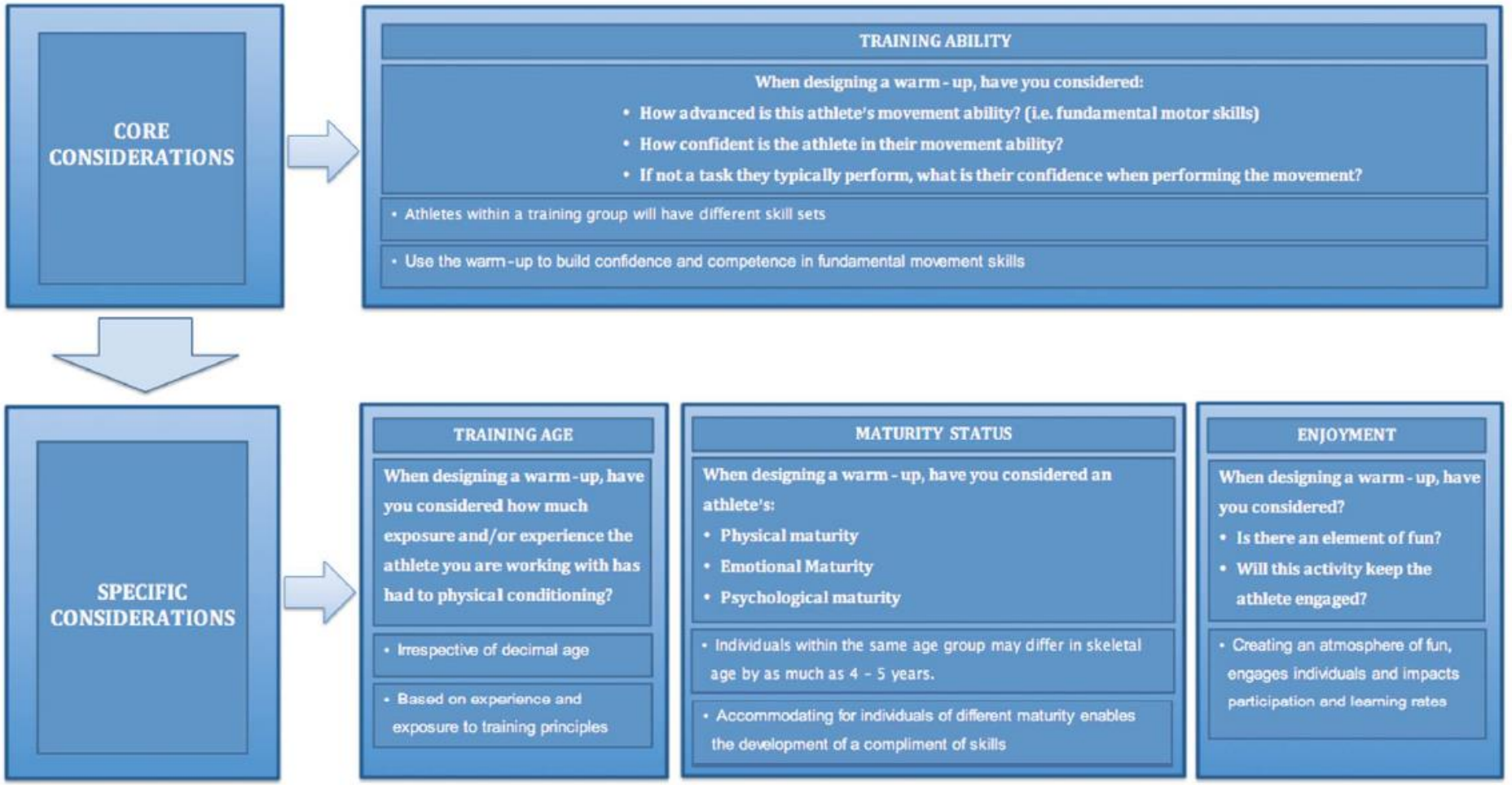

Figure 6 Primary considerations and questions considered when designing a warm-up.

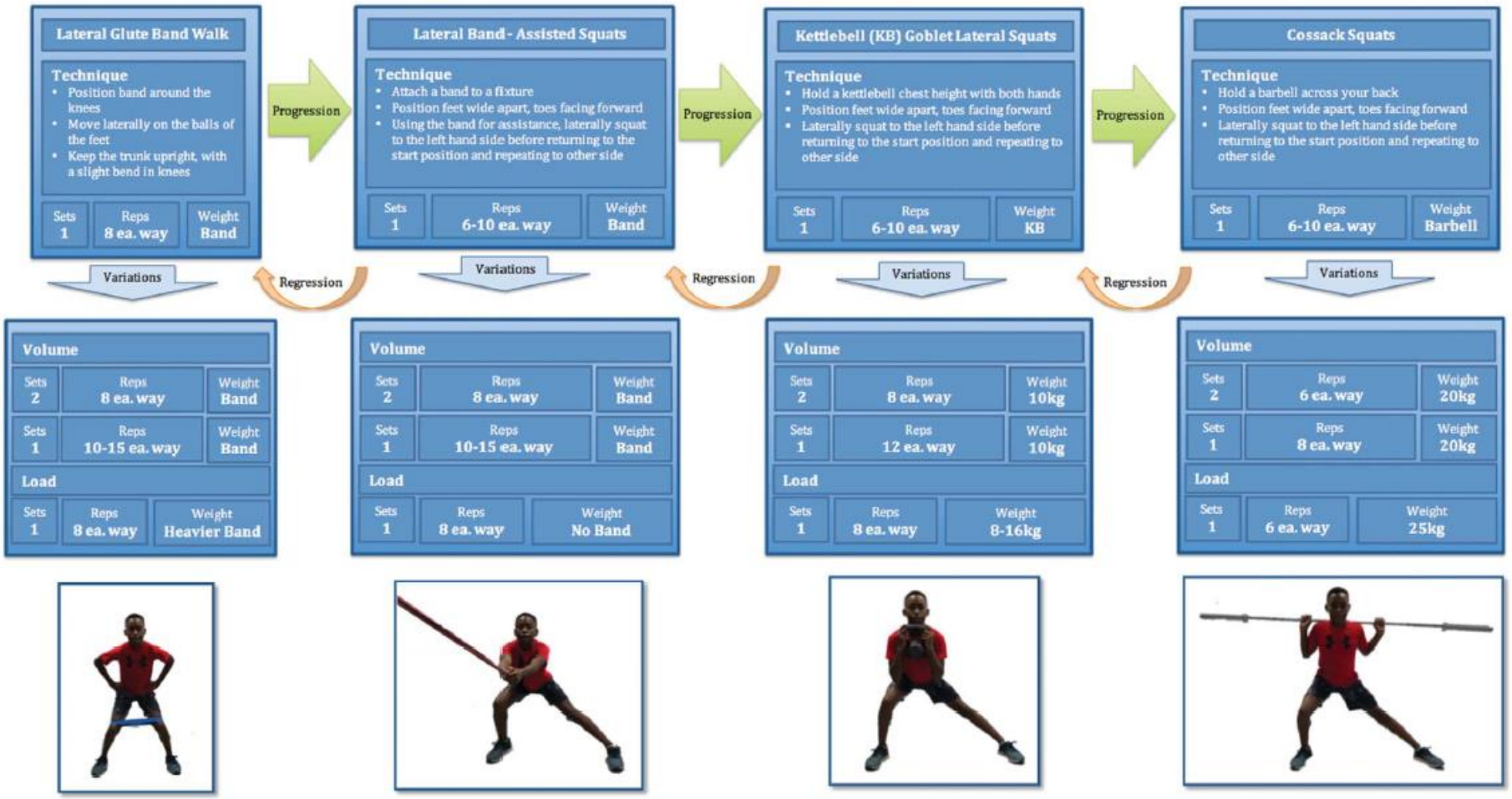

Figure 7 Example of a progressive and regressive exercise sequence for developing lateral hip strength.

individual has experienced a break in training due to competition, time off, injury, and/or illness. Understanding a youth athlete's motor competency and exposure to an exercise will assist coaches and practitioners to determine whether to progress or regress the exercise complexity.

Positive physiological and performance changes with youth athletes of varying capabilities may be achieved through proper manipulation of the intensity, duration, and recovery time of, and within, a warm-up (3). Consistent exposure to fundamental movement patterning exercises and core skills required in a chosen sport will also offer more opportunity for youth to build confidence and competency in their movement abilities. Exposing individuals to various forms of movement that targets physical literacy during the warm-up may also enable individuals to progress faster because they are able to use their physical training sessions to build upon the foundation work introduced in the warm-up (10). Adding an element of fun to the activities has also been shown to impact the movement learning process (11). Building confidence and competence in physical exercises through the interaction of positive, fun, and enjoyable experiences increases participation in activity, reduces anxiety, and likely impacts performance in sport (11).

Adjusting the complexity and intensity of exercise prescription within the context of the maturity will ensure appropriate exposure to challenge and enable players to develop a compliment of skills (5). This is in part due to the fact that youth of the same chronological age may differ considerably in their rate of growth and maturation (15). Differences in skeletal age in children (aged 7–8 years) can be as much as 4–5 years (6). Furthermore, while some youth take 2 years to pass from the prepubertal to the mature state, others take up to 5 years (6). Although the assessment of skeletal maturity is invasive and expensive, anthropometric assessments have been developed to provide an estimate of maturity status and timing (5). Evaluating a youth athlete's physical capabilities, within the context of maturity, highlights the significant variation among individuals of differing maturation (6). In boys, those who are advanced in maturation have been shown to possess greater strength, speed, power, and endurance measures (15,16,19). In girls, the degree to which maturity timing impacts physical characteristics depends on the characteristic assessed. For example, early maturing girls may possess greater strength and power values than their late maturing peers; however, greater absolute and relative fat mass may negatively impact their performances in activities that require rapid movement through space (25).

Periodizing the warm-up

The development of physical capabilities in youth is nonlinear, with periods of improvement, stagnation, and decline present throughout normal growth and maturation (4,14,22,24). Differences exist between the sexes, with boys typically having steady improvement in physical skills during middle to late childhood, before experiencing a rapid improvement during adolescence (14). Girls' physical development trajectory on the other hand tends to increase until the age of 13–14 years before plateauing (14). These differences necessitate that practitioners and coaches adjust their training prescription according to both the sex and individual needs of the youth athlete.

Regressing the complexity, intensity, and volume (sets and reps) of the prescribed exercises can be an effective tool to allow individuals to understand the desired movement patterns, build confidence, and remain involved in a training program. For example, an inexperienced young athlete (Table 1) may perform stationary, rather than ambulatory, dynamic mobility exercises, or be allowed to initially anchor themselves when performing balance or coordination exercises. Regression of specific physical components, such as force production, may involve shortening the desired distance of bounds or involve controlled jumping on the spot. In speed and quickness drills, total volume can

be reduced, focussing on quality rather than quantity, exposing athletes to maximal velocity work within a controlled environment. Regression can also involve manipulating the equipment used, with coaches and practitioners varying the strength of elastic band used, and/or ensuring competence in body weight exercise before adding load (e.g., kettlebell, dumbbell, barbell, or medicine ball). Once a youth athlete has mastered the desired movement pattern, they can either return to the more complex drill or progress to a new, more challenging exercise.

Similar to inexperienced young athletes, manipulating the complexity, intensity, and volume for competent older athletes may assist them through periods of stagnation, decline, or a lack of coordination. Identifying the source of an individual's performance barrier will aid the targeted adjustment of the warm-up. For instance, if the barrier is as a result of periods of accelerated growth, reducing volume and intensity and ensuring additional time is spent on re-educating movement patterns may assist a youth athlete during this period. If the stagnation or decline is as a result of minimal exposure to training, time spent on each component will aid the maintenance an individual's physical capabilities until greater exposure is feasible. Periodizing a warm-up, similar to the traditional methods applied to strength and conditioning programs, will allow for the progressive attainment of identified physical goals during a defined period.

Summary

In addition to being essential for optimal performance, the warm-up can be effectively used in a youth population to develop physical literacy (18). Consistent exposure to targeted physical activity that accommodates for individuals of different abilities, maturity, and training history is essential to ensure progressive improvement. By manipulating the volume, intensity, and complexity of the exercises, a warm-up can be tailored toward individual needs within a group environment. Moreover, ensuring the prescribed exercises are age appropriate and contain components of fun; cooperative learning (if in a team setting) and problem solving are likely to promote regular participation, therein increasing physical literacy. Furthermore, adopting a long-term approach when periodizing the warm-up will assist in developing sound, robust athletes, reduce the likelihood of injury, and likely impact current and future performance.

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