National Coaching Certification Program

HOCKEY CANADA

High Performance 1
Physical Preparation:
Additional Coaching Resource Material

Version 1.0

CANADA

National Coaching Certification Program

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TRAINING METHODS — GUIDELINES AND EXAMPLES

Introduction

- This section presents guidelines for training each of the athletic abilities, as well as examples of training methods for each athletic ability.
- Training methods and examples are presented in terms of a number of training variables, including intensity, frequency, and progressions.

Choosing Training Methods

- For any athletic ability, choose training methods that are consistent with:
  - Athletes' training objectives
  - The demands of their sport
  - Athletes' stage of growth and development
  - Athletes' training background
  - Athletes' injury history
  - Athletes' individual strengths and weaknesses
  - The time of the year the training is occurring
  - The training environment

Training for Speed

Key Words

- Short efforts
- All-out or near all-out intensity
- Long recovery: W:R = 1:12 - 15
- Highly sport-specific movements

Guidelines

Variable	Must be …
Type of training	Based on intervals
Activities/ movements	Dynamic and highly sport-specific A lot like the movements for which an increase in speed is desired
Intensity	Performed at maximum or near-maximum speed
Duration	Relatively short (less than 5 - 8 seconds), for speed to remain high
Number of repetitions	Relatively low overall; 10 - 16 is the norm, as speed tends to decrease with more reps because of fatigue; a few more reps can be performed if efforts are really short
Recovery between repetitions	Long enough to allow CP stores to return to a high level in the active muscles; W:R = 1:12 - 15 ; this allows the athlete to perform subsequent repetitions at high speed with no major decrease in power output
Recovery between sets	Long, to allow a good replenishment of CP stores A *pause* for 3 to 10 minutes between sets; this results in a more complete recovery and forces the correct energy system to function
Type of recovery	*Very light activity* involving the muscles used during the work interval (e.g., a slow walk after sprinting)
Position in training session	At the beginning of the main part of the training session, when athletes are not yet tired
Safety considerations	Performed after a thorough warm-up to avoid injury
Position in training program	Scheduled when the athlete is not too tired from previous training sessions Preceded by several weeks of other forms of preparatory training (strength-endurance, strength, aerobic stamina)

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Examples of Training Methods for Speed of Locomotion[1]

This Variable…	Should be …	
Type of training	Interval training	
Activities/movements	❑ As sport-specific as possible ❑ Progressive acceleration before initiating the effort OR ❑ Accelerations performed from a standing start OR ❑ Sudden acceleration when changing direction	
Intensity of each repetition	95% or more of maximum speed for the type of activity involved (running, cycling, swimming, skating; etc.)	
Duration of each repetition*	3 - 5 s or a distance suitable for the type of activity	6 – 10 s or a distance suitable for the type of activity
Number of repetitions per set	4 - 6 +	3 - 5 +
Number of sets	2 - 4	2 - 3
Total number of repetitions	8 - 24	6 - 15
Duration of recovery between repetitions	45 - 75 s	75 - 120 s
Type of recovery between repetitions	Active, very low-intensity recovery, followed by passive recovery for 20 - 30 s before the next effort	
Recovery between sets	Active, low-intensity recovery for 5 to 8 minutes, followed by passive recovery for about 1 minute	
Stop if…	Speed of movement or quality of execution decreases	
Total time (repetitions and recovery)**	15 to 58 minutes	16 to 50 minutes
Frequency***		
❑ For development	2 - 3 X per week, for 4 to 12 weeks	
❑ For maintenance	1 X per week	
For significant improvements in…	4 - 6 weeks	
Dominant energy system(s)	Anaerobic alactic (power component)	
Other training effects, including degree	Coordination, agility Anaerobic alactic system (endurance component) and speed-strength: moderate	

* Excluding the progressive acceleration phase ** Excluding warm-up and cool-down
*** If the ability has high importance in the athlete's sport, use the highest weekly frequency, and apply a progression that enables athletes to complete the maximum volume suggested for each session. This may take several weeks. If the ability has moderate importance in the athlete's sport, start with the lowest weekly frequency, and apply a progression that enables the athlete to complete the minimum volume suggested for each session. This may take several weeks. If there is enough time during practices, try to do more work. If the ability has low importance in the athlete's sport and there isn't enough time to include it in your program, encourage athletes to participate in different sport activities outside your program or during the off-season. This will help them achieve a balanced athletic development.

[1] *Speed of locomotion* refers to covering a given distance as fast as possible, e.g., a sprint in running.

Examples of Training Methods for Speed of Movement[2]

This Variable…	Should be…
Type of training	Interval training with long pauses
Activities/movements	Ultra-specific sport movements performed against low or no resistance Use of lighter implements or exercise conditions that reduce resistance to movement (e.g., very small gear ratio in cycling)
Intensity	As fast as possible
Duration of each repetition	Less than 1 s for single-action movements About 5 s for cyclical movements
Number of repetitions per set	4 - 5
Number of sets	2 - 4
Total number of repetitions	8 - 20
Duration of recovery between repetition	20 to 30 times longer than the effort
Type of recovery between repetitions	Active, very low-intensity recovery, followed by passive recovery for 20 - 30 s
Recovery between sets	Active, low-intensity recovery for 2 - 3 minutes
Stop if…	Quality of execution or speed of movement decreases
Total time (repetitions and recovery)*	5 to 16 minutes (excluding warm-up and cool-down)
Frequency**	
❑ Development	2 - 3 X per week
❑ Maintenance	1 X per week
Significant improvement in…	4 - 6 weeks
Dominant energy system(s)	Alactic (power component)
Other training effects, including degree	Coordination, agility Speed-strength: moderate

* Excluding warm-up and cool-down

** If the ability has high importance in the athlete's sport, use the highest weekly frequency, and apply a progression that enables athletes to complete the maximum volume suggested for each session. This may take several weeks. If the ability has moderate importance in the athlete's sport, start with the lowest weekly frequency, and apply a progression that enables the athlete to complete the minimum volume suggested for each session. This may take several weeks. If there is enough time during practices, try to do more work. If the ability has low importance in the athlete's sport and there isn't enough time to include it in your program, encourage athletes to participate in different sport activities outside your program or during the off-season. This will help them achieve a balanced athletic development.

[2] *Speed of movement* refers to performing a sport-specific movement as fast as possible without necessarily moving the body, e.g., throwing a ball or moving a racquet in a tennis serve.

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Other Considerations for Speed Training

- Speed training must *not* be viewed as a general conditioning session where more is better and work is harder when recovery is short. Rather, speed training must always be seen as quality work, and recovery between efforts must be long enough to preserve proper technique. This will ensure that the proper adaptations take place at the neuromuscular and energy-systems levels.
- Neural factors play a key role in speed. Athletes can further activate the central nervous system in sprint-type efforts lasting a few seconds by rapidly moving the body parts responsible for moving the body (2 or 3 vertical jumps in running, rapid movements with the arms in swimming, etc.) 30 seconds or so before the actual sprints.
- Performance in speed activities is affected by other athletic abilities such as strength, speed-strength, coordination, and agility.
- During the few seconds of passive recovery that precede the effort, the athlete should concentrate and prepare psychologically to perform at maximum speed while maintaining good technique (mental imagery).
- Maintaining good technique is essential to the development of inter- and intra-muscular coordination. Speed exercises should be interrupted if technique starts to deteriorate. During a speed-training session, coaches must pay attention to the speed or times athletes are achieving *and* to the athlete's technique.
- Progression can be applied by increasing total volume: by adding repetitions within sets, by adding a set, or by increasing intensity. Recovery periods must *not* be reduced when the primary training effect desired is greater speed.
- Whether and how to increase volume depends on the goals of the training program and the athlete's response to speed training. If the athlete can perform the minimal number of reps and sets prescribed in the previous tables without a decrease in speed and quality of execution and without feeling undue fatigue, volume can be increased. Volume can be increased every 2 or 3 weeks thereafter.
- Given the relatively important contribution of the aerobic system in most short-duration cyclical events, preparation for speed events should include *some form* of aerobic conditioning.
- Heredity seems critical with regard to speed; the potential for improvement is relatively limited (in the order of 10 - 15%).

More Advanced Methods

- Maximum limb velocity can be increased by adapting training conditions to reduce the resistance that must be overcome during certain movements.
    - In running, cycling, and cross-country skiing, a slightly downward-sloping surface may be used for sprinting; in activities involving throwing or swinging motions, lighter equipment may be used.
    - When air resistance is important (e.g., in cycling, speed skating, and sprinting), athletes may benefit from working with a strong tailwind, at altitude, or behind a motorized vehicle.
    - When an inclined surface is used in running, the eccentric component of the movement will be high, and damage to muscle fibre damage can therefore be more severe than on a flat surface. This can lead to delayed onset muscle soreness in the days that follow, which can impair performance. Also, there may be a greater degree of stretching in the antagonist

muscles such as the hamstrings. *The slope of the surface should therefore be low (1 to 3%), and the athlete should be in excellent specific physical condition when this type of method is used.* Careful attention should also be paid to the warm-up before the exercise and to the development of flexibility in agonist and antagonist muscle groups in the weeks leading up to the use of such methods. This approach should accordingly be used with caution (not more than once a week), and it should be avoided near important competitions.

Training for Speed-endurance

Key Words

- Below maximal speed, but above maximal aerobic speed
- Repetitions in the range of 10 - 75 s
- Long recovery; length affects the dominant energy system
- Sport-specific movements
- Highly demanding

Guidelines

Variable	Must be …
Type of training	Based on intervals
Activities/ movements	Dynamic and highly sport-specific A lot like the movements for which an increase in speed-endurance is desired
Intensity	Below maximum speed, but above maximum aerobic speed
Duration	Variable, between 10 and 75 s or so, depending on the primary energy system and component (power or endurance) targeted
Number of repetitions	Variable, between 6 and 24 or so, depending on the primary energy system and component (power or endurance) targeted; fewer reps for longer efforts
Recovery between repetitions	W:R of 1:8 to 1:12 for short efforts (10 to 15 s) W:R of 1:6 to 1:8 for moderate and long efforts (20 to 75 s)
Recovery between sets	Long, in the range of 6 to 8 minutes
Type of recovery	*Very light* activity involving the muscles used during the work interval (e.g., a slow walk after sprinting)
Position in training session	Early in the main part of the training session, when athletes are not yet tired
Safety considerations	Performed after a thorough warm-up to avoid injury
Position in training program	Preceded by several weeks of other forms of preparatory training (strength-endurance, strength, aerobic stamina)

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Examples of Training Methods for Speed-Endurance

This Variable…	For Short Efforts, Should Be …	For Intermediate Efforts, Should Be …	For Long Efforts, Should Be …
Type of training	Interval	Interval	Interval
Activities/movements	As sport-specific as possible	As sport-specific as possible	As sport-specific as possible
Target intensity	All-out or near all-out ≈ 95% of the maximum speed associated with 1 rep*	Controlled, paced, in between maximal speed and maximum aerobic speed (MAS) 92%-95 % of the maximum speed associated with 1 rep	Paced, above MAS (110 to 115% of MAS in running, or 92% - 95% of the maximum speed associated with 1 rep)
Duration of each repetition	10 s: W:R = 1:12 15 s: W:R = 1:8	20 s: W:R = 1:6 30 - 45 s: W:R = 1:6 to 1:8	60 - 75 s 90 s (1 set only)
Number of repetitions per set**	4 - 6	3 - 5	4 - 5
Number of sets	3 - 4	2 - 3	1 - 2
Total number of repetitions	12 - 24	6 - 15	4 - 10; maximum of ≈ 12 minutes of effort
Duration of recovery between repetitions***	1 min 30 s - 2 min	1 min 30 s - 4 min	6 min
Type of recovery between repetition	Active, very low intensity	Active, very low intensity	Active, very low intensity
Recovery between sets	Active, low-intensity recovery for ≈ 6 minutes	Active, low-intensity recovery for ≈ 10 minutes	Active, low-intensity recovery for ≈ 10 minutes
Stop if…	Athlete can no longer maintain a high speed	Athlete can no longer maintain the target speed	Athlete can no longer maintain a high speed
Total time (repetitions and recovery)	34 - 70 minutes	28 - 90 minutes	38 - 80 minutes
Frequency******			
❑ For development	2 X per week	2 - 3 X per week	2 X per week
❑ For maintenance	1 - 2 sets, 1 X per week	1 - 2 sets, 1 X per week	1 set, 1 X per week
For significant improvements in…	4 - 6 weeks	4 - 6 weeks	4 - 6 weeks
Dominant energy system(s)	Anaerobic alactic (capacity component)	Anaerobic lactic (power component)	Anaerobic lactic (endurance component)

This Variable…	For Short Efforts, Should Be …	For Intermediate Efforts, Should Be …	For Long Efforts, Should Be …
Other training effects, including degree	Anaerobic alactic and lactic energy systems (power component); coordination; agility	Anaerobic lactic energy system (endurance component); anaerobic alactic (capacity component); coordination; agility	Anaerobic lactic energy system (power component)

* Set a target distance such that the athlete can work all-out for the work interval chosen

** The higher number of repetitions per set should be for shorter efforts

*** Longer recovery may be needed for efforts closer to all-out intensity for the duration considered

**** If the ability has high importance in the athlete's sport, use the highest weekly frequency, and apply a progression that enables athletes to complete the maximum volume suggested for each session. This may take several weeks. If the ability has moderate importance in the athlete's sport, start with the lowest weekly frequency, and apply a progression that enables the athlete to complete the minimum volume suggested for each session. This may take several weeks. If there is enough time during practices, try to do more work. If the ability has low importance in the athlete's sport and there isn't enough time to include it in your program, encourage athletes to participate in different sport activities outside your program or during the off-season. This will help them achieve a balanced athletic development.

Setting Intensity for Speed-endurance Workouts

For the development of speed-endurance, intensities must be set *between the values for maximum speed and maximum aerobic speed (MAS)*. To adjust such intensities appropriately, given (1) the exercise durations for which the anaerobic energy systems can contribute and (2) the demanding nature of the efforts that must be produced, follow these steps:

- Select a distance corresponding to approximately what the athlete should cover, given the duration selected for the work interval (e.g., 400 m for running efforts lasting 50 to 60 s).
- Have the athlete perform *one maximal effort* over that distance.
- If the time achieved by the athlete over the chosen distance is roughly the intended one, set the distance as an appropriate work interval for speed-endurance work. If not, use a somewhat shorter distance (10 to 15% shorter or as needed) for the work intervals, and repeat the previous step after 10 to 15 minutes of recovery.
- Calculate the *speed corresponding to one maximal repetition over the distance*:
  Speed (m/s) = Distance (m)/Time (s).
- Set the *target training speed*. Depending on the length of the work intervals, the athlete should aim to produce efforts at 92% to 95% of the speed determined above.
- Determine *target times for the selected work intervals:*
  Target Time (s) = Distance (m)/Target Training Speed (m/s)

Example: Work intervals of 60 s are to be performed. During the maximal effort, time over 400 m is 61 seconds. The *speed corresponding to one maximal repetition over the distance* is therefore 400 m/61 s = 6.56 m/s. A *target training speed* set at 95% of this value would equal 6.23 m/s. The *target times for the selected work intervals of 400 m* would be 64.2 seconds.

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Other Considerations

- The systematic development of speed-endurance before puberty is NOT recommended.
- Speed-endurance can be developed in sport-specific situations (e.g., team, racquet sports) by designing drills that require athletes to perform various types of technical tasks at high intensity and alternating the periods of effort with active recovery at much lower intensity in accordance with the guidelines in the table above.
- Given the importance of the aerobic system in most events where speed-endurance is an important athletic ability (see Section 1), *some form* of aerobic conditioning and resistance training should precede the use of specific methods designed to improve speed-endurance.
- In cyclical sports, the high-intensity bouts performed during fartlek may contribute to the development or maintenance of speed-endurance; the actual training effect will be determined by the intensity and length of the efforts, as well as their number. Given the random nature of the efforts produced, bouts lasting between 30 and 90 seconds at intensities well above maximal aerobic speed may represent a good stimulus for improving speed-endurance and the power or endurance components of the anaerobic lactic system.

Training for Aerobic Stamina

Key Words

- IT at 95 to 105% of MAP for effective MAP training
- IT at 80 to 90% of MAP for quality aerobic endurance training
- CT at 75 to 85% of MAP for quality aerobic endurance training
- CT at 60 to 70% of MAP for general aerobic endurance and conditioning training

Guidelines

Variable	Must be …
Type of training	Variable, depending on whether the power (MAP) or the endurance component is being trained. IT is the most efficient approach for MAP; IT, CT, or fartlek can all be used for aerobic endurance training.
Activities/ movements	Dynamic and sport-specific; should at least involve the same muscle groups as those primarily responsible for locomotion in the sport.
Intensity	Variable, depending on whether the power (MAP) or the endurance component is being trained. IT intensities in the range of: • 95 to 105% of MAP are optimal for MAP training • 80 to 90% of MAP are optimal for aerobic endurance training CT intensities in the range of: • 75 to 85% of MAP are optimal for aerobic endurance training • 60 to 70% of MAP can be used for aerobic endurance training
Duration	Variable, depending on whether the power (MAP) or the endurance component is being trained. When training for:

Variable	Must be …
	• MAP, IT work efforts can range from a few seconds to 3 minutes or so • Aerobic endurance, IT work efforts can range from 90 s to 6 minutes or more • Aerobic endurance, CT, or fartlek sessions can last between 20 minutes and 3 hours or more
Number of repetitions	CT: One repetition. IT: Variable, depending on intensity and work interval. Can range from about 4 to 30 or so; fewer reps for longer efforts.
Recovery between reps	Not applicable for CT. Active for IT, with the length depending on the duration of the effort; in general, W:R ranges from 2:1 to 1:2 or so.
Position in training session	Should *not* take place before activities aimed at training motor abilities, sport-specific skills, speed, and speed-endurance, as well as most forms of resistance training.
Safety considerations	Ensure proper hydration throughout CT or IT sessions, particularly when exercising in hot and humid conditions. Carbohydrate should be ingested every 20 minutes or so during continuous efforts lasting 90 minutes or more.
Position in sport program	Aerobic endurance before MAP; some aerobic stamina training should take place before emphasizing speed and speed-endurance, with the exact nature of the training for aerobic stamina (type, frequency, volume, etc.) depending on the athlete's sport or position.
Programming considerations	Increase duration first, *then* intensity **Development**: 2 – 3 X per week **Significant improvements** in 6 – 8 weeks **Maintenance:** 1 X per week

Setting Workout Intensities for Aerobic Stamina

The most accurate measure of work intensities in training for aerobic stamina is *percentage of maximum aerobic power (MAP)*. Three methods of estimating percentage of MAP are discussed below:

- ❑ Percentage of maximum aerobic speed (MAS)
- ❑ Percentage of MAP expressed in watts
- ❑ Heart-rate reserve, or the Karvonen formula

Of the three, the method based on heart rate is the *least* accurate.

Percentage of MAS

This method applies to running. Because energy expenditure and speed have an almost perfect linear relationship in running, it is easy to determine the submaximal training speeds corresponding to a given percentage of MAP once maximal aerobic speed (MAS) is known. Such estimates are also very accurate.

The two Léger MAP tests are very useful tools for setting training intensities for a wide range of IT and CT aerobic workouts.

For instance, if MAS is 20 km/h, a target training speed of 12 km/h corresponds to about 60% of MAP, a target training speed of 15 km/h to 75% of MAP, a target training speed of 18 km/h to 90% of MAP, etc.

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Once the target training speed is established, the target time for covering a specific distance can be calculated from this formula:

Target Time = Distance/Target Training Speed

Note: *When using the 20-m shuttle run to estimate MAP, the value obtained for MAS must be adjusted to reflect training intensities under normal running conditions.*

Percentage of MAP Expressed in Watts

This method applies to training on ergometers or bicycles.

Energy expenditure and intensity expressed in watts have an almost perfect linear relationship. Once the wattage corresponding to MAP is known from a test conducted on an ergometer or on a bicycle equipped with the appropriate measurement devices, it is easy to determine the wattage corresponding to a given percentage of MAP, and the estimates are quite accurate.

For instance, if MAP is reached at an intensity of 300 watts, 180 watts is 60% of MAP, 240 watts is 80% of MAP, 270 watts is 90% of MAP, etc.

Heart-rate Reserve, or the Karvonen Formula

Because the relationship between HR and work intensity is somewhat linear, HR is frequently used to estimate the percentage of his or her MAP that an athlete is working at.

While HR has certain limitations as a measure of aerobic intensity, it is a useful guide to exercise intensity. This is especially true if HR is used with other methods (e.g., percentage of MAP in watts) or for activities where the relationship between energy cost and speed is not as linear as in running.

Of the various approaches to using HR to estimate the intensity of aerobic workouts, the most accurate is the heart-rate reserve method; it is also called the Karvonen formula. Three HR measurements are needed to calculate HR reserve:

- Max HR
- Resting HR
- HR during exercise

The HR reserve formula is:

Percentage of MAP = (HR during exercise – Resting HR)/(Max HR – Resting HR)

Example

Athlete A has a maximum HR of 205 bpm and a resting HR of 55. Athlete B has a maximum HR of 190 and a resting HR of 52 bpm. To exercise at an intensity of approximately 80% of MAP, the target HRs should be 175 for Athlete A and 162 bpm for Athlete B.

For Athlete A:

0.8 = (x – 55)/(205 – 55), where x represents the target HR (unknown at this point)

0.8 = (x – 55)/150

150*0.8 = x – 55

120 = x – 55

175 = x

The target heart rate for Athlete A is 175 bpm.

For Athlete B:

0.8 = (x – 52)/(190 – 52), where x represents the target heart rate (unknown at this point)

0.8 = (x – 52)/138

138*0.8 = x – 52

110 = x – 52

162 = x

The target heart rate for Athlete B is 162 bpm.

When using this formula, coaches are advised to target a *HR range* rather than a *specific value.* For instance, if the objective is to train at about 80% of MAP, Athlete B in the example above could exercise anywhere between 158 and 166 bpm. If the intent is to perform at a relatively constant workload throughout the session, the target range should be increased by 5 to 8 bpm after an hour or so to reflect the rise in HR resulting from dehydration and increased core temperature. Similarly, target HR may need to be adjusted to take into account the type of clothing worn and environmental conditions.

Continuous Training for Aerobic Stamina

For many coaches and athletes, continuous training (CT) is *THE* form of training that comes to mind when the objective is to train aerobic stamina. However, the actual training effects of CT may vary significantly, depending on the intensity and the duration of the workout, as well as the athlete's specialization.

Here are a few key points about CT:

- At low to moderate intensities, the subset of aerobic stamina most likely to be improved or maintained through CT is aerobic endurance, *not MAP*; for CT to affect MAP, the athlete's aerobic fitness must be fairly low.
- At intensities above 80-85% of MAP, CT may lead to improvements in MAP, especially if the athlete's sport *does not* have very high aerobic demands. However, the best way to improve MAP is to do IT at intensities ranging between 95 and 105% of MAP.
- When using CT, the best training effects on aerobic endurance come from workouts performed at intensities higher than 70-75% of MAP.
- Athletes can sustain low-intensity CT (60-65% or less of MAP) for very long periods (up to several hours in the case of endurance athletes), especially if they consume adequate amounts of carbohydrate and water.
- In well-trained endurance athletes, muscle glycogen stores should not decrease markedly during low-intensity CT, because the rate of glycogen use by the muscles is not very high, and a large proportion of the energy needed comes from fat.
- At intensities of approximately 75% or more of MAP, glycogen is the primary energy source for the working muscles, and the rate of use increases as the effort gets more intense; in most

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athletes, glycogen stores are greatly diminished after 75 to 90 minutes of exercise at such intensities.

- Low-intensity CT (60-65% or less of MAP) of short to moderate duration can serve as light training sessions, particularly during the Competition Period or the Specific Preparation Phase.

The two tables below outline the likely effects of CT sessions of various duration on (1) subjective feelings of fatigue at the end of the exercise (an indicator of the training load) and (2) aerobic endurance and MAP.

To account for event specialization, separate tables are presented for endurance and non-endurance athletes. Training methods (intensity and duration of effort, for example) assume an average level of endurance. Since aerobic endurance may vary greatly among individuals, this information is only as a general guide. Training effects may also depend on the athlete's age or training background.

CT for Non-endurance Athletes (team sports, racquet sports, etc.)

Intensity (% of MAP)	Duration (minutes)	Subjective Feeling of Fatigue at the End of the Session	Effect on the Development of…	
			Endurance	Power
60	≤ 30	Easy	Low	Negligible
	30 - 45	Easy to moderate	Some	Negligible
	60 - 75 +	Somewhat demanding	Moderate	Negligible
	90 - 120 +	Demanding	Good to very good	Negligible
70	≤ 20	Easy	Low	Low
	30 - 45	Moderate	Some to moderate	Low
	60 - 75	Somewhat demanding to demanding	Good	Low
	90 +	Demanding to very demanding	Very good	Low
75 - 80	30	Moderate	Moderate	Some
	45 - 60	Somewhat demanding to demanding	Good to very good	Some
	75 - 90	Demanding to very demanding	Very good to excellent	Some
	90 +	Very demanding	Excellent	Some
85 - 90	15 - 20	Demanding	Good to very good	Good
	20 - 30 +	Very demanding	Very good to excellent	Good

CT for Endurance Athletes

Intensity (% of MAP)	Duration (minutes)	Subjective Feeling of Fatigue at the End of the Session	Effect on the Development of…	
			Endurance	Power
60	30	Very easy	Negligible	None
	60 - 75	Easy	Low	None
	90 - 120	Moderate	Some	None
	150 +	Somewhat demanding	Moderate	None
70	45	Easy	Some	None
	75	Moderate	Moderate	None
	90	Somewhat demanding	Good	None
	120 +	Demanding	Very good	None
75	30	Somewhat easy	Some	None
	45 - 60	Moderate	Moderate	None
	75	Somewhat demanding	Good	None
	90 +	Demanding	Very good	None
80	20	Moderate	Some	Negligible
	30	Somewhat demanding	Moderate	Negligible
	60	Demanding	Very good	Negligible
	75 +	Very demanding	Excellent	Negligible
85	20 - 25	Demanding	Very good	Minor
	40 +	Very demanding	Excellent	Minor
90	12 - 15	Demanding	Very good	Some
	18 - 20	Very demanding	Excellent	Some

- When establishing an initial training progression for the use of Continuous Training (CT):
  - Given your assessment of the athlete's fitness level, start with the *lowest* combination of volume and intensity proposed for a session that is either *moderate* or *somewhat demanding*
  - Based on how the athlete responds to this training load, adjust as necessary. For instance:
    - Decrease the volume if the athlete has difficulty completing the entire workout at the prescribed minimal intensity
    - Use a higher prescribed volume if it's very easy for the athlete to complete the entire workout at the prescribed minimal intensity
  - Once you have a general feel for the athlete's capabilities, select a combination of volume and intensity that represents an appropriate challenge for the athlete, given the training objectives

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Interval Training for Aerobic Stamina

Since the duration of effort, the length of recovery, and the type of recovery can all affect the degree to which the aerobic energy system contributes during exercise, a wide range of protocols can be effective for the development of both aerobic endurance and MAP. As the following tables show, interval or intermittent training (IT) with work intervals ranging from a few seconds to several minutes can be used. Even if they are of short duration, dynamic activities where work intervals are longer than or equal to the recovery (e.g., W:R of 3:1; 2:1; 1:1) are predominantly aerobic after the first few reps. Efforts at intensities slightly above MAP (105 - 110% of MAP) with a W:R ratio of 1:2 or 1: 2.5 can also be effective for aerobic training if several reps are performed.

MAP is usually best developed by working at 95% to 105% of MAP for relatively short work intervals. Endurance, on the other hand, is best developed by working at 80% to 90 % of MAP. Intensities below 80% of MAP should not be used for IT; they are best used in CT sessions.

Examples of IT Sessions for Maximum Aerobic Power

Example #	Intensity (% MAP)	Sets	Repetitions/ Set	Repetitions (min:s)	Recovery (min:s) between		Duration of the Session*
					Repetitions	Sets	
MAP 1**	110	4	7	0:30	1:00	3:00	50 min 1 h 15 min
MAP 2**	105	3	8	0:45	2:00	5:00	51 min
MAP 3**	105	3	6	0:45	1:30	5:00	1 h 11 min
MAP 4	100	3	6	1:00	2:30	5:00	1 h 02 min
MAP 5**	105	2	6	1:00	3:00	10:00	56 min
MAP 6	95	4	6	1:00	1:00	3:00	55 min
MAP 7	100	2	6	1:15	2:00	10:00	55 min
MAP 8**	105	2	4	1:15	2:30	10:00	45 min
MAP 9	95	3	6	1:15	2:00	5:00	1 h 08 min
MAP 10	100	2	5	1:30	3:00	10:00	59 min
MAP 11**	105	1	6	1:30	4:00	-----	33 min
MAP 12	95	2	8	1:30	3:00	10:00	1 h 26 min
MAP 13	100	2	4	1:45	3:00	10:00	52 min
MAP 14**	105	1	5	1:45	4:00	-----	29 min
MAP 15	95	2	6	1:45	3:00	10:00	1 h 11 min
MAP 16	100	1	6	2:00	4:00	-----	36 min
MAP 17	95	2	5	2:00	3:00	10:00	1 h 04 min
MAP 18	100	1	4	2:30	4:00	-----	26 min
MAP 19	95	1	6	2:30	4:00	-----	39 min
MAP 20	95	1	4	3:00	4:00	-----	28 min

* Excluding the warm-up and cool-down ** Also benefits the endurance of the anaerobic lactic system

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Examples of IT Sessions for Aerobic Endurance

Protocol	Intensity (% MAP)	Sets	Repetitions/ Set	Repetitions (min:s)	Recovery (min:s) between		Duration of the Session*
					Repetitions	Sets	
END 1	85	4	7	1:30	1:00	3:00	1 h 18 min
END 2	85	4	6	1:45	1:00	3:00	1 h 14 min
END 3	90	3	7	1:30	2:00	5:00	1 h 23 min
END 4	90	3	6	1:45	2:00	5:00	1 h 17 min
END 5	85	3	7	2:00	2:00	5:00	1 h 33 min
END 6	85	3	5	2:30	2:00	5:00	1 h 17 min
END 7	90	2	7	2:00	3:00	10:00	1 h 24 min
END 8	90	2	5	2:30	3:00	10:00	1 h 09 min
END 9	90	2	4	3:00	3:00	10:00	1 h 02 min
END 10	85	2	6	3:00	3:00	10:00	1 h 26 min
END 11	85	2	5	3:30	3:00	10:00	1 h 19 min
END 12	85	2	4	5:00	3:00	10:00	1 h 18 min
END 13	90	1	6	3:30	4:00	-----	45 min
END 14	90	1	5	4:00	4:00	-----	40 min
END 15	90	1	3	5:00	4:00	-----	27 min
END 16	85	1	7	4:30	4:00	-----	1 h 00 min
END 17	85	1	5	6:00	4:00	-----	50 min
END 18	85	1	4	7:00	4:00	-----	55 min
END 19	80	4	6	2:30	1:15	5:00	1 h 45 min
END 20	80	3	5	4:00	2:00	8:00	1 h 48 min
END 21	80	2	6	5:00	2:00	8:00	1 h 36 min

* Excluding the warm-up and cool-down

Progression in the Use of IT for Aerobic Stamina

Once you have determined that the athlete is capable of completing IT workouts without undue stress (see Section 3), you may want to consider the types of progression that can be used in an IT program for aerobic stamina.

Type of Progression	Possible Progressions	Rationale
Progression in **intensity**	❑ Progress from endurance to MAP ❑ When working on endurance, start with sessions of lower intensity, e.g., 80% of MAP, and increase intensity to 85%, then 90% ❑ When working on power, start with sessions at 95% of MAP, and increase to 100%, then 105%, then 110% of MAP	❑ Allows metabolic, technical/motor, articuloskeletal, and psychological adaptations to occur at lower intensities first, before moving on to the stress of higher intensities
Progression in **duration**	❑ From shorter to longer sessions, regardless of the intensity of the workout	❑ Prepares the athlete to complete progressively longer training sessions
Progression from **quantity** to **quality**	❑ Use sessions with a high number of repetitions but shorter work intervals at the start of the training program, and then progress to longer work intervals but fewer repetitions ❑ This approach can be used for MAP and aerobic endurance, regardless of the intensity of the workouts	❑ Emphasizes total work time at targeted intensities earlier in the program ❑ Progressively increases the ability to sustain longer and longer repetitions before recovering

Fartlek for Aerobic Stamina

Fartlek is a form of training characterized by continuous exercise where the intensity and duration of efforts can be quite variable but there is no set pattern to the change in intensity, as there is in IT. Depending on the intensity and duration of efforts, a fartlek session can contribute to the development of both the aerobic *and* the anaerobic lactic energy systems.

Fartlek can be used as a hard session at any stage of the season, especially during the Specific Preparation Phase and the Pre-competition Phase.

Here's an example of a group fartlek session in cycling on a circuit that is 5 to 8 km long and includes a good hill:

- ❑ Perform a 15-to-20-minute warm-up at 60 - 65% of MAP while inspecting the circuit.
- ❑ Lap 1 of the circuit:
  - Ride at a constant pace and at moderate intensity (70 - 75% of MAP) for a few km, then speed up and cycle as hard as possible over 2 or 3 km; then recover actively at 60% or so of MAP for a few minutes before reaching the hill.
  - Start the climb at a good pace, then accelerate suddenly to near-maximal intensity in the middle of the hill, and continue the intense effort for the 2 or 3 km after the hill.
  - Complete the rest of the circuit at a constant speed that corresponds to 70 - 75% of MAP.

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- Lap 2 of the circuit:
  - Cycle the circuit at moderate speed, sprinting on the hill and maintaining the effort on the flat for 300 or 400 m; then recover at low speed for several minutes for the rest of the lap.
- Lap 3 of the circuit:
  - Cycle the circuit as quickly as possible, with riders taking turns setting the pace for 30 to 45 seconds; the athlete who leads rides at his or her own pace, and all riders sprint to an imaginary finish at the end of the lap.
- Finish with a cool-down period of several minutes.

Other Considerations

- Aerobic endurance can be looked as:
  - The ability to sustain a high relative power output for a given period of time (for instance, an athlete capable of sustaining 80% of his or her MAP for 1 hour has greater endurance than another who can sustain only 75% of MAP for1 hour)

    OR
  - The ability to maintain a given percentage of MAP for the longest possible time (for instance, an athlete capable of sustaining 100% of his or her MAP for 8 minutes has a greater endurance than another who can sustain the same workload for only 6 minutes)
- An athlete's aerobic endurance is *independent of the level of his or her MAP*. Therefore, athletes with a very high MAP may or may not have a lot of endurance, and athletes with a low MAP may have extremely high endurance.
- A number of factors can affect aerobic endurance:
  - Fuel supply (glycogen stores in the muscles, as well as the ability to spare glycogen by mobilizing and using fat)
  - Hydration status
  - Capacity to dissipate heat
  - Availability of glucose to maintain blood sugar level (glycemia) during exercise
  - Economy of motion (i.e., spending less energy at a given intensity because of superior technique)
  - Motivation and psychological factors
- MAP and endurance both play key roles in endurance events in cyclical sports:
  - For short events (time ≤ 15 minutes), MAP is by far the most important determinant of performance
  - Even for longer events, such as marathon running, MAP remains an important determinant of performance, but other factors such as running economy (technical efficiency) and endurance also play a key role
  - Athletes with very high endurance and a high but not exceptionally high MAP can still perform well, particularly in events lasting three hours or more

- Interval or intermittent training for aerobic stamina training:
  - Usually makes it possible to do a higher volume of high-intensity work during a training session than would be possible with CT
  - Can be considered more specific than CT for many sports (team sports, racquet sports, combative sports, etc.)
  - May benefit athletes prone to injury when they do high volumes of CT work
- In non-cyclical sports (e.g., team sports, racquet sports), aerobic stamina can be developed in sport-specific situations through drills that require athletes to perform various technical tasks at high intensity for 30 seconds to 2 minutes with a W:R of 1:1 or 2:1, repeated for a total of 12 to 15 minutes at high intensity. These types of intermittent efforts should allow athletes to maintain relatively high intensity throughout, which can be effective in improving MAP. Athletes can also simulate game-like situations by playing non-stop for 5 to 10 minutes. Coaches should have extra balls, pucks, etc., on hand to minimize recovery periods if the ball or puck goes out of play.

Resistance Training

Resistance training is a program of regular exercises designed to increase strength, speed-strength, or strength-endurance in which athletes use any one or a combination of training methods and devices: free weights, machines, body weight, pneumatic devices, medicine balls, etc. Resistance training is not the same as powerlifting or competitive weightlifting.

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The Basics

Types of Contractions

The following table defines the key terms in resistance training used in this section. The focus is on terms describing types of muscle contractions and types of strength.

Term	Definition	Key Points
Concentric Contraction	Contractions in which 1) muscles *shorten* under tension and 2) movement occurs at a joint	❑ Examples: • The biceps shorten in chin-ups as the athlete *raises* himself or herself and the angle at the elbow decreases (say from 180° to 15°). • The triceps work concentrically in the bench press as the angle at the elbow *increases* (as the weight is raised).
Eccentric Contraction	Contractions in which 1) muscles *lengthen* under tension and 2) movement occurs at a joint	❑ Examples: • The biceps contract eccentrically in chin-ups when the athlete *lowers* his or her body and the angle at the elbow increases (say from 15° to 180°). • The triceps work eccentrically in the bench press as the angle at the elbow *decreases* (as the weight is lowered). ❑ Compared to isometric or concentric contractions, eccentric contractions: • Can generate 45 - 50% more tension. • Recruit fewer motor units, which causes each muscle fibre to be subjected to higher levels of tension. • Involve fewer muscle fibres and therefore have a lower energy cost. • Cause more damage to muscle fibres, which can result in some pain in the muscles in the hours that follow; this is called delayed onset muscle soreness (DOMS[3]).
Isokinetic Contraction	Contractions in which force is produced at a constant speed throughout the movement	❑ Although theoretically possible, such contractions are unlikely to occur in the human body. ❑ Even when speed of movement is controlled by a machine and remains constant during the movement, there is no guarantee that muscle fibres contract at constant speed; in this case, it's more accurate to refer to isokinetic movement than to isokinetic contraction.

[3] DOMS is usually felt 8 to 12 hours after exercise, reaches a peak within 24 to 48 hours, and can persist for 3 to 5 days. DOMS may be associated with a significant decrease in force generation and range of motion; such performance decreases are observed mostly at the beginning of a program or in untrained individuals.

Term	Definition	Key Points
Isometric Contraction	Contractions in which muscles develop tension but *joint angles* remain the same	❑ No movement occurs. ❑ Isometric contractions are often called *static* contractions. ❑ In isometric contractions, muscles try to shorten, but this contraction is balanced by an equally strong contraction of the opposing muscle partner (antagonists) OR by an effort against an immovable external resistance. ❑ Examples: Contracting the biceps in one arm in the absence of movement (the triceps will also contract); putting one hand in the palm of the other and pushing hard without any movement occurring.
Isotonic Contraction	Contractions in which the level of force is the same throughout the movement	❑ Although theoretically possible, such contractions are unlikely to occur, as the demands on the muscles involved in moving a given resistance vary throughout the movement.

Key Points about Resistance-training Variables

Variable	Key Points
Repetition (rep)	❑ A repetition is one complete execution of an exercise. Athletes should always aim to do each repetition properly, that is, with the proper grip, throughout the desired range of motion, and under control. See also the information on the repetition maximum (RM) continuum, on page 25.
Intensity	❑ Intensity is generally expressed: • As a percentage of maximum strength. For example, if an athlete can lift 50 kg during a maximum contraction, working at 80% of maximum strength involves lifting 40 kg. OR • In RMs, that is, in terms of the number of times a given weight can be lifted. For instance, 1 RM means the weight can be lifted only once, and 5 RMs means the weight can be lifted 5 times but not 6. ❑ The greater the intensity, the greater the amount of weight lifted.
Number of Exercises	❑ The number of exercises in a training session depends mainly on the athlete's training objectives and training status. ❑ Sessions usually involve 6 to 12 different exercises, and several sets of each are usually performed.
Number of Repetitions	❑ In general, the more repetitions an athlete does in a row, the lower the intensity.

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Variable	Key Points
Number of Sets	❑ In general, the lower the number of reps per set, the higher the number of sets should be, and vice versa. ❑ One or two sets of an exercise may be enough for beginners. But after 3 to 4 weeks of training, athletes should do 3 or more sets, as it promotes strength gains more efficiently. ❑ At a given relative intensity, e.g., 70% of 1 RM, smaller muscle groups (e.g., biceps) tend to recover faster than larger ones (e.g., quadriceps). It's therefore usually possible to do more sets for smaller muscles. ❑ Muscle groups not used much in daily activities (e.g., neck muscles) usually make significant gains even if only a few sets are performed. ❑ Athletes should do at most 30 to 36 sets per session. Some experts recommend a maximum of 20 to 25 sets. ❑ Training sessions should take approximately one hour or less, depending on the training objective.
Speed/ Tempo	❑ Speed/tempo is the pace at which an exercise is performed, and it is usually expressed as a 3-digit number. For example, 2-1-4 means: • 2 seconds for the concentric phase • 1-second pause after the concentric phase • 4 seconds for the eccentric phase ❑ When the resistance to overcome is high, speed of movement is generally slower. And when the resistance to overcome is low, speed of movement can be faster. ❑ Speed/tempo can have a significant effect on the adaptations that occur at the cellular and neuromuscular levels: • Training done at slower tempos but with greater resistance leads to increases in strength but has little effect on the rate of force development. • Training done with faster tempos but with less resistance significantly increases the rate of force development but does not yield large strength gains.
Recovery or Rest Interval	❑ In general, • The fewer the number of RMs in one set, the longer the rest period should be before the next set. • Short rest intervals tend to promote greater metabolic adaptations, while longer rest intervals promote neural adaptations. Adaptations depend on the training methods used, which should closely reflect the demands of the athlete's sport. • Reducing the rest interval between sets involving the same muscle group may involve the anaerobic lactic system more, at the expense of the alactic system. This is especially true when working in the 6 to 12 RM range.

Resistance-training Methods

There are many exercises athletes can do to improve maximum strength, speed-strength, and strength-endurance, and there are also different ways of ensuring that muscles work against an appropriate level of resistance.

The table below lists some of the advantages and disadvantages of the standard methods and equipment.

During training, resistance can come from…	This has the following advantages…	This has the following disadvantages…
Body-weight Exercises	❑ Very low cost ❑ Excellent for young athletes ❑ May simulate some sport movements ❑ Effective for developing strength-endurance	❑ Limited effect on development of maximum strength ❑ Hard to isolate specific muscles
Free Weights	❑ Wide range of overload possibilities ❑ Relatively low cost ❑ Greatest variety of movements ❑ Trains the stabilizing muscles ❑ Requires little space	❑ Initially requires more supervision ❑ Requires more technical instruction ❑ Training alone on some exercises can be dangerous ❑ Can be hard to isolate some muscles
Dynamic Strength (Tubing, Medicine Balls, Swiss Balls, etc.)	❑ Good for recovery from injury ❑ Excellent for developing speed-strength or strength-endurance, depending on the type of exercise ❑ May help simulate sport movements	❑ Produces unnatural resistance patterns
Machines	❑ Safe for beginners ❑ Requires minimal instruction ❑ Isolates specific muscles ❑ Requires minimal supervision or spotting ❑ Can create overload throughout a greater part of the range of movement	❑ Overloads stabilizer muscles minimally ❑ Some machines cannot accommodate very tall or very short individuals ❑ Available mainly in gyms ❑ High cost

Exercise Sequence

Four guidelines are commonly used to determine exercise sequence in a resistance-training session.

Approaches	Key Points
New Movements First	❑ New lifts, especially those with complex movements, should precede well-practised lifts. If an athlete is learning how to do a new exercise that is technically challenging, it is often better to practise these lifts when the body is less tired; it promotes the acquisition of the appropriate motor patterns. ❑ Athletes should do total-body exercises and those requiring balance and coordination at the start of their training sessions.
Multi-joint Exercises before Single-joint Exercises	❑ Multi-joint exercises such as the squat have higher skill, coordination, and balance requirements than single-joint exercises (e.g., leg extension). ❑ Doing multi-joint exercises first ensures that the synergist muscles and stabilizers that contribute to proper technique are less tired. ❑ This approach is useful for all athletes, and it is highly recommended for athletes with less resistance-training experience.
Large Muscles First	❑ Exercising the large muscles first ensures that the prime movers are overloaded

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Approaches	Key Points
	effectively. For example, working the forearms before doing chin-ups may weaken the grip and prevent the latissimus dorsi from receiving enough stimulation. ❑ The order generally recommended for exercising body parts is legs → back → chest → shoulders → upper arms → abdominals. ❑ When this approach is used, athletes do all sets at a single station with appropriate rest between sets.
Alternation of Body Parts	❑ This approach alternates exercises for the lower body, the upper body, and core muscles; that way, the same region doesn't work twice in a row, which promotes recovery. However, the athlete may find it quite demanding to alternate exercises involving large muscles (for example, thighs and upper back), given the generalized fatigue that may result. ❑ This approach is particularly suited for strength-endurance work.

Training for Different Types of Strength

The table below provides an overview of the general relationship among intensity, the number of repetitions and sets, and the adaptation that occurs when velocity of contraction is not emphasized during training.

Training Variable			Primary Adaptations/Improvements In:
Intensity (RMs)	**Approximate % of Maximum Strength***	**Number of Sets**	
1	100	6	Maximum strength (relative strength); neural drive; alactic power
2	95		
3	90		
4	88	5	Maximum strength (relative strength); neural drive; alactic capacity; some hypertrophy of fast-twitch fibres
5	85		
6 - 8	80 - 83	4	Optimal range of intensities to improve maximum strength through both enhanced neural activation and hypertrophy in fast- and slow-twitch muscle fibres; alactic capacity; lactic power
8 - 10	75 - 80	3 - 4	Optimal range of intensities to improve maximum strength through gains in muscle mass (hypertrophy in fast- and slow-twitch muscle fibres); lactic power and capacity
10 - 12	70 - 75		
15	65	3	Strength-endurance; some but limited hypertrophy, especially as the number of repetitions increases (mostly in slow-twitch and fast-twitch fibres); lactic power (especially with fewer repetitions) and lactic capacity (especially with higher numbers of repetitions)
20	60	2 - 3	
30	50	2	

* General guide only.

Recommended Values for Training Variables

The table below presents the recommended values for the training variables for maximum strength, speed-strength, and strength-endurance.

There are two types of maximum strength:

- *Absolute maximum strength*. This is the maximum force a muscle or muscle group can generate during a maximum voluntary contraction, regardless of body weight.
- *Relative maximum strength*. This is the maximum force a muscle or muscle group can generate during a maximum voluntary contraction, expressed per unit of body weight.

Variable	Maximum Strength		Speed-strength	Strength-endurance
	Absolute Strength	Relative Strength		
Intensity	60 - 80% of maximum strength	85 - 100% of maximum strength	❑ Starting strength: 30 - 40% of maximum strength ❑ Explosive strength: 60 - 80% of maximum strength	30 - 50% of maximum strength
Repetitions per Set	6 - 15	1 - 5	3 - 10	20 - 50
Sets	3 - 6	5 - 12	3 - 6	2 - 3
Tempo (seconds) **Concentric phase** **Eccentric phase**	Can vary* 2 - 3 3 - 4	Slow** 2 - 5 4 - 5	Explosive*** < 1 2 - 4	Constant 1 - 2 2 - 3
Recovery between Sets (min:s)	2:00 - 3:00	3:00 - 5:00	3:00 - 5:00 +	0:30 - 2:00
Training Sessions per Week	2 - 3	2 - 3	2 - 3	2 - 4
Key Words	Variety Volume Loading time	High loads Low volume Good recovery	Acceleration Low volume Complete recovery	Many reps Low intensity

* Total duration of a set should not exceed 60 seconds. Some advanced methods emphasize longer concentric contractions.

** Total duration of a set should not exceed 40 seconds.

*** Total duration of a set should not exceed 20 seconds; only the concentric contraction is done explosively.

Safety Guidelines

- Include a thorough warm-up and cool-down in every training session.
- Emphasize proper technique at all times, and stop an exercise when the quality of technical execution starts to break down. Pay particular attention to proper alignment of body segments during exercises.
- Using methods that are too advanced or loading patterns that are too intense can result in potentially serious injuries.
- In exercises with free weights, the barbells or dumbbells must be equally loaded.

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- Except for strength-endurance and speed-strength exercises done with low to moderate weights (50% or less of maximum strength), free-weight exercises require one or more spotters. This includes exercises where a bar:
  - Moves over the head
  - Is positioned on the back
  - Is racked at the front of the shoulders
  - Passes over the face
- Spotters should:
  - Ensure the lifting area is clear of objects and that the athlete can do the movements without being distracted or affected by the presence of others
  - Be at least as strong as the lifter
  - Use an alternated hand grip when holding a bar
  - Assume a straight back and stable position; it optimizes leverage
  - Spot at the wrists or dumbbells when this equipment is used
- Athletes training without spotters should use machines or reduce exercise intensity.

Programming Guidelines

- In an athlete's career, strength-training methods usually follow this progression:

  Strength-endurance methods ➔ hypertrophy methods ➔ the method of maximum weights ➔ speed-strength methods, including plyometrics
- The time spent emphasizing a training method depends on several factors, including the athlete's age and the sport's strength, power, and muscular-endurance demands.
- The proper application of the Individualization and Overload principles is critical to the effective and safe development of maximum relative strength and speed-strength. The development of those two athletic abilities must follow certain progressions and should start only when the athlete has reached late puberty and has at least 1.5 to 2 years of regular, uninterrupted training in other forms of resistance training.
- Training programs should initially have the same number of exercises for the lower body, upper body, and core. Core muscles, which include abdominal, spinal, and hip muscles, stabilize the spine and pelvis. When they have enough resistance-training background, athletes can do more sets of sport-specific exercises and follow a maintenance program for less sport-specific exercises.
- Increase resistance when athletes can do more than the target number of repetitions. This can occur fairly regularly, especially early in a program. For instance, increase resistance by one to three percent once the required number of RMs can be exceeded.
- Volume can be increased by:
  - Increasing the number of reps
  - Increasing the number of sets
  - Increasing the number of exercises

- Decreasing the speed of contraction (this increases the time the muscle is under tension)

- Include lots of variety in resistance-training programs — it keeps athletes interested, motivates them, and promotes continued gains and improvements. Variety can be achieved by changing such factors as intensity, speed of contraction, the exercises performed, training volume, exercise order, and training equipment.
- For sports where speed, power, and strength are critical performance factors, resistance training is usually performed throughout the program, including the Competition Period. For sports where speed, power, and strength are not as important, athletes should follow a maintenance program for resistance training during the Competition Period.

Sample Training Methods

Maximum Strength

Strength can be improved by working at intensities greater than 60% of 1 RM and by doing 1 to 15 repetitions in a set. When many repetitions are performed (10 or more), the term *extensive* is sometimes used to refer to the higher volume of work done against lower resistances. When fewer repetitions are performed in a set and intensity is closer to maximum strength, the term *intensive* is used.

This Variable…	**Has this value for developing strength mainly through hypertrophy and increases in muscle mass…**		**Has this value for developing strength mainly through increased neural drive…**
	Extensive Approach	***Intensive Approach***	
Number of Repetitions per Set (when using the RM method for intensity)	10 - 15	6 - 10	1 - 5
Intensity (when expressed relative to maximum strength)*	≈ 60 - 75% of maximum strength	≈ 75 - 85% of maximum strength	≈ 85 - 100% of maximum strength
Tempo (seconds) **Concentric phase** **Eccentric phase**	 2 - 3** 3 - 4		 2 - 5 4 - 5
Number of Sets	2 - 4	2 - 4	3 - 5
Recovery between Sets (min:s)	2:00	2:00 - 3:00	2:00 - 5:00
Training Sessions per Week	2 - 3		
Number of Weeks before Method is Varied	4 or 5 weeks	3 or 4 weeks	2 or 3 weeks

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This Variable…	Has this value for developing strength mainly through hypertrophy and increases in muscle mass…		Has this value for developing strength mainly through increased neural drive…
	Extensive Approach	***Intensive Approach***	
Main Adaptations	❑ Increase in absolute strength ❑ Hypertrophy of slow-twitch (Type I) muscle fibres ❑ Hypertrophy of intermediate (Type IIa) muscle fibres	❑ Increase in absolute strength ❑ Hypertrophy of intermediate (Type IIa) and fast-twitch (IIb or IIX) muscle fibres	❑ Increase in relative strength ❑ Some but limited hypertrophy of intermediate (Type IIa) and fast-twitch (IIb or IIX) muscle fibres

* May vary with muscle group and training status.

** Some advanced methods emphasize longer concentric contractions.

Note: Advanced methods using high-intensity eccentric contractions to improve maximum strength are not covered in this document.

Speed-strength

This Variable…	Has this value for developing and maintaining speed-strength…	
	Against Light Resistance	**Against Heavy Resistance**
Number of Repetitions per Set	5 - 10	3 - 5
Intensity	Use a resistance corresponding to 25 - 40% of maximum strength (1 RM) for the chosen exercise	Use a resistance corresponding to the 8 - 10 RM load for the chosen exercise
Tempo	Explosive right from the start of the movement; try to accelerate the load as fast as possible	Explosive right from the start of the movement; try to accelerate the load as fast as possible even if the actual movement doesn't occur at a fast speed.
Number of Sets	3 - 6	
Recovery between Sets (min:s)	Complete; 3:00 or more, as more recovery may be needed in later sets	Complete; 3:00 - 5:00 or more, as more recovery may be needed in later sets
Training Sessions per Week	2 - 3	
Number of Weeks before Method is Varied	3	
Main Adaptations	Increased power output through faster recruitment of motor units	Increased force through faster recruitment of motor units

Plyometric Training to Improve Speed-strength

Muscles that are stretched before a concentric contraction contract faster and generate more force: 15 - 20% more force at the beginning of a concentric contraction than muscles that aren't pre-stretched. This

is called the *stretch-shortening cycle*, or SSC. Plyometrics are essentially SSC exercises. They involve three steps:

- The muscle is stretched, often as a result of eccentric muscle action.
- There is a transition phase between the end of the muscle lengthening (or pre-stretch) and the beginning of the concentric contraction. *The shorter this transition phase, the more powerful the concentric muscle contraction will be.*
- The muscles contract concentrically; this produces the desired movement, such as a jump or a throw.

Given their fundamental characteristics, plyometric exercises are particularly effective in the development of speed-strength.

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Guidelines for Plyometric Training

Plyometric exercises make high demands of the musculoskeletal system, so certain precautions are needed. A few key cautions are outlined in the table below.

Area Requiring Caution	Key Points
Prerequisites	❑ Athletes shouldn't start systematic plyometric training until they've been involved in a general conditioning and resistance-training program for at least one full year ❑ Athletes shouldn't do demanding lower-body plyometric exercises until they can squat 1.5 times their own body weight ❑ Athletes shouldn't do demanding upper-body plyometric exercises until they can bench-press 1 to 1.5 times their own body weight ❑ A minimum level of balance is necessary: • Athletes shouldn't do low-intensity plyometric exercises until they can balance on one foot for at least 30 seconds • Athletes shouldn't do more intense plyometric exercises until they can balance on one foot in a semi-squat position for at least 30 seconds ❑ Athletes with little or no resistance-training background should introduce plyometric exercises very gradually and carefully; see the following table for key guidelines.
Type of Equipment and Landing Surface	❑ Athletes should use proper footwear, i.e., footwear with good ankle and arch support and a wide, anti-slip sole ❑ The landing surface must have adequate shock-absorbing characteristics: • Suitable surfaces include grass fields, padded artificial turf, suspended floors, and wrestling mats • Harder surfaces such as asphalt, concrete, tile, and hardwood are not recommended, and neither are thick shock-absorbing mats or trampolines ❑ Any boxes used must be solid and have a non-slip landing surface at the top
Exercise Intensity	❑ Exercise intensity is greater if: • One leg or one arm is used, as opposed to both • The start of the exercise involves impact; for instance, when athletes perform in-depth jumps (jumping off a box to the ground and quickly jumping up as high as possible), the intensity is very high, and the higher the box, the higher the intensity • The athlete carries additional weight (e.g., a weighted vest or a barbell) when doing movements that involve impact as an exercise starts • The athlete has some horizontal speed, as opposed to no speed, at the start of the exercise • Two or more of the above are combined
Progression of Volume and Intensity	❑ The progression should be from: • Low to higher volume at a given intensity • Low-intensity exercises to moderate-intensity exercises to higher intensity exercises
Athlete's Weight	❑ Athletes weighing 90 kg or more should: • Avoid high volumes of lower-body plyometric exercises (see below for general recommendations about volume in plyometric training programs)

Area Requiring Caution	Key Points
Jumping Height	❑ Assuming good landing technique and the use of an appropriate landing surface, the most likely cause of injuries in lower-body plyometric exercises is excessive jumping height ❑ In-depth-jumping heights between 50 and 110 cm seem to have the same effect on performance; athletes therefore shouldn't jump higher than 50 cm

Plyometric Training Must Be Introduced Gradually and Follow a Well-designed Progression

While all plyometric exercises rely on SSC, their specific characteristics have a direct effect on intensity and on the stress to the musculoskeletal system.

To increase effectiveness and reduce the risk of injury, a plyometric program should progress gradually from lower intensity drills to more advanced plyometric exercises — especially if athletes have a limited resistance-training background — and from lower to higher volume of contact times with the ground or throws for upper-body exercises with medicine balls.

The following table outlines general guidelines for loading parameters and the progressions to follow when using plyometrics.

Plyometric-training Variable	Athletes with Little or No Plyometric-training Background	Athletes with Some Resistance- and Plyometric-training Background	Athletes with Extensive Resistance- and Plyometric-training Background
Exercise intensity	Mostly low	Low and moderate	Low, moderate, and high
Example of exercises	Rope skipping; jumps with both legs; movements with both arms; movements initiated from the floor, not above it; movements with no prior horizontal momentum.	Some movements involving one limb, horizontal component, and limited vertical component (0.4 - 0.6 m).	All types of plyometric exercises, including in-depth jumping from heights of about 0.5 m*
Number of different lower-body exercises performed in a session (additional upper-body exercises can be included if relevant to the sport)**	2 - 3	3 - 4, all low intensity early in the program; then 2 low intensity, 2 moderate intensity	4 - 6, low and moderate intensity early in the program; then 1 - 2 low intensity; 2 - 4 high intensity
Number of reps of a given exercise per set	4 - 8	6 - 10	8 - 12
Number of sets of a given exercise	2	2 - 3	2 - 3
Recovery time between sets	10 to 15 times the time it takes to complete the set Plyometric training sessions must not be viewed as conditioning sessions, and recovery must be long enough for the athlete to do high-intensity and high-velocity contractions in the exercises		

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Plyometric-training Variable	Athletes with Little or No Plyometric-training Background	Athletes with Some Resistance- and Plyometric-training Background	Athletes with Extensive Resistance- and Plyometric-training Background
Total volume of training per session (e.g., number of contacts with the ground or throws)**	Early in the program: 40 - 60	Early in the program: 60 - 80	Early in the program: 80 - 100
	Mid-part of the program: 60 - 80	Mid-part of the program: 80 - 100	Mid-part of the program: 100 - 120
	Latter part of the program: 80 - 100	Latter part of the program: 100 – 120 +	Latter part of the program: 120 – 140 +
Training sessions per week	1 - 2	2	2 - 3
Recovery between sessions	A minimum of 48, and up to 72 hours, between sessions Athletes should be fresh at the beginning of each plyometric training session Plyometric training should not take place the same day as or the day following a heavy resistance-training session, as muscles may still be sore; as a solution to the potential planning issues this may create in the program of some athletes, heavy resistance-training sessions for the upper body and low-intensity plyometrics sessions for the lower body can be scheduled for the same day, and vice versa, to achieve the desired number of sessions during a week		
Program duration	8 - 12 weeks of development, then one session a week for maintenance		

* Some studies have measured vertical jump performance following training at different in-depth jump heights (50, 75, 80, and 110 cm). Similar results were observed for jumps of 75 cm and 110 cm and for jumps of 50 cm and 100 cm. The training benefits of jumping from heights above 50 cm seem limited, given the higher risk of injury as height increases.

** General guideline only; may be lower.

Strength-endurance

This Variable…	Has this value for developing and maintaining strength-endurance
Number of Repetitions per Set When Using the RM Method for Intensity	20 - 50
Intensity Expressed relative to Maximum Strength*	30 - 50% + of maximum strength
Tempo	Regular and controlled, e.g., 2-1-2 or 2-1-3
Number of Sets	2 or more
Recovery between Sets (min:s)	0:30 - 2:00
Training Sessions per Week	2 - 4
Number of Weeks before Method is Varied	2 - 3 weeks

This Variable…	Has this value for developing and maintaining strength-endurance
Main Adaptations	❑ Some but limited hypertrophy of slow (Type I) and intermediate (Type IIa) muscle fibres ❑ Improved anaerobic lactic endurance

***** May vary with muscle group and training status.

Circuit Training to Improve Strength-endurance and Base Strength

Circuit training or circuit weight training is a conditioning approach in which the athlete completes stations of exercises with his or her own body weight (push-ups, sit-ups, jumping jacks, squat thrusts, chin-ups, dips, etc.) or resistance-training equipment such as free weights or machines. Other forms of exercise can also be included, such as stretching, running, bicycling, and rope skipping. Successive stations are arranged close to one another. Athletes usually exercise different muscle groups at each station, which allows some recovery to occur.

Who Should Use Circuit Training?

Circuit training can be used with beginners to improve strength-endurance or to introduce them to resistance training. In the latter case, the main benefits are:

- ❑ Learning to execute specific resistance-training movements and exercises with proper form using relatively low weights
- ❑ Developing a level of base strength and inducing some adaptations in the musculoskeletal system that prepare the athlete to sustain the stress of higher loads

Circuit training is also a good way of introducing children to resistance training.

However, if athletes have a resistance-training background, the effectiveness of circuit weight training may be limited.

The table below outlines the general features of a circuit weight training.

Circuit-training Variable	Key Points
Number of Stations	May vary, but is usually between 6 and 15.
Exercise Intensity	In exercises using resistance-training equipment, intensity is normally set at 30 - 40% of maximum strength for beginners, at 40 - 60% of maximum strength for more experienced athletes.
Activities at a Station	In stations where resistance-training exercises are performed, athletes perform a fixed set of repetitions (12 - 15) at a regular cadence OR work non-stop and try to perform as many reps of the exercise as possible in a designated time period (e.g., 30 or 45 seconds). However, the movements are not executed explosively, as they would be in speed-strength training.
Recovery between Stations	Rest intervals between stations can be in the order of 60 - 90 seconds OR kept to a minimum (15 - 20 seconds or so). In the latter case, the athlete normally walks or jogs from one station to the next; this promotes near-continuous effort throughout the circuit and therefore leads to some aerobic adaptations.

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Circuit-training Variable	Key Points
Completion of a Circuit and Circuit Duration	A circuit is completed once the athlete has performed the exercises at all the stations. The time to complete a circuit depends on the type of exercises, as well as the number of exercises; however, a circuit normally takes 5 - 15 minutes to complete.
Number of Circuits	The number of circuits depends on the time available, training objectives, and the athlete's fitness level. Athletes usually complete 2 or 3 circuits, but they may do as many as 5 if there are fewer stations in a circuit.
Recovery between Circuits	The rest period between each circuit can be short (1 or 2 minutes) or long (3 - 5 minutes).

Guidelines for Adolescents or Adults with Little or No Background in Resistance Training

Consider the following when designing resistance-training programs for adolescents and adults who have little or no background in resistance training or who haven't been involved in such training for a long time:

- In an athlete's career, strength-training methods usually follow this progression:

  Strength-endurance methods ➔ hypertrophy methods ➔ the method of maximum weights ➔ speed-strength methods, including plyometrics

- The time spent emphasizing a training method depends on several factors, including the athlete's age and the sport's strength, power, and muscular-endurance demands.
- Regardless of the sport's demands, athletes should have a good resistance-training background before using the method of maximum weights and specific speed-strength methods. A long-term view about the development of relative strength and speed-strength is therefore essential.
- The premature use of advanced methods or of intense loading patterns can cause injuries, as well as delay or prevent the achievement of the desired performance level.
- Athletes new to resistance training should start with body-weight exercises and progress to free weights. During the first year of resistance training,
  - Focus on general development
  - Expose athletes to a variety of exercises and training methods
  - Avoid training programs that are too specific
  - *Do not use advanced methods* such as maximum weights for relative strength, speed-strength, and plyometrics.
- At the start of a resistance-training program using free weights or machines, focus on strength-endurance for several weeks, especially with adolescents.
- Circuit weight training can be an effective introduction to resistance training for adolescents. It allows athletes to use low to moderate resistance and to focus on proper technique on each repetition.
- After a basic introductory phase and several weeks of strength-endurance training, athletes can move on to a more intense phase and work on the development of maximal strength (see

below). This requires an appropriate transition in loading and intensity between the end of the strength-endurance phase and the start of maximal strength training.

- Beginners can make similar strength gains with a variety of training methods. For instance, athletes with no resistance-training background have made comparable improvements in maximum strength using intensities ranging from 5 to 10 RMs. To ensure safety and proper progression, use loading patterns that range from 8 to 12 RMs, with 8 RMs representing the highest intensity.
- Discourage competition in general and competition among teenage boys in particular — they like to show how strong they are. Resistance training should be viewed as an individual activity.
- Because of the rapid strength gains that usually occur at the start of a resistance-training program, adjust loads as necessary to ensure that athletes do the required number of RMs.
- Initially, a training frequency of twice a week (every 3 days or so) should be adequate.
- Training frequency can be increased to 3 sessions a week after several weeks of training. Given the same volume of work, three shorter sessions a week are generally more effective than two longer ones with beginners. Daily training is also an option, but one session should focus on the upper body, the next on the lower body.
- With beginners, the order of exercises should be such that the body parts alternate (e.g., lower body, core, upper body). This makes athletes feel less tired, promotes proper technique, and allows them to complete the entire workout.
- With beginners, increase only one variable at a time (e.g., number of reps or number of sets) when adjusting loading parameters or varying the program.

Guidelines for More Advanced Athletes with a Good Background in Resistance Training

- A greater proportion of training time can be spent on sport-specific muscle groups and on exercises specific to the types of movements and contractions used in competition.
- Strength can be trained using intensities corresponding to 85% or more of maximum strength, i.e., RMs in the range of 6 and less.
- Speed-strength can be trained with weights and low-intensity plyometrics initially, and a progression to more intense plyometric exercises can take place later in the program (see specific guidelines regarding the implementation of plyometrics programs).
- Resistance training can be systematically periodized in the athlete's annual program. In general, the use of resistance-training methods in the annual program can follow this general progression:

  Strength-endurance methods ➔ hypertrophy methods ➔ the method of maximum weights ➔ speed-strength methods, including plyometrics

- The optimal duration and sequence of each phase of a resistance-training program varies with the demands of the sport and the athlete's position. Consult sport-specific guidelines for long-term athlete development (LTAD) for more details in this regard. In general:
  - The number of weeks focusing on general strength and strength-endurance at the start of the Preparation Period can be shortened to 3 to 5 or so, especially if the athlete followed a maintenance program for resistance training in the Competition Period.

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- Vary the training variables regularly to promote continued progression; it is possible to change 2 or 3 training variables at the same time (see the table below for an example).
- Periodization of strength training for more advanced athletes typically involves alternating cycles of accumulation (a few weeks where the athlete works in the range of 8 to 12 RMs and total volume is relatively high) and intensification (a few weeks where the athlete works in the range of 1 to 5 RMs and total volume is lower because of the higher intensity). The first accumulation cycle can be 2 or 3 weeks long, with subsequent ones only one week long. Intensification cycles are two weeks long. This adds variety to the resistance-training program; it is also a sound approach to preventing overtraining and reducing the risk of injury to the joints when training relative strength. This cyclical approach can also be used for training speed-strength. The table below provides an example of how to alternate accumulation and intensification cycles to improve relative strength.

Training Variable	Training Week and Cycle					
	Weeks 1-2 Accumulation	Weeks 3-4 Intensification	Week 5 Accumulation	Weeks 6-7 Intensification	Week 8 Accumulation	Weeks 9-10 Intensification
RMs	8 - 12	4 - 6	10 - 12	2 - 4	8	1 - 3
Number of Sets	4	5	3	6	4	8
Recovery/Set	3 min	5 min	1 min	5 min	2 min	5 min
Tempo of Contractions (seconds)	3C*/3E*	4C/5E	2C/3E	2C/4E	2C/5E	1C/4E
Total Number of Reps	32 - 48	20 - 30	30 - 36	12 - 24	32	8 - 24

C: Time to perform a concentric contraction

E: Time to perform an eccentric contraction

- ❑ The frequency of training can be 3 times or more per week, and split routines (see following table) may be planned to reflect the higher volume of work in each session.
- ❑ Athletes with a good resistance-training background can add some creativity and variety to their resistance-training routines while still respecting the principles and guidelines outlined in this document. Some commonly used approaches for doing this are presented below.

Advanced Approach	This Approach Consists of…
Super Setting	❑ Alternating exercises for the agonist and antagonist muscles at a joint. ❑ This is more demanding than alternating the body parts exercised, as the same body part works twice in a row. It is therefore better suited to well-conditioned athletes than to beginners. ❑ To save time during a workout, athletes can pair exercises that involve the same joint.
Compound Sets	❑ Performing two different exercises for the same muscle group in a row, with limited or no recovery in between (e.g., leg press and leg extension, curls with dumbbells followed by biceps curls with a barbell). ❑ This is more demanding than super setting, which consists of alternating exercises for the agonist and antagonist muscles at a joint.
Pre-exhaustion	❑ Performing a single-joint exercise before a multi-joint exercise involving the same muscle groups. The single-joint exercise induces some fatigue, thus making the multi-joint exercise more demanding. ❑ Examples include performing dips before bench pressing and performing leg curls or leg extensions before squatting. ❑ This approach can be used when multiple-joint exercises alone are not providing sufficient stimulation to the targeted muscles.
Pyramids	❑ Performing a few consecutive sets of the same exercise with limited rest between each set, starting with several reps at relatively low intensity (e.g., 15 reps at 50% of 1 RM) and then increasing the load and decreasing the number of reps in subsequent sets (e.g., 7 reps at 80% of 1 RM, 5 reps at 85% of 1 RM, 3 reps at 90% of 1 RM). ❑ This is a form of pre-exhaustion. ❑ Spotters must be present when this type of work is done, as athletes may become exhausted in the higher intensity sets.
Partial Repetitions	❑ Performing an exercise over only parts of the range of motion (e.g., quarter or half movements) after reaching a point of failure in the full range of motion because of fatigue.
Forced Repetitions	❑ Completing a set of a given number of RMs (e.g., 10 RMs) and then, at the point of fatigue, performing 2 or 3 more reps with the help of a partner.
Negative Repetitions	❑ Completing a set of a given number of RMs (e.g., 10 RMs) and then, at the point of fatigue, performing 2 or 3 more reps of the concentric phase of the exercise with the help of a partner *while controlling the eccentric phase by oneself*.
Super-slow Repetitions	❑ Performing each repetition at a very slow tempo (for instance, 5 to 10 seconds as opposed to 2 or 3); this can apply to the concentric or eccentric phase or both. ❑ This increases the time during which the muscles are loaded, both from a metabolic and from a neural point of view. ❑ This approach is useful mainly when developing maximum strength. ❑ It is generally recommended that sets should be completed within 60 seconds.
Consecutive Sets to Failure	❑ Completing a set of a given number of RMs (e.g., 10 RMs) and then, at the fatigue point, reducing the weight and going again to failure. This can be repeated up to 4 or 5 times. ❑ An appropriate recovery period is essential, as the muscles get very fatigued.

Advanced Approach	This Approach Consists of…
Split Routines	❑ Focusing on specific body parts during one session (e.g., upper body) and focusing on other body parts (e.g., lower body) the next day. ❑ This is particularly useful for well-trained athletes whose sport requires large volumes of resistance training, once the number of sets in a session exceeds 30 to 36.

Flexibility Training

Key Words

- ❑ Warm muscles
- ❑ Controlled stretching
- ❑ Large range of movement
- ❑ No pain

Guidelines

Variable	Key points…
Type of training	❑ Individually or with the assistance of a partner
Activities/ movements	❑ Reaching the limit of the range of motion under control and with no pain ❑ Stretching the muscles and connective tissues
Intensity	❑ Performed so that some tension is felt in the muscle being stretched, but no pain
Duration of each repetition	❑ Varies with the type of stretching: • Up to 30 seconds or more for static stretching • Up to 20 seconds for active stretching • Up to 15 seconds for assisted stretching using the proprioceptive neuromuscular facilitation (PNF) method (see page 43)
Number of repetitions	❑ At least one exercise for each of the major muscle groups ❑ Where applicable, do the exercise on both the right and the left sides of the body ❑ 3 to 4 repetitions of each exercise, using the same kind of stretching (passive, active, etc.) for all reps
Duration of recovery between repetitions	❑ A few seconds
Duration of recovery between sets	❑ Optional; relatively short
Type of recovery	❑ Passive, or gentle, relaxed movements
Position in training session	❑ Stretching should *follow* a vigorous general warm-up: • Do moderately intense aerobic activity lasting at least 10 to 15 minutes; this can vary, depending on the time it takes to elevate the temperature of the muscles and connective tissue, especially in a hot or cold environment • Use the muscle groups that will be stretched • Be sweating by the time flexibility training starts

Variable	Key points…
	❑ Do static stretching exercises first, then active stretching exercises, then assisted stretching exercises, and finally dynamic stretching exercises ❑ Within a session, move from the general (major joints) to the specific (sport-specific joints and ranges of motion) ❑ Do specific flexibility training late in the session, when the muscles are warm
Safety considerations	❑ Stretch muscles only when they're warm ❑ Avoid jerky movements when doing stretching exercises ❑ Keep muscle stretching under control at all times ❑ If any pain occurs while stretching, slowly decrease the intensity of the stretch ❑ Breathe slowly and stay relaxed when stretching ❑ Stretching must be viewed as an individual activity; don't compete against one another when doing flexibility training ❑ Partners who assist in flexibility training must apply force slowly and in a controlled manner
Position in training program	❑ Focus on static stretching first ❑ After a few sessions of static stretching, start extending the stretch slightly beyond the limit of the range of motion; for example, if trying to touch the toes, grasp the ankles to pull the body a bit closer to the toes ❑ Then introduce active stretching, assisted stretching, and dynamic stretching — in that order ❑ Three to five sessions a week

Types of Stretching

The demands of the sport and the position the athlete plays are key factors in determining the flexibility the athlete needs.

To improve flexibility, muscle fibres and connective tissue must be *stretched*. The table on the following pages describes the five main types of stretching used in flexibility training:

- ❑ Static stretching
- ❑ Active stretching
- ❑ Assisted stretching
- ❑ Dynamic stretching
- ❑ Ballistic stretching

Each type of stretching is based on one or more of these facts:

- ❑ Flexibility increases when muscle tension is reduced.
- ❑ Flexibility increases when force is applied to increase range of movement.
- ❑ Flexibility is specific to a joint. It can vary from joint to joint and with the direction of movement. For example, an athlete could have good shoulder flexibility but poor trunk flexibility.

- The range of motion at a joint can be limited by bone or soft tissue. Soft tissue includes ligaments, tendons, cartilage, joint capsules, and muscle.
- Flexibility increases when connective tissue — muscle sheath and tendon — is lengthened. By contrast, flexibility decreases when connective tissue is shortened; for example, even a few days in a cast can cause connective tissue to shorten and resist stretching.

Types of Stretching Used in Flexibility Training

Type of Stretching	Description	Examples	Notes
Static Stretching	❑ Get into the starting position for the stretching exercise ❑ Assume the stretched position slowly and in a controlled manner; at this point, the muscles are stretched only slightly ❑ Increase the intensity of the stretch progressively and in a controlled manner until the limit of the range of motion is reached; at this point, some tension is felt, but no pain ❑ Hold the position for 20 to 30 seconds, more if possible ❑ At the end of the stretch, release the tension slowly, and get into the starting position again ❑ Stay relaxed, and breathe normally throughout ❑ Repeat 2 to 4 times ❑ If applicable, repeat the stretch for the other side of the body	❑ Sitting toe touch performed slowly ❑ Hold one leg in front of the body, rest it on a chair, and stretch the hamstrings	❑ Apply light force throughout the stretch ❑ When the limit of the range of motion is reached, the muscles opposing those being elongated do not contract to allow the stretch to increase further ❑ Don't use bouncing movements at the end of the stretch ❑ If pain occurs during the stretch, slowly decrease the intensity of the stretch ❑ Static stretching: • Is easy to learn • Produces little soreness • Has a generally low risk of injury • Doesn't trigger the myotatic stretch reflex
Active Stretching	❑ The steps involved in active stretching are very much like those for static stretching, except that the athlete's own force is used to move the body part to be stretched and brings it into the appropriate stretching position ❑ Stretch in a controlled manner ❑ Hold the stretch position for 10 to 20 seconds ❑ Repeat 2 to 4 times ❑ If applicable, repeat the stretch for the other side of the body	❑ Stand on one leg, lift the other leg out in front of the body as high as possible, and twist from side to side	❑ Active stretching doesn't trigger the myotatic stretch reflex ❑ Static stretching is preferable when the elasticity of the muscles being stretched (agonists) restricts flexibility ❑ Active stretching is preferable when the weakness of the muscles being stretched (agonists) restricts flexibility

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Type of Stretching	Description	Examples	Notes
Assisted Stretching	❑ Assistance may come from self-applied force, from a partner, or from a device (e.g., a towel or rubber tubing)	❑ Wrestling moves ❑ Partner-assisted movements where the partner puts pressure on a limb	❑ Assisted stretching: • Involves a greater range of motion than in other types of stretching • Is very effective at increasing the range of motion • Can lead to some muscle soreness and stiffness ❑ Stretch to as full a range as possible before getting extra stretch from either self-applied force or force from a partner
	Assisted Stretching with Self-applied Force ❑ Apply force in static or active stretching to increase range of motion ❑ For instance, when stretching the neck, lean the head to the side, and use the hand to apply some force to increase the range of the stretch		❑ Apply force slowly and in a controlled manner
	Assisted Stretching with Force from a Partner ❑ The dominant form of assisted stretching with force from a partner is proprioceptive neuromuscular facilitation (PNF) ❑ The following variant of PNF is called contract-relax PNF technique: • Perform a slow, controlled, and holding stretch where the limb reaches the limit of its range of motion  • Have a partner assume a stable position that enables him or her to provide resistance against the limb being stretched • At a signal from the partner (e.g., "push"), perform a 3-to-4-second progressive isometric contraction against the resistance provided by the partner; the tension in the muscle(s) previously stretched increases gradually, but no 		❑ The effect of the inverse myotatic reflex makes it possible to increase the range of motion after the isometric contraction ❑ There should be at least 48 hours between PNF stretching routines ❑ Do only one exercise per muscle group ❑ PNF stretching is not recommended for children or adolescents ❑ If PNF stretching is a separate exercise session, do it AFTER a thorough warm-up consisting of at least 10 minutes of light aerobic exercise and some static and

Type of Stretching	Description	Examples	Notes
	movement occurs • Follow this progressive contraction with a near-maximal isometric contraction lasting about 5 seconds • The partner must not allow the limb whose muscles are being stretched to move. • At the end of the isometric contraction, relax the muscle(s) for 3 to 4 seconds (the partner may signal the start of the relaxation period) • The partner applies controlled force to passively increase the degree of the stretch • Hold the new stretching position for 10 to 15 seconds • Repeat 2 to 5 times from the starting position ❑ A variant of contract-relax PNF called contract-relax antagonist-contract PNF differs only slightly from contract-relax PNF: • Follow the steps for contract-relax PNF up to and including the 3-to-4-second relaxation period • *While the partner applies force to the limb and increases the stretch*, perform a submaximal concentric contraction with the muscles that work opposite the ones being stretched • Hold the new stretching position for 10 to 15 seconds • Repeat 2 to 5 times from the starting position		dynamic stretches ❑ Partners must always apply force slowly and in a controlled manner ❑ Partners must assume a stable position that enables them to resist the force generated during the isometric contraction
Dynamic Stretching	❑ Start with a thorough warm-up and appropriate static and active stretching exercises ❑ Then do sport-specific movements in sets of 8 to 12 repetitions ❑ Do movements slowly at first (e.g., half speed), and progress to faster movements ❑ As movements get faster, the range of motion increases ❑ A few sets may be necessary to reach the full range of motion ❑ Stop if any signs of fatigue appear or form deteriorates	❑ Leg action that mimics kicking a ball (soccer player) ❑ High knee raises, with an emphasis on knee height and arm action (sprinter)	❑ Triggers the myotatic stretch reflex and must therefore be performed with caution ❑ Potentially hazardous if done incorrectly ❑ Initially, coaches should supervise this type of stretching to ensure correct form and appropriate intensity

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Type of Stretching	Description	Examples	Notes
Ballistic Stretching	❑ Use rapid movements that involve high forces (e.g., crouching, bouncing, pulling) to stretch muscles and other connective tissue	❑ Sitting, with a bar on the shoulders, and twisting rapidly from side to side ❑ A series of very fast toe touches followed by a return to the standing position	❑ The momentum caused by the rapid movements is used to increase muscles' range of motion ❑ The forces involved can be high and may not be under control ❑ Evokes the *myotatic stretch reflex* ❑ May cause more soreness than other types of stretching ❑ Higher risk of injury than in other types of stretching ❑ Not recommended for beginning or developing athletes[4]

[4] Specific aspects of ballistic stretching may be dealt with in sport-specific or in other multi-sport workshops.

Other Considerations

- Before planning a flexibility program, identify the muscle groups and movement patterns that require flexibility training. Use the sport-specific movements required, including the extreme body positions, as the baseline for analyzing the athlete's current flexibility level and the improvement needed.
- Many exercises can help athletes improve their flexibility, and there are often several variations of the same exercise.
- Most exercises can be executed using more than one stretching method (passive, active, etc.).
- To maximize gains, establish specific times outside the regular training sessions, warm-up, and cool-down for flexibility training. If time restrictions apply, schedule activities designed to improve flexibility for the end of a session, not the warm-up.
- Athletes can do several flexibility training sessions a day. For instance, one flexibility session can take place at the end of a morning workout, a second one later in the day.
- To build strength at vulnerable, stretched-out positions, perform static (isometric) contractions, and hold them for three to five seconds.
- Varying flexibility training can help athletes adhere to the program. Vary the types of stretches, exercises, and equipment used (towels, resistance balls, etc.) to add variety and effectiveness to the program.
- Athletes can significantly *increase* flexibility in about 12 weeks. In many cases, athletes can *maintain* (or even improve) flexibility through sport-specific training, as it develops patterns of joint flexibility unique to that sport. For example, swimmers develop flexibility in their shoulders as they train. Nevertheless, once athletes have achieved adequate flexibility through a stretching program, they should do one flexibility-specific training session per week.
- Unlike the other athletic abilities, which all deal with energy systems, flexibility is concerned with bone and soft tissue. Soft tissue includes ligaments, tendons, cartilage, joint capsules, and muscle.

Motor Abilities Training

Limited information is available on optimal training frequency or the minimum amount of time needed to create a training response for athletic abilities such as agility, balance, and coordination.

These abilities are probably best developed through sport-specific drills, as they have a large neuromuscular component. They should also be emphasized during the early part of the athlete's preparation, i.e., during the General Preparation Phase and the Specific Preparation Phase of the sport program.

Motor abilities can be trained on their own or as components in programs designed to train strength, speed, flexibility, and aerobic capacity.

Agility

Agility is the ability to execute movements or to move rapidly, with precision, and with ease. As such, it requires balance and coordination (see the following sections) and depends on the rate at which energy can be provided to the working muscles to meet the demands of the task.

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An improvement in an athlete's agility is the end result of a well-balanced program, i.e., one that effectively combines training for the energy systems, strength, and flexibility; specific technical preparation; and general motor development.

Activities that have the following characteristics should be used in the development of agility:

- Movements performed at high speed
- Changes in direction while moving at high speed
- Accelerations while changing direction
- Sudden stops, followed by a quick start to the right or the left
- Sport-specific drills that require the athlete to move from side to side while performing a task, to jump and quickly move laterally on landing, to jump and sprint forward on landing, etc.
- Drills that require the athlete to perform several times in a row and at quick intervals a sport-specific task that involves moving the entire body, even though this task is not normally performed at this rate in competition

Balance

- To improve balance, perform activities where:
  - Difficult or unusual positions must be assumed and maintained

    OR
  - Normal movements are performed in unusual positions

    OR
  - Balance is challenged by external factors or an effort is required to maintain balance
- Although their primary focus is slightly different, some coordination or general motor-development activities may contribute to the development of balance.
- The use of large exercise balls (stability balls) can present interesting motor challenges and help athletes improve their balance. Incorporating such balls into simple activities such as sitting or trying to maintain a horizontal body position makes the activities much harder. Appropriate safety measures must be taken when using these balls.
- To improve static balance and stability, athletes must lower their centre of gravity (e.g., bend the knees), make the base of support larger (e.g., widen their stance), increase the number of contact points on the ground (e.g., put one hand on the ground), and ensure the weight is evenly distributed on each contact point.

Coordination

- To improve coordination, activities must involve a sequence of actions that are to be performed in a given order.
- The level of difficulty of activities that develop coordination depends mainly on the number of movements that must be performed in a row. Beginners and children should do activities that involve only two or three activities in a row.

- Coordination activities can involve general or sport-specific movements, depending on the goal. Young children should focus on general coordination activities.
- Athletes must master basic motor patterns before they try more complex sequences. For instance, athletes must be able to control basic motor patterns such as running, throwing, and catching before trying activities requiring more advanced coordination.
- Movement sequences can be designed for specific body parts (e.g., arms only), for several body parts at a time, or for the entire body. Coordination activities can also take the form of agility games (e.g., follow the leader).
- Athletes must perform movements correctly, as the neuromuscular system learns the motor patterns athletes *actually perform*. This is why it's important to start with movements at low speed or intensity and to *progress* to full speed.
- It's a good idea to create conditions that require athletes to perform movements in various directions or to use their weaker side.
- Activities can be made more challenging by adding these variations gradually, after the basic sequence has been mastered:
  - Increase the speed of execution
  - Add new movements
  - Modify the order in which movements are performed
  - Combine various actions already mastered, but perform them in an unusual manner (e.g., dribble the ball while squatting or running in the snow)
  - Add restrictions (e.g., less time, less space, less stable environment)
  - Add uncertainty (e.g., perform the action with the eyes shut)
- Activities specifically used to enhance coordination should be performed before tiredness sets in.
- It's better to do short training sessions for motor abilities more often than to do longer sessions less often. For example, two 5-minute sessions four times a week are likely to be more effective for motor learning than one 40-minute session once a week.

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12 PAK OF PERFORMANCE AND PREVENTION

This section identifies and describes how to perform 12 movement patterns. The 12 PAK is a group of movement patterns that, taken together, improve body control.

Body control is the basis of almost every sport skill, and the movement patterns that correspond to sport skills should be trained in the training phase BEFORE the skills are trained. Similarly, dynamic warm-ups in a practice should include the movement patterns that will be used in the sport skills that form the main part of the practice.

This 12 PAK of performance and prevention will improve sport performance and reduce the incidence of injury. In general, these movement patterns help athletes gain more control over their bodies, generate more power, and reduce the number of repetitions of skill training needed to perform at a higher level. In particular, these movement patterns:

- Help muscles protect joints from injury through improved proprioception
- Help muscles control the movement pattern of the leg when landing or accelerating
- Help the muscles of the body's core (lower back, abdomen, and hips) limit sway when skills are performed
- Help athletes improve balance and stability
- Help athletes improve their technique in sport-specific skills

Why 12? There's no magic to the number 12. There could have been 11, and there could have been 13 or more. For example, FIFA has developed a group of exercises called *The 11* for soccer (available at http://www.fifa.com/aboutfifa/developing/medical/the11/). The point is to improve body control, and these 12 movement patterns do it.

Variations? There are lots of variations of each movement pattern that would achieve similar body control. Coaches who have successfully used other movement patterns should share them with the other coaches in their group.

Progression? The 12 PAK was designed for athletes at the Train to Train and the Train to Compete developmental stages. If an athlete has trouble controlling a movement pattern, one option is to choose an easier version of the movement pattern. For example, with Dynamic One-foot Landing (12 PAK pattern #1), the athlete could follow this progression:

1. Standing in the landing position
2. Stepping into the landing position
3. Dynamic one-foot landing

Caution: As with all movement patterns or sport skills, athletes with growth-related injuries such as Osgood Schlatter's Disease or Little League Elbow may have to alter or omit movement patterns that aggravate the injury until the condition is resolved.

12 PAK Terminology

The table below defines the movement terms used in the descriptions of the 12 PAK on pages 52 through 63.

Movement Term	What the Term Means…
Proprioception	❑ *Proprioception* refers to reaction time in response to a change in joint position. This ability to sense the location, position, orientation, and movement of the body and its joints allows the muscles to be called into play. The muscles can then prevent the body from getting into positions associated with greater risk of injury.
Kinesthetic Awareness	❑ *Kinesthetic awareness* is the ability to know where your body parts are in three-dimensional space.
Proprioception/ Kinesthetic Awareness Training	❑ This training is common in the rehabilitation of injured athletes, but it is also effective in preventing joint injury. ❑ For example, an ankle can sprain when an athlete runs on uneven ground if the muscles aren't trained to react appropriately to the rough ground. Slight deviations in terrain require slight adjustments of balance to avoid injury. The movement patterns included in the 12 PAK are designed to prevent these injuries. The movement patterns may be done with the eyes open or closed.
Balance Training	❑ Why does balance matter? It's a basic skill needed in practically every sport. From soccer to tennis to rock climbing, changing the centre of gravity to match body moves is the key to efficiency in sport. ❑ Balance training improves proprioception and kinesthetic awareness. Balance also gets better, and the risk of injury decreases.
The Role of Muscle in Protecting Joints (ligaments)	❑ When joints start to move through a dangerous range of motion, muscles trained through balance training respond by contracting to control the range of motion.
Sway Reduction	❑ *Sway reduction* refers to reducing the back-and-forth or side-to-side movements that often occur during skill acquisition.
Core Stability	❑ *Core stability* is the ability of the lower back and hip to control abnormal sway and to return to normal from abnormal positions. ❑ Stability is achieved through muscle training.

Observing and Training the 12 PAK

Look for:

- ❑ Control of balance
- ❑ Absence of ankle wobble
- ❑ Limited knee sway
- ❑ Hips parallel to the floor
- ❑ Shoulders parallel to the floor
- ❑ Limited sway of the spine line
- ❑ Head looking straight ahead

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- Equal contribution to movement from the right and left side
- Controlled deceleration or landing — it's just as important as acceleration

When training the 12 PAK, work to minimize errors in movement. One effective approach is to start with the core (spine line), work down to the foot, and then work up to the head.

When teaching sport skills, use the Coaching Focus sections of the 12 PAK descriptions to provide feedback on skill execution.

1. Dynamic One-foot Landing

Performance Enhancement	Injuries Prevented
❑ Improves stability, balance, proprioception, and kinesthetic awareness ❑ Reduces unnecessary movements during sport performance, making performance more efficient	❑ Ankle sprains ❑ Chronic knee injuries, including patello-femoral syndrome and chondromalacia ❑ Anterior cruciate ligament (ACL) sprains ❑ Other ankle, knee, hip, and trunk injuries
Starting Position	**Description of Movement**
❑ Stand with the feet shoulder width apart, chest and eyes facing forward	❑ Jump forward and land on one foot ❑ Hold the landing position for a minimum of 3 seconds ❑ Repeat 10 times ❑ **Note:** If the lateral rotators of the hip do not fire immediately, the hip, knee, ankle, and foot will cave in medially; this results in lost power and invites chronic injury to one or more of the above joints
Coaching Focus	**Progression**
❑ Limit sway at all joints from the core down to the foot (hip, knee, and ankle) ❑ Identify weak links by looking for excessive sway at specific joints ❑ Limit side-to-side movement at the knee, and keep the hips level ❑ Stand tall through the trunk	❑ Increase the distance jumped ❑ Increase the height jumped ❑ Land after stepping down from a step (start step height at 15 cm and progress) ❑ Think about sport specificity when developing progressions; for example basketball players benefit from landing from a height, whereas runners might benefit from more horizontal progressions
  	

2. Walking Lunges

Performance Enhancement	Injuries Prevented
❑ Improves the strength of the push-off when running or jumping ❑ Can contribute to better control and efficiency during the push-off phase of running or jumping	❑ ACL sprains ❑ Hamstring strains ❑ Chronic knee injuries, including patello-femoral syndrome, chondromalacia, and jumper's knee ❑ Other hip, knee, and core injuries
Starting Position	**Description of Movement**
❑ Stand with good posture and the feet shoulder width apart	❑ Take a long step forward ❑ Drop the back knee toward the ground (until it's about 2.5 cm above the ground) ❑ Pull yourself forward onto the front leg, thinking about the front leg doing the work rather than pushing off with the back leg ❑ Repeat the movement with the other foot; as the motion becomes more fluid, it will look like walking with long, deep, exaggerated strides ❑ Start with 8 repetitions for each leg, and add reps as comfort with the movement increases
Coaching Focus	**Progression**
❑ Focus on good posture ❑ The front knee is above the front foot, does not dip in or out, and does not move forward much beyond the toes ❑ The toes of both feet point forward ❑ The shoulders stay above the hips throughout the movement pattern; those with weaker leg muscles may be tempted to lean forward over the knee to assist movement, but the core muscles (abdominals and lower back) should stay contracted to maintain good posture ❑ Movement is efficient; all movement is forward (avoids wasting energy by swaying)	❑ To further challenge proprioception, delay setting the swinging foot down, and transition right into the next stride ❑ Add trunk rotation to further challenge stability and flexibility and to practise sport-specific upper-body movements ❑ Pivot from side to side to practise sport-specific lateral movements ❑ Use dumbbells or other weights to focus more on strength gains



3. Side Lunges

Performance Enhancement	Injuries Prevented
❑ Improves strength and control when pushing off laterally and moving laterally across a court or field ❑ Can contribute to better agility in sports that involve many changes in lateral movement and changes in direction	❑ Groin pulls ❑ Hamstring injuries ❑ ACL and other knee ligament injuries ❑ Other core, hip, knee, and ankle injuries
Starting Position	**Description of Movement**
❑ Assume an athletic ready position with the hands in front of the body, shoulders back, knees bent, hips pushed slightly back, shoulders above the knees, and weight centred above the balls of the feet	❑ Take a large side step, and then pull the feet back together using the lead foot to pull the trailing foot toward it ❑ As the movement becomes more fluid, it should look like a longer, deeper, exaggerated shuffle step moving laterally down or across the court or field ❑ Start with 8 reps in each direction, and add reps as comfort with the movement increases
Coaching Focus	**Progression**
❑ Focus on good posture and good balance ❑ Ensure the shoulders are always above the knees ❑ Ensure the knees are always above the feet when the feet are planted ❑ Minimize sway at the knee, hip, and trunk	❑ Pivot on each side step so that you face the opposite direction with each step



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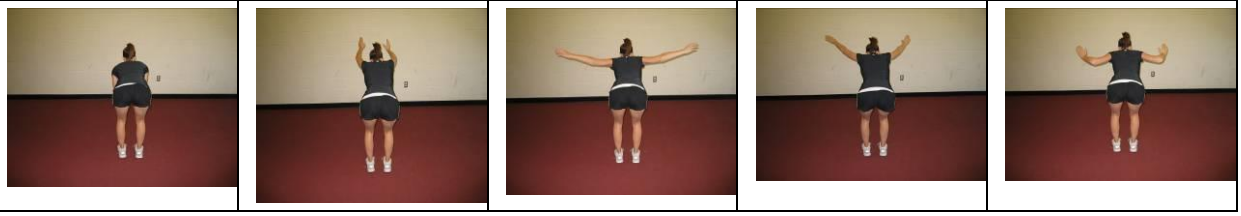
4. Walking Deadlifts

Performance Enhancement	Injuries Prevented
❑ Improves stability, resulting in more controlled movement patterns during sport and more efficient transfer of energy from the legs to the ground ❑ Strengthens the hamstring muscle and can improve running technique	❑ Hamstring strains ❑ Injuries associated with pelvic and lumbar instabilities ❑ Other injuries to the ankle, knee, hip, and lower back
Starting Position	**Description of Movement**
❑ Stand with good posture with the feet shoulder width apart	❑ Take a slow step forward and balance on the front foot ❑ Keep the arms out to the side for balance and body awareness ❑ Using an eccentric contraction of your hamstrings, reach toward the ground with your upper body ❑ Keep both legs straight until you feel a stretch through the hamstrings on the planted leg ❑ Return to the starting position by concentrically contracting the hamstrings on the planted leg ❑ Repeat with the opposite foot and continue for 6 repetitions on each leg ❑ Add reps once stable and confident throughout every repetition
Coaching Focus	**Progression**
❑ Keep the back very flat by thinking about reaching for the ground with the chest instead of with the head ❑ The hips and shoulders stay level as the athlete bends toward the ground ❑ Observe the range of motion — a bend in the planted leg or an inability to raise the back leg above parallel to the ground may indicate a shortened hamstring ❑ Watch for sway at each joint in the planted leg ❑ Watch for larger movements such as swaying forward to backward or side to side	❑ This is a very challenging movement pattern for most athletes ❑ Add reps once confident and stable throughout the entire movement ❑ To achieve eccentric strength gains in the hamstrings, hold weights in the hands

5. I, T, Y, W

Performance Enhancement	Injuries Prevented
❑ Improves the ability to stabilize the shoulder blades ❑ Creates a solid base to push or pull from	❑ Tendonitis, including supraspinatus tendonitis and biceps tendonitis ❑ Bursitis
Starting Position	**Description of Movement**
❑ Position the feet shoulder width apart with the knees bent slightly ❑ Bend the trunk forward so that the upper body is close to parallel to the ground or there is significant tightness in the hamstrings ❑ The arms hang straight down from the shoulders, and the lower back and abdominals contract to keep a neutral lower back posture	❑ I: Lower the shoulder blades, slowly raise the arms straight up above the head, and return the arms to the starting position ❑ T: Squeeze the shoulder blades together, slowly raise the arms straight out to the sides, and return the arms to the starting position ❑ Y: Squeeze and lower the shoulder blades, slowly raise the arms out to 45°, and return the arms to the starting position ❑ W: Squeeze the shoulder blades together, slowly bring the elbows back to the sides with the elbows bent at 45°, and return the arms to the starting position ❑ Motions are slow and controlled; take at least 4 seconds to form a letter and return to the starting position ❑ Start by forming each letter 3 times; add reps as the task feels easier, provided posture stays good and the shoulder blades complete a full range of motion
Coaching Focus	**Progression**
❑ The shoulder blades move down the back of the rib cage (depression) during the I, back together (retraction) during the T, down and together (retraction and depression) during the Y, and back together (retraction) during the W ❑ Watch for signs of fatigue; as athletes tire, they stand more upright or round the lower back, suggesting the core is unstable or the lower back is weak ❑ Observe which motions are most challenging; many athletes struggle with scapular depression, so watch that their I and Y stay high above their head and that they don't get closer to a T as they tire	❑ Once comfortable with 8 reps of the cycle of four letters, add resistance by using light weights, elastic bands/tubing, or a cable system



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6. Push-ups

Performance Enhancement	Injuries Prevented
❑ Increase the strength of shoulder adduction and elbow extension, which can translate into stronger pushing motions ❑ May improve stability through the hand, wrist, elbow, and shoulder girdle, which can in turn improve the efficiency and strength of movements of the upper limb	❑ Shoulder dislocations and partial dislocations ❑ Injuries to the rotator cuff muscles of the shoulder ❑ Ligament injuries at the shoulder joint
Starting Position	**Description of Movement**
❑ The toes are on the ground and the hands are on the ground directly under the shoulders ❑ The back and legs are straight, and the arms and legs are fully extended ❑ Contract the abdominals and lower back to maintain a straight line between the heels and the top of the head	❑ Lower the body toward the ground in a controlled manner ❑ Stop when the elbows get to 90° or when the chest is about 5 cm from the ground ❑ Return to the starting position by extending the elbows ❑ Start with 8 reps, if possible, and increase the number of repetitions to 25
Coaching Focus	**Progression**
❑ The back and legs are straight ❑ The body position is stable, maintaining a straight line from the heels through the top of the head ❑ There is a full range of motion, but the elbows do not flex much beyond 90°, as this may stress the rotator cuff muscles of the shoulder	❑ Do push-ups with one or two hands on a half ball, wobble board, medicine ball, or basketball ❑ Do plyometric push-ups, pushing off more powerfully and catching yourself before pushing off again



7. Dynamic Plank

Performance Enhancement	Injuries Prevented
❑ Strengthens the core and enables the core to stay stable throughout sport movements, making energy transfer more efficient ❑ Produces strength and stability in the hip abductors, which can improve movement mechanics, as well as strength and stability during lateral movements and changes in direction	❑ Chronic lower back injuries ❑ Pelvic and lumbar instabilities ❑ Hamstring strains ❑ ACL and other ligament injuries in the knee ❑ Other lower back, hip, knee, ankle, and foot injuries
Starting Position	**Description of Movement**
❑ The toes are on the ground and the hands are on the ground, directly under the shoulders ❑ The back and legs are straight, and the arms and legs are fully extended ❑ Maintain a straight line between the heels and the top of the head by contracting the abdominals and lower back	❑ While in the push-up position, the back and legs are straight; hold this position for 5 seconds ❑ Keeping a plank-like posture, slowly rotate to one side until the shoulders and hips are aligned to one side and only one arm and one leg are touching the ground; the other leg is higher than its hip, and the other arm points to the ceiling; hold this position for 5 seconds ❑ This is a difficult movement pattern; if control cannot be maintained, keep the upper arm at the side, the upper leg close to the lower leg ❑ Rotate back to the central position, and hold this position for 5 seconds ❑ Rotate through to the other side, and hold this position for 5 seconds ❑ Focus on keeping a straight line in all planes throughout the movement ❑ Perform the series of planks 3 times
Coaching Focus	**Progression**
❑ Look for an *absence* of sway ❑ There is no extraneous movement, and the back and legs stay straight, forming a straight plank throughout the rotation ❑ The pelvis and lower back are in a neutral position (straight) throughout the movement ❑ The upper arm and leg are as high as possible; this challenges the abductor muscles	❑ Do the movement pattern on a dynamic surface such as a half ball or wobble board **Modification** ❑ Start from the elbows instead of a push-up position
 	 

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8. Supine Bridge

Performance Enhancement	Injuries Prevented
❑ Helps improve hip, pelvis, and trunk stability ❑ Strengthens muscles that extend the hip and the lower back (these muscles include the hamstring, gluteal, and lower back muscle groups) ❑ Improves strength and control in many sport-specific movements	❑ Chronic lower back injuries ❑ Hamstring strains ❑ Various hip and groin injuries
Starting Position	**Description of Movement**
❑ Lie flat on the back with the legs extended and the arms across the chest	❑ Bend both knees to position the feet flat on the floor or ground ❑ Push the feet into the ground to raise the body off the ground, and extend one leg ❑ Maintain rigid form, straight in all planes and forming a straight line from the shoulders through the knees to the raised foot ❑ Hold this position for 30 seconds, and try to increase this time
Coaching Focus	**Progression**
❑ Only the shoulder blades and the planted foot touch the ground during the up phase ❑ Body position forms a straight line from the head to the raised foot, and the pelvis and lower back are neutral (straight)	❑ Extend both legs completely, and raise the body by pushing the heels into a step that is at most 30 centimetres high ❑ To further increase the challenge of this variation, alternate lifting one leg a few centimetres off the step, or place the heels on an uneven surface such as a half ball, ball, or wobble board ❑ Variations that involve straightening the legs increase the load on the hamstrings relative to the gluteal muscle group and the muscles in the lower back ❑ The hamstring, gluteal, and lower back muscle groups work as a team to maintain hip and lumbar extension, so there are advantages to both variations



9. Zig Zag Run

Performance Enhancement	Injuries Prevented
❑ Improves agility by improving the eccentric strength needed to decelerate, the stability needed throughout changes in direction, and the power needed to accelerate in the opposite direction ❑ Decelerating well is as important as accelerating well	❑ Ankle sprains ❑ ACL injuries ❑ Other knee ligament tears ❑ Chronic knee injuries, including patello-femoral syndrome ❑ Many other soft-tissue injuries
Starting Position	**Description of Movement**
❑ Stand in an athletic ready position at the start of a pylon or tape course with pylons or tape on alternating sides of the court or field (~10m across and 10m down the field)	❑ Run in diagonal lines across the field or court ❑ Focus on the 3 phases of agility (deceleration, stability or change in direction, and acceleration in the other direction) ❑ Start slowly to **feel** the muscles work to stabilize from the ground through the foot, ankle, knee, hip, trunk, and shoulders ❑ Gradually increase the pace until you are moving through the drill as fast as you can ❑ Repeat the pylon course (10 pylons) 5 times
Coaching Focus	**Progression**
❑ Move fluidly and quickly from one direction to the next ❑ Minimize trunk sway ❑ Keep the knee over the foot and the shoulders over the knees	❑ Once proper mechanics have been achieved, work on minimizing the time it takes to change from moving quickly in one direction to reaching full speed in the other direction ❑ Make the drill as much like the athlete's sport as possible; for example, squash players would make many changes in direction in a very short distance, whereas tennis players would change direction less often but at a higher running velocity




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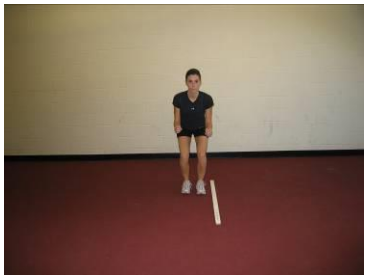
10. Side Jumps over a Line

Performance Enhancement	Injuries Prevented
❑ Improves the strength and power of lateral movements ❑ Improves the ability to move laterally in a controlled and stable manner	❑ Ankle sprains ❑ Knee ligament sprains ❑ Chronic knee injuries, including patello-femoral syndrome and jumper's knee ❑ Various hip, knee, ankle, and foot injuries
Starting Position	**Description of Movement**
❑ Assume an athletic ready position with the knees bent, the knees above the feet, and the shoulders above the knees ❑ Stand to the side of a line on the ground	❑ Flex the knees and hips, and jump sideways over the line ❑ Immediately jump back across the line
Coaching Focus	**Progression**
❑ Monitor the body position ❑ On landing, the knees stay above the feet and don't dip in or out ❑ The shoulders stay centred above the knees, and there is little or no sway forward to back or side to side ❑ Focus on lateral movement; there should be little or no forward or backward movement on a jump ❑ As stability improves, the goal becomes minimizing the time spent in contact with the floor	❑ Jump over a barrier ❑ Do the drill on one foot ❑ Do multiple hops in different directions



11. Bounding

Performance Enhancement	Injuries Prevented
❑ Improves the strength, power, and stability of running and jumping	❑ Ankle sprains ❑ ACL sprains ❑ Other knee ligament sprains ❑ Chronic knee injuries, including patello-femoral syndrome and jumper's knee ❑ Hip and trunk injuries
Starting Position	**Description of Movement**
❑ Stand on one foot in an athletic ready position with the knees over the feet and the shoulders over the knees	❑ Bend at the knees and hips, and propel yourself forward onto the other leg ❑ Immediately jump back to the other foot. and continue forward down the field or court ❑ Start with 8 hops in each direction, and increase the number over time
Coaching Focus	**Progression**
❑ Maintain a stable position on each landing, with limited sway at the hip, knee, and ankle and throughout the trunk ❑ As stability improves, focus on minimizing contact time while maximizing the distance of each bound	❑ Bound over a barrier ❑ Add more lateral movement or more forward movement, depending on the athlete's sport ❑ Do two-foot jumps; determine which variation will train the movement patterns closest to the athlete's sport



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12. Side Sliding on a Smooth Surface

Performance Enhancement	Injuries Prevented
❑ Improves the strength and control of push-offs in horizontal movements such as skating or moving laterally across a court or field ❑ Improves lateral mobility and speed	❑ Groin pulls ❑ Ankle sprains ❑ Knee ligament sprains ❑ Various other hip, knee, ankle, and foot injuries
Starting Position	**Description of Movement**
❑ Stand with the feet shoulder width apart, the knees bent, the feet under the knees, and the shoulders over the feet	❑ Slide to the side by pushing off from one side and shifting the weight to the other ❑ Immediately transition from one side back to the other by pushing off the other leg ❑ Make the movement 8 times in each direction, and progress to more reps as comfort increases ❑ Time goals are also appropriate for sports with similar repetitive movements (e.g., skating and hockey)
Coaching Focus	**Progression**
❑ Movement is smooth, fluid, and continuous ❑ The athlete looks stable throughout the entire motion ❑ Eliminate unnecessary sway at the ankle, knee, hip, and trunk	❑ Use only one leg to slide ❑ Slide on different surfaces; surfaces with more friction require greater force to move from one side to the other, whereas surfaces with less friction require more stability during the deceleration and change in direction
	Modification
	❑ Do lateral jumps instead of slides ❑ On landing, focus on controlling the deceleration



THE DYNAMIC WARM-UP FOR PERFORMANCE AND PREVENTION

A dynamic warm-up is 10+ minutes of activity that prepares athletes physically and mentally for practice or competition. Athletes should do dynamic warm-ups before each practice or competition because they:

- Improve performance
- Reduce the risk of injury

Dynamic warm-ups have several advantages over traditional static stretching. Effective dynamic warm-ups accomplish these seven things:

1. Increase heart rate more effectively
2. Increase muscle temperature
3. Improve force-generating capacity
4. Train neural pathways used in the athlete's sport
5. Provide the working muscles with energy from the energy systems used in the athlete's sport
6. Improve mental preparation
7. Help reduce the risk of injury

An effective dynamic warm-up has three components

1. *Active exercise*. Active exercise gradually raises the heart rate, increases muscle temperature, and improve range of motion.
2. *Dynamic stretching and body awareness*. The athlete activates muscles through a large range of motion, gains a better sense of balance, and develops body control.
3. *Sport-specific drills*. These prepare the athlete mentally and physically for participation in his or her sport.

An effective dynamic warm-up is specific to the athlete's sport

- *An effective dynamic warm-up uses the same muscle groups as the athlete's sport.* Example: Cycling does not increase muscle temperature in the upper body, so it would not be an appropriate warm-up for a discus thrower.
- *An effective dynamic warm-up trains the neural pathways required in the athlete's sport.* Example: While running uses the same muscle groups as cycling, the order in which the muscles are recruited is very different, so running would not be the best warm-up option for a cyclist.
- *An effective dynamic warm-up uses the same energy systems as the athlete's sport.* Example: Hockey relies primarily on anaerobic glycolysis to provide energy to the working muscles, whereas long-distance running requires mainly oxidative sources. The hockey player's warm-up should therefore include shorter, more intense bouts of skating interspersed with rest periods to mimic a typical hockey shift.

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An effective dynamic warm-up prepares the athlete for sport without causing fatigue

- Effective warm-ups and fatigue have the opposite effect on certain aspects of sport performance:

Warm-ups…	Fatigue…
❑ Increase the ability to generate maximum force	❑ Decreases the ability to generate maximum force
❑ Increase the maximum velocity of contraction	❑ Decreases the maximum velocity of contraction
❑ Increase the maximum rate of force development	❑ Decreases the maximum rate of force development
❑ Decrease the time needed to "turn the muscle on" and "turn the muscle off"	❑ Increases the time needed to "turn the muscle on" and "turn the muscle off"
❑ Decrease the risk of injury	❑ Increases the risk of injury

- Three variables determine the effectiveness of a dynamic warm-up:
  1. The intensity of the warm-up activities
  2. The duration of the warm-up
  3. The length of time between the end of the warm-up and participation in the event
- If you alter one of these three variables, you must adjust the other two to produce the same results. For example, if you increase the intensity of the warm-up, you must either shorten the warm-up or provide more recovery time after the warm-up. And some variables may be easier to change than others. For example, the warm-up's duration and the length of time before the event may be set by event coordinators or referees. In such cases, you must adjust the intensity of the warm-up to match the other two variables.

Examples of Dynamic Warm-ups

Example 1	
Athletes:	Youth lacrosse team
Event: **Duration:** **Time between warm-up and event:**	Warm-up before a game 20 minutes 10 minutes
Active warm-up: **5 minutes**	❑ 5 minutes of jogging and ball handling ❑ Increase intensity gradually ❑ Mimic movement patterns in the sport ❑ Practise the skills necessary for sport performance at a lower intensity ❑ Make it fun!
Dynamic stretching and body awareness: **5 minutes**	Do two reps of each drill listed below, covering 20 metres on each rep; jog lightly back to the starting position between each rep: ❑ A walks/A skips ❑ B walks/B skips ❑ C walks/C skips ❑ Walking deadlifts ❑ Spider man ❑ Walking lunges ❑ Walking lunges with trunk rotation ❑ Side lunges ❑ Side lunges with pivot ❑ Kareoka (grapevine) ❑ Bounding with forward and lateral movement ❑ Sprints ❑ Backward sprints
Sport-specific skills: **10 minutes**	❑ Partner passing (gradual increase in distance) ❑ 1 on 0 ❑ 1 on 0 after breaking through a check ❑ 2 on 1 ❑ Goalie clear drill — players to get open, goalie to make pass ❑ Scoop on the run ❑ The gauntlet

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Example 2	
Athletes:	Youth cyclist
Event: **Duration:** **Time between warm-up and event:**	15km time trial 50 minutes 5 minutes
Active warm-up: **5 minutes**	❑ 5 minutes of cycling on a trainer at 50% of VO_2 max ❑ Focus on a fluid and efficient pedal stroke
Dynamic stretching and body awareness: **5 minutes**	Do two reps of each drill listed below, covering 40 metres on each rep; jog lightly back to the starting position between each rep: ❑ A skips ❑ C skips ❑ Walking lunges with rotation ❑ Side lunges with pivot ❑ Step-ups with focus on stability ❑ Dynamic plank ❑ Linear jumps ❑ Bounding
Sport-specific skills: **(40 minutes)**	❑ 10 minutes at 50-60% of VO_2 max and 90-95 rpm ❑ 10 minutes tempo at 75-80% of VO_2 max and 75-85 rpm ❑ 2 minutes recovery at 50% of VO_2 max ❑ 6 minutes steady state 90-95rpm just below lactate threshold (80-85% of VO_2 max if not tested) ❑ 2 minutes recovery at 50% of VO_2 max, 90-95 rpm ❑ 2 minutes power intervals, 105 rpm (~90% of VO_2 max) ❑ 2 minutes recovery ❑ 2 minutes power intervals, 105 rpm (~90% of VO_2 max) ❑ 2 minutes recovery

Cool-down

An effective cool-down can speed up recovery following practice or competition, as it increases the rate at which the byproducts of exercise are removed from the working muscles. The accumulation of these byproducts can contribute to fatigue, but low-intensity exercise can help accelerate recovery by decreasing the concentration of these byproducts.

Accelerating recovery can have major effects on performance and injury prevention:

- ❑ The gains made in the rest period following a workout may be greater.
- ❑ The ability to perform in future events may improve.
- ❑ The ability to train harder during subsequent workouts may improve.
- ❑ The risk of injury may decrease, as fatigue predisposes the athlete to injury.

Principles of an Effective Cool-down

- The cool-down should consist of low-intensity aerobic exercise at 30-45% of VO_2 max or heart rate reserve.
- The cool-down should use muscle groups similar to those used in the athlete's sport.
- The cool-down should provide opportunities to slow down skills and focus on technique.

What about Static Stretching?

- There's no high-quality evidence to suggest that static stretching before or after sport activity reduces the risk of injury.
- So why would I use static stretching?
  - To improve sport performance in sports in which range of motion is important.
    - Example: Gymnasts and figure skaters improve how they perform some technical skills when they improve their range of motion AND may be judged on their range of motion.
  - To return muscles to their pre-exercise length. In sports that include many repetitive movements, muscles that are contracted repeatedly may become shorter over time. While this may benefit the specific skill being repeated, it may cause performance in other skills to suffer.
    - Example: In triathletes, frequent cycling can cause one of the quadriceps muscles to become shorter as the muscle adapts to cycling's flexed-hip position. This means the muscle is an optimal length during cycling, but running performance may suffer because the muscle is no longer the optimal length for running. Triathletes are encouraged to stretch their quadriceps muscles after cycling
  - To maintain or improve posture. Good posture minimizes the incidence of chronic injuries in the extremities. Static stretching over time helps minimize sciatica and thoracic outlet syndrome (a reduction of the space through which the blood vessels and nerves supplying the legs and arms pass), both of which are related to overuse injuries in the extremities. Improving posture often takes weeks or months of diligence. Muscles that are repeatedly contracted and become shorter over time can have a significant negative effect on posture.
    - Example 1: As described above, frequent cycling can cause the hip flexors to shorten, as can the defensive or receiving positions in sport. Shortened hip flexors in turn contribute to an anterior rotation of the pelvis. This rotation may increase the risk of lower-back, pelvis, and hamstring injuries.
    - Example 2: In sports like football, where athletes spend more time pushing than pulling, the shoulder spends a lot of time in a flexed, adducted, and internally rotated position. This in turn causes a shortening of the muscles that hold the shoulder in that position. This adaptation can result in a forward-shoulder posture that both increases the risk of shoulder injuries and may lead to thoracic outlet syndrome (see above). Athletes in these sports are encouraged to stretch the muscles that internally rotate and adduct the shoulder.
- How do I effectively use static stretching?
  - Static stretching should take place when the muscles are warm (usually after a practice or event).

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- Static stretching should NOT take place before sports in which high-velocity or high-force muscle contractions are needed, because performance may suffer.
- It is important to balance opposing muscle groups when stretching and to balance both sides of the body.
- Athletes should feel only a mild stretch at the start of the stretch but should then feel a gradual release or elongation of the muscle.
- The number of repetitions and the duration of each stretch depends on the reason for doing the stretch. For example,
  - To increase range of motion: do 3 30-second repetitions
  - To return muscles to their pre-exercise lengths: do 1 30-second repetition
  - To improve posture: do 1 progressive stretch that lasts up to 120 seconds

RECOVERY AND REGENERATION TECHNIQUES

Fatigue and Overtraining

Fatigue, overtraining, and recovery are all areas with many unknowns. Scientists have attempted to identify specific indicators of fatigue. Although many indicators have been identified, some athletes with these indicators perform at very high levels while other athletes with the same indicators perform poorly.

What is Fatigue?

Fatigue is a critical factor in athletic injuries: when athletes are tired, their bodies cannot respond to athletic demands and cannot avoid acute injuries. There is evidence that tissues are less elastic and therefore more predisposed to injury when fatigued.

Athletes walk a fine line between a training load that creates a positive adaptation and one that leads to breakdown. Athletes need to train hard on high-intensity days and recover hard on low-intensity days.

Before exploring various techniques for ensuring recovery, let's review the terminology.

This Term…	Means This…
Recovery	❑ The physiological processes taking place after exercise when the body is restored to its pre-exercise condition. Recovery processes include replenishment of muscle glycogen and phosphagen, removal of metabolites, reoxygenation of myoglobin, and protein replacement.
Acute Fatigue	❑ The muscle fatigue that occurs after strenuous training. Acute fatigue is considered normal following hard training; recovery occurs in 24-48 hours.
Chronic Fatigue	❑ The muscle fatigue that accumulates over time when there is not enough recovery. ❑ Chronic fatigue may occur after several days of hard training. It takes 3-7 days to recover from the resulting fatigue. This is a higher risk approach to using fatigue as an adaptation mechanism and must be monitored closely when used.
Overtraining	❑ Failure to recover from acute or chronic fatigue. Recovery from overtraining may take weeks, and overtraining may make it impossible for the athlete to peak as planned.

What is Overtraining?

Overtraining — aka staleness or burnout — occurs when athletes train intensely but do not recover from acute or chronic fatigue. Performance deteriorates instead of improving, even after an extended period of rest.

Signs and Symptoms of Overtraining	
Physical	**Emotional/Behavioural**
❑ Deteriorating performance*	❑ Depression
❑ Inability to maintain training load*	❑ Decreased self-confidence
❑ Chronic fatigue*	❑ Mood changes*
❑ Elevated resting heart rate*	❑ Apathy
❑ Slower heart-rate recovery	❑ Inability to concentrate
❑ Elevated blood pressure	❑ Anxiety
❑ Persistent muscle soreness	❑ Sleep disturbances
❑ Unexplained loss of body weight	❑ Irritability/excitability
❑ Headaches	❑ Boredom
❑ Heavy-legged feeling	❑ Loss of appetite
❑ Frequent illness (colds, flu)	❑ Excessive emotional displays
❑ Gastrointestinal disturbances	❑ Inability to relax
❑ Menstrual irregularities	❑ Anger/aggressiveness
❑ Decrease in power output over time	❑ Lethargy
❑ Low hemoglobin levels	❑ Low motivation
❑ Elevated resting lactic-acid levels	

*Signs and symptoms that, when considered together, appear to best indicate overtraining.

Note:

- ❑ Not all of these responses occur in any one overtrained athlete at any one time. There is great individual variation in the signs and symptoms of overtraining.
- ❑ Two of the most important signs of overtraining are a change in mood and a drop in performance.

Identifying Fatigue and Overtraining

Fatigue can have physiological, psychological, neurological, or emotional dimensions. As a result, identifying fatigue and responding to it is both an art and a science. The key is to collect information about athletes (signs) and from athletes (symptoms) and to interpret this information based on your experience and knowledge of the athletes.

Field tests and the Heavy Legs Index are good sources of information about athletes' fatigue and overtraining.

Field Tests

Field tests can indicate how athletes are managing their training load and the stresses in all areas of their life.

- ❑ Select the physiological parameter that is most important to your sport, e.g., sprint speed.
- ❑ Design a sport-specific distance and movement configuration that takes 6 to 10 seconds to complete and matches a competition situation.
- ❑ Test the athlete periodically to see if he or she is improving or regressing.

- If the athlete is regressing, you need to identify why and take action accordingly. The training load may need to be reduced while recovery takes place. Other recovery and regeneration techniques to consider are listed on page 73.

Heavy Legs Index

Another way to identify fatigue and overtraining is to use the Heavy Legs Index with your athletes:

- Determine the muscle group that fatigues first in your sport.
- Set a scale, for example, 1-10, where 1 = the muscle group feels great and 10 = the muscle group is totally tired OR establish a set of words that equals the scale of 1-10.
- Agree on how and when you are going to ask the athlete how the muscle group feels.
- Agree that this index is only one indicator of fatigue and agree on how this information will be used to design training load.
- If the score on the index is regressing, you need to identify why and take action accordingly. The training load may need to be reduced while recovery takes place. Other recovery and regeneration techniques are listed on page 73.

Understanding Responses to Training

The body needs time to adapt to repeated sessions of intense training. The things athletes do at rest are just as important as the workouts they complete. Quality training and quality rest are essential to top performance.

The challenge is to maximize recovery without jeopardizing the positive adaptations from training. Recovery is so important that banned substances have been created and used in an unethical manner to accelerate recovery.

Muscle Tissue Response to Training

Hard training creates microtears in the muscle fibres. The body normally repairs these fibres between workouts. But when hard workouts occur too close together, the body cannot fully regenerate. This may result in prolonged muscle fatigue, soreness, and sub-par performance. Taking time to recover helps athletes avoid muscle damage.

Connective Tissue Response to Training

Tendons adapt more slowly than muscle tissue, and it takes longer to regenerate tendon than to regenerate muscle.

Coaches need to:

- Pay close attention to work/rest ratios in practice and workouts
- Pay close attention to weekly schedules for practices, workouts, and competition
- Monitor daily for signs of fatigue
- Use field tests that measure/assess fatigue
- Include recovery techniques in daily, weekly, monthly, and annual plans

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Athletes need to:

- ❑ Watch for the stages of tendonitis pain:
  - Stage 1: Pain after activity
  - Stage 2: Pain at the start of and after activity
  - Stage 3: Pain before and after activity with minimal pain during activity
  - Stage 4: Pain continues between training sessions
  - Stage 5: Pain interferes with performance
  - Stage 6: The athlete has to stop altogether or the tendon ruptures
- ❑ Listen to their bodies for the early signs of tendon breakdown and alter their training or accelerate their recovery strategies if Stage 2 signs start to appear.
- ❑ Live an athlete's lifestyle. Give their body a chance to recover:
  - Sleep more and better to allow the body to repair itself
  - Develop a sense of when a pain or niggle calls for a day off; chronic soreness and signs that the pain is moving from Stage 2 to Stage 3 are good indicators that a day off is needed
  - Rest or cross-train at the first sign of an injury
  - Add core training to every workout
  - Honour the tapering plan
  - Eat strategically; nutrition provides the building blocks for recovery and repair, and this is how you build muscle; the workout alone does not accomplish this
  - Pre-hydrate and hydrate; fluid delivers nutrients to your body and removes the by-products of training
  - Do yoga to regain energy, improve breathing technique, and find inner peace

Recovery and Regeneration Techniques

Recovery and regeneration are areas lacking unanimous scientific agreement about the effectiveness of various techniques. However, some professions have used recovery and regeneration techniques for thousands of years, and coaches around the world currently use some or all of the techniques listed below.

Recovery starts with how you plan practices, schedule weeks, and approach competition. You need to schedule recovery within practices and within the week, and you need to be alert to the balance between hard competitions and hard practices.

Think of recovery techniques in terms of the active, psychological/emotional, passive, and postural techniques identified below, and combine them with any effective techniques you are currently using.

Active

- ❑ Recovery practices
  - Lower intensity practices, e.g., recovery runs for 30 minutes at a heart rate of 110-130 bpm or even less. These practices help remove the metabolic by-products of fatigue from the muscles by transporting them to the nearby aerobic muscle fibres and to the abdominal organs for recycling and removal.

- ❑ Work/rest ratios within a practice
    - Appropriate recovery time between work bouts. This will help prevent chronic fatigue and make possible quality repetitions.
- ❑ Periodized recovery and tapering
    - Structuring the practice, the week (microcycle), the month (mesocycle), and the year (annual sport plan). This creates opportunities for physical, psychological, and emotional recovery.
- ❑ Cross-training and recreational sport
    - Involvement in other sports during the off-season. This creates a physical and mental change of pace that allows athletes to rejuvenate.
    - A periodic cross-training or recreational session within a season of hard training. Such sessions can rejuvenate the athlete. One caution here is to keep the intensity low so that injury does not occur.
- ❑ Complete rest days or days off

Psychological/Emotional

- ❑ Psychological techniques for taking care of distractions and finding the right level of intensity. Acquiring these skills contributes significantly to reducing chronic injury and to improving performance.

Passive

- ❑ Massage
    - Manual massage. This is a long-established and effective recovery therapy used for the relief of pain, swelling, muscle spasm, and restricted movement.
- ❑ Contrast baths
    - Alternation of hot and cold water. For example, if the legs are fatigued after a hard workout, alternate between sitting in a hot tub for 3-5 minutes and sitting for 1-3 minutes in a cold tub with water at 13.9-12.8 degrees Celsius. The hot tub encourages blood flow to the fatigued muscles. The cold tub sends blood away from the fatigued muscles toward the heart and abdominal organs. This pumping action encourages recovery without the athlete having to do anything! If tubs are not available, sit or stand in a hot shower and then a cold shower for the times suggested above.

Postural

- ❑ Treatment and exercises to improve posture. Although perfect posture is often difficult to come by, better posture increases the flow of nutrient-building blocks to the muscles and maximizes the recruitment of muscles. Improved neck posture, shoulder position, and lower back posture are particularly important.

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ANNEX A: GUIDELINES FOR THE TRAINING OF ATHLETIC ABILITIES BY ATHLETES' AGE

Athletic Abilities		Developmental Age in Years														
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Aerobic Power (intense, short efforts of 2-10 min)	F	☹	☹	☹	☹	☹				☺	☺	☺	☺			
	M	☹	☹	☹	☹	☹	☹				☺	☺	☺			
Aerobic Endurance (long efforts)	F	☹	☹	☹	☹		☺	☺	☺	☺						
	M	☹	☹	☹	☹	☹		☺	☺	☺	☺					
Speed-Endurance	F	☹	☹	☹	☹	☹			☺	☺	☺					
	M	☹	☹	☹	☹	☹	☹			☺	☺	☺				
Strength-Endurance	F	☹	☹	☹			☺	☺	☺	☺	☺	☺				
	M	☹	☹	☹			☺	☺	☺	☺	☺	☺	☺			
Maximum Strength	F	☹	☹	☹	☹	☹	☹	☹			☺	☺	☺			
	M	☹	☹	☹	☹	☹	☹	☹	☹	☹		☺	☺	☺	☺	
Speed-Strength (muscular power)	F	☹	☹	☹	☹	☹	☹	☹	☹			☺	☺	☺		
	M	☹	☹	☹	☹	☹	☹	☹	☹				☺	☺	☺	
Flexibility	F	☺	☺	☺	☺	☺										
	M	☺	☺	☺	☺	☺										
Speed (efforts of 8 seconds or less)	F	☺	☺	☺			☺	☺	☺	☺						
	M		☺	☺	☺				☺	☺	☺	☺				
Speed (fast cadence of movement, short efforts)	F	☺	☺	☺												
	M	☺	☺	☺												
Agility/Balance/ Coordination	F	☺	☺	☺	☺	☺										
	M	☺	☺	☺	☺	☺										
Basic Techniques	F			☺	☺	☺	☺	☺								
	M				☺	☺	☺	☺	☺							
More Advanced Techniques	M F							F	FM	☺	☺	☺	☺			
Tactics and Decision-making	F	☹	☹	☹					☺							
	M	☹	☹	☹					☺							

Legend: ☹ Should be avoided ☺ Optimal training age ☐ Not a priority
In moderation As needed by the sport
F Female M Male

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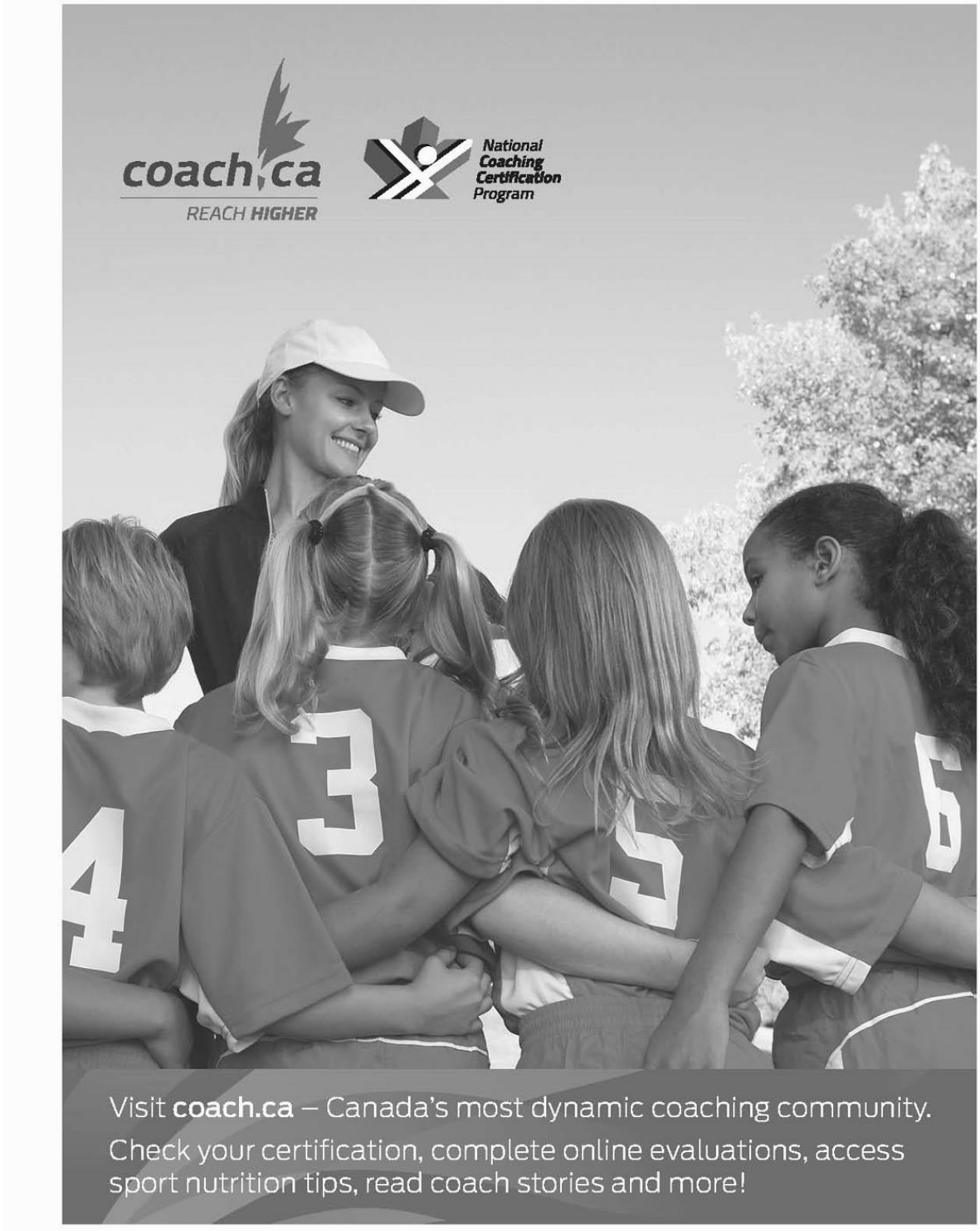
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