

Modern Scientific Innovations in Warming Up and Cool- Down in Sports

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Abstract

Sporting performance is dependent upon the athlete's readiness to act, which facilitates the strengthening of the bond between stimulus and response. Thus, an athlete is highly motivated and eager to exhibit the best performance in the modern sporting world under tremendous load. For elevating the performance in the main competition it is extremely necessary to prepare the physical, physiological, and psychological condition of an athlete before the mega- events. That is the core concept of warming up. At the end of any sporting event, it is highly recommended to maintain homeostasis by lowering the intensity and volume of the work stimulus. This is termed as cool-down in sports training. The present research article discussed various research-based scientific innovations for promoting better warming up and cool-down protocols of sports training. The means and methods of warming up and cool-down are critically discussed for the promotion of modern sports training.

Keywords: Warming up, Cool-down and Sports.

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INTRODUCTION

Sports readiness refers to the body's ability to adapt to the needs of a particular sport or activity. This has become a world-renowned term for physical therapy and physical preparation, and for good reason. In the past, athletes relied on common experience and "feel" to rank their training volumes and intensities for the day. While this has worked for many decades, the growing world of wearable technology allows us to abandon this subconscious due to high data- driven ground. This history of negligence increases the chances of training less or less [1].

The effectiveness and capabilities of a good sports / strength program & evaluation system should be assessed for the effective and efficient use of program resources, processes, and priorities [2]. Resources especially staff, equipment, technology and relationships. Processes are the way your resources, especially your employees, communicate and direct their work. Resources and processes are the same as you can have good resources and bad processes, or vice versa, and your system can still be garbage. How to use resources and processes is a statement of what is important to an athlete depending upon the type of athletes we are developing [3].

Law which states that learning is dependent upon the learner's readiness to act, which facilitates the strengthening of the bond between stimulus and response. Thus, an athlete who is highly motivated and eager to learn is more likely to be receptive to learning than one who is poorly motivated. See also Thorndike's stimulus-response theory of learning [4]. Warming up is the falling in the category of law of readiness for upcoming mega events.

The purpose of warm-ups before sporting activities is to mentally and physically prepare for the task you have chosen. Warming up increases heart rates and therefore, facilitates blood to flow which allows more oxygen to reach to the working muscles. Warming up and working out also enables communication between nerves and muscles, which improves the proper functioning of the movement. In addition, range of motion (flexibility) should be increased with strong stretching. Gently stretching each of the main muscle groups for 10–15 seconds will restore their length and can help bring your mind and body back to a resting state [4, 5]. "Warming up and cooling down are good for your exercise performance — you'll do better, faster, stronger — and for your heart since the increased work on the heart 'steps up' with exercise," [5].

Warming up is intended to prepare one's body for the physical activity are about to complete. This could be a time for exercise, cardiovascular exercise, sports training or a competitive sport. Generally, warmth should always include vigorous physical activity, stretching and exercise.

Completing a low-intensity workout with warmth helps to increase blood flow to the muscles we need for exercise. This increases the delivery of oxygen to the muscles and enhances metabolic activity to improve muscle readiness to start working with the contractor. Aerobic warming also helps to increase heart rate by preparing for exercise so the cardiovascular system is ready to work.

With the increase in blood flow from aerobic activity, our body temperature also rises. This improves muscle flexibility and tenderness and joint flexibility. Since muscle stiffness is thought to be related to muscle damage, increasing muscle flexibility and reducing viscosity should help reduce this risk. Adding some powerful exercises to your warmth will continue to help muscle flexibility. Strong stretching has been shown to be higher than a strong (continuous) drop in warmth as it also helps to reduce muscle stiffness (Haddad *et al*, 2014). Strong stretching involves walking and controlling back and forth through a distance that helps the muscles cope with sudden movements and augmentation while exercising.

In contrast to warming, cooling is all about lowering your body temperature and returning to normal. Cooling down will include a very simple aerobic activity and a consistent (continuous) stretching. Doing simple aerobic exercise after vigorous exercise, such as walking will help restore body temperature back to the core and continue to help bring oxygen to the muscles so that they recover faster. This will help eliminate muscle lactic acid and other chemicals built up throughout the trial, reducing the risk of initial muscle injury. Adding a static stretch to your cool down may help the muscles continue to relax and return to their normal range of motion. This is also a good time for your heart to beat back to normal while you are still working before you fully rest. Cooling down can take 10-20 minutes and dry stretching should be held within 10 seconds to 30 seconds to properly stretch and relax muscles [6].

It is generally accepted that prior to any type of athletic performance a warm-up period precede the actual training phase. As with much of what occurs in Judo training, the warm-up has all too often become a ritual performed without any clear purpose or goal. Traditionally, warm-ups have been viewed primarily as a method to prevent injuries or lessen their severity. While this article will not cover flexibility training or debate whether warm-ups prevent injuries- research by sports scientists can't empirically validate this claim nor

do they refute it- it will address issues pertaining to the purposes, goals and training parameters of warm-ups [7].

Concept and Importance

Warming up is the set of exercises, sorted and graded, all muscles and joints whose purpose is to prepare the body for physical sports to perform properly and avoid injury. The purpose of warming up is to get our body to reach optimum performance level gradually so that from the beginning of the effort, we can perform at our best. If you've warmed up before performing an exercise regularly, you will be able to give the best of yourself from the start. Therefore, it is essential that you warm up before any physical exertion. If you do not, your body will adapt quickly and inadequately, function and have more chances of suffering an injury [8]. In a simple terminology warming up is a set of physical exercises in order to increase body temperature and better upcoming sporting events.

1. It Increases the Body Temperature and Muscle Tone

Good warming will increase your body temperature, which greatly helps muscles to contract sequentially. As muscle temperature rises, more oxygen is found in your muscles, allowing them to enter and relax more easily - so the athlete will be able to perform more complex tasks more easily. The heart is also given a chance to prepare, which means it will not be too disturbed during your workout.

2. Reduce the Risk of Injury

Warming up will improve muscle strength and allow for effective cooling, which means less chance of accidental injury or overheating during your workout and wasting your day.

3. Improve Mentally Preparedness

Direct jumping into exercise without adequate preparation can completely eliminate it, especially if the preparation is mental rather than physical. It is easy to give up when exercise is difficult, but it is less likely to do so if you take the time to remember why you are working. Use your time to warm up and think about what you are going to do, making sure your body and mind are ready for success.

4. Increase Flexibility

Stretching is often regarded as something that should be done to add normal warmth. Stretching will increase blood flow to the working muscles, and allow body to increase its flexibility both in the short and long term.

5. Prepared To Deal with Heavy Equipment in the Gym or Mega Sporting Events

Using machines to help build muscle is a great way to spend your time in the gym, but it should not be used before you have the opportunity to free your joints.

Warming up will ensure that body and mind are in a good position to manage exercise equipment, and reduce the risk of injury.

6. Augmented Oxygen Delivery

Warming-up helps to deliver oxygen to the exercising muscle groups. Warming-up help the body to deliver oxygen to the exercising muscle groups.

7. Body Temperature Increase

Warming-up increases the core body temperature, thus reduce the chance for muscle and tendon injuries.

8. Increase Blood Flow

Warm-up increases blood flow to the exercising muscles. A greater level of blood reaching the muscles involved in the activity aids in the delivery of the important fuels (e.g., glucose and free fatty acids) required for energy production.

9. Respiratory Increment

Increase the rate of respiration for more availability of oxygen in the working muscle and removal of carbon dioxide from the body.

9. Increase Mechanical Efficiency

Warming up increases the suppleness of the muscle, thereby enhancing the mechanical efficiency and power of the exercising muscles. An appropriate warm-up prepares the cardiovascular system for the upcoming (more strenuous) physical activity. Warming up helps to ensure that the cardiovascular system (heart and blood vessels) is given time to adjust to the body's increased demands for blood and oxygen [9, 10].

Developmental Components of Warming Up

Warming up is beneficial for sporting performance of an athlete and the basis of functional capacities of warming up can be divided into three heads, viz. Physiological benefit, Psycho motor benefit and improvement of kinesthetic sense [11].

Table 1: Benefited Areas of Warming up in sports

• Physiological	• Psychomotor	• Kinesthetic	• Psychology
• Oxygen delivery	• locomotor	• <i>perceptual and physical abilities</i>	• mental Preparedness
• Blood flow	• non-locomotor	• Awarness of Bodily Positio	• Mental imagery
• Respiratory rate	• manipulative		• Self-Talk
• Body temperature			

A. Physiological Considerations

It can be further subdivided into two groups as temperature related and non-temperature related (11-12)

Temperature Related

If the core temperature of the Body is increases by 1°C then (BMR) are increased by 14 % increased thus enhance the physical work capacity.

- Decreased resistance of muscles and joints.
- Greater strength of contraction due to improve elasticity of muscles fibers.
- Improve speed of contraction which is necessary former transmission to Muscles fibers.
- *It helps to minimize threat of injuries which helps to increase speed of Contraction due to an increase in blood flow which help stormed more oxygen Supply to the muscles.*
- Greater release of oxygen from haemoglobin and myoglobin
- Speeding of metabolic reactions
- Increased nerve conduction rate
- *It also help to prepare respiratory system, Nervous system, muscular skeletal for the main physical activity.*
- Warming up helps to increase chemical reactions and release more energy to the Muscles along with increased blood flow to

the muscles to increase supply more Oxygen and remove waste product from the body.

- Increased thermoregulatory strain

Non-Temperature Related

- Increased blood flow to muscles
- Elevation of baseline oxygen consumption

B. Basic Psychomotor Skills

These are the primary skills upon which the complex athletic skills are based on. Theses kills can be divided into three categories such as **locomotor skills**, **non-locomotor skills** and **manipulative skills**.

- Locomotor skills involving change of location and direction: such as carrying, supporting, crawling, pushing, pulling, climbing, hopping, jumping, running, skipping etc.
- Non-locomotor skills involving the movements around imaginary axis of the body. The limbs in motion around an axis with no change of location: twisting, bending etc.
- Manipulative skills involving grasping or handling objects with hands or feet. It the improvisation of locomotor and non-locomotor skills.

C. Kinesthetic Awareness

It is the sense of awareness of body in space. Traditionally kinesthetic is developed through coaching but it is the athlete's personal ability to move in airborne position and it is based on perception and physical abilities. Excellent kinesthetic sense consists of, concise text on movement behavior, perceptual and physical abilities, and non-discursive communication which is also related to warming up before any sporting action.

D. Psychological Considerations

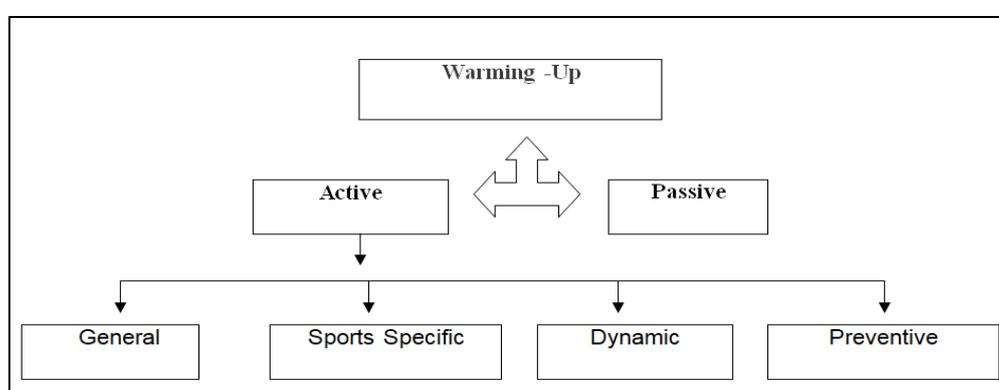
- Adequate time is necessary focus on their upcoming challenge through mental imagery.
- Performers are allows to interact with the teammates, which helps the performer to relax and develop the process of socialization.

- Warming up develops the confidence of the performer.
- Based on the objectives of the performance, allowing the performer to focus in on their upcoming task. Performance goals rather than outcome goals are discussed.
- Positive self-talk is encouraged by the coach who always speaks in the positive frame.

A warm up is not simply a process of increasing body temperature. The warm up allows the performer to find their zone and to prepare their mind for the tough challenge to come [13].

Types of Warming Up

The types of warming up are as follows [14-16].



- **Active Warming Up:** The athlete has to perform set of exercises in order to raise the body temperature for better sporting events later on. It can be a combination of dynamic and static exercises.
- **General Warm-Up:** General warm up includes several activities and a light workout that helps to increase the blood flow and stimulates the major working muscles. Some of the most effective and straightforward general warm-up activities are stretching, skipping, squatting, jogging and running. It is the general preparation of an athlete involving all the major muscle groups.
- **Sport Specific Warm-Up:** The purpose of specific warm up is to stimulate specific body muscles that are going to be used most of the time in the sport. For specific muscle groups specific warming up is necessary as for example hand running is the most appropriate warm-up for a sprint runner.
- **Dynamic Warming up:** Dynamic heating is distinguished by the implementation of a wide variety of biological processes: **strength, flexibility, proprioception and balance, breath control**, Sharpening of reflexes, etc. the above types of warm-up differ in particular by emphasizing the parts of the body involved, in this case the main characteristic is the nature of the activity to be carried out.
- **Preventive Warming Up:** It is the implementation of specific instructions indicated by a professional that has given guidelines for preventing a specific injury class or worsening of an injury that already exists. By its nature, it is low intensity, although its nature can vary considerably depending on the case and the possible risk incurred by athletes. Depending upon the past injury point of view the exercise schedule has been prepared for an athlete before performing sporting action.
- **Passive Warming Up:** Passive warm up is basically using external heating sources to warm body. Sauna, steam bath and Jacuzzi are the most common and popular method of passive warming up. If a sauna is not available, one can use a sauna blanket with infrared technology since it works like being inside the regular sauna. Though it increases the body temperature and relaxes the muscles, it contributes little to stimulate the cardiovascular system.

The Sequence of warming up exercises is as follows:

- **General to specific**
- **Simple to complex**
- **Slow to fast**
- **Known to unknown**

Component of Warming Up

The six important component of warming are as follows in the Table-2 [17, 18].

Table 2: Component of Warming up

Pulse raiser	Slowly increases heart rate and body temperature Eg- jogging and skipping
Mobility	Take joints through their full range of movement Eg-arm swing and hip circles
Dynamic movement	Change in speed and direction Eg-shuttle runs
Stretching	Developmental stretches and dynamic stretches are linked to the sport Eg-groin walk and open and close the gate
Skill rehearsal	Rehearsing common movement patterns and skills which will be used in the activity Eg-passing drills for football
Heighten kinesthetic awareness to improve proprioception	Take a quiet moment to come into the practice of listening to bodily response. Release unnecessary tension and aware of movement behavior. Consider the tripod of balance of the feet to rest restore balance. 

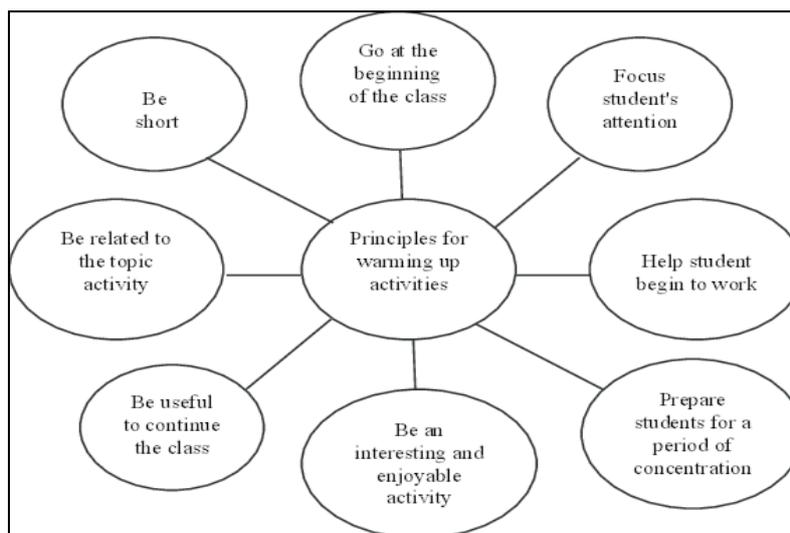


Figure 1: Principles of Warm up Activities [19, 20]

Warming Up Design

A well-designed warm-up can increase blood flow, muscle temperature, core temperature [21, 22], and also disrupt temporary connective tissue bonds [23]. These effects can have the following positive effects on performance:

- Faster muscle contraction and relaxation of both agonist and antagonist muscles [24].
- Improvements in the rate of force development [25].
- Improvements in reaction time [26].
- Improvements in muscle strength and power [27].
- Lowered viscous resistance in muscles [23].

- Improved oxygen delivery due to the Bohr Effect where higher temperatures facilitate oxygen release from haemoglobin and myoglobin [22].
- Increased blood flow to active muscles [22].
- Enhanced metabolic reactions [23].

The framework “RAMP” protocol developed by Dr. Jeffreys [28] allows for activities to be easily classified and constructed in the following warm-up sequence:

- **Raise**
- **Activate**
- **Mobilise**

- **Potentiate** (or Performance in this articles modified variation of the RAMP protocol)

Phase 1 – Raise

The aim of the ‘raise’ section is too: ↑ Body temperature, ↑ Heart rate, ↑ Respiration rate, ↑ Blood flow and ↑ Joint viscosity

Phase 2 & 3 – Activate and Mobilize

The aim of this phase of the warm-up is two-fold: Activate key muscle groups, Mobilize key joints and ranges of motion used in the sport or activity, during this phase of the warm-up, typical activation and mobilization movements include.

Mini-band routines, Balance work, Superman’s and inchworm’s Squats and lunges, Sumo shuffles, Spinal mobility exercises (flexion, extension, lateral flexion, and rotation).

Phase 4 – Potentiation or Performance (Modified Version)

The aim of this phase is to ‘prime’ the athletes for their session or competition.

This phase of the warm-up is fixated on exercises which will directly lead to performance improvements in following activities. Developed using the principle of post-activation potentiation, this phase of the warm-up will now begin to unidentifiably transit into the workout/sport itself, meaning it will begin to

incorporate sports-specific activities using rising intensities. This phase serves two primary objectives:
↑ Intensity to a comparable level the athletes’ are about to compete in.

↑ Improve subsequent performance utilizing the effects of post-activation potentiation.

Pre exercise static stretching in not recommended in an ideal warming-up plan for any sporting events. The recent research evidence suggest that pre-exercise static stretching also compromises subsequent performance by reducing force production [29, 30], power output [31], running speed [32], reaction time [33], and strength endurance [34] and this may increase the risk j of injury.

Cool Down

Cooling down is similar to warming up. You generally continue your workout session for five minutes or so, but at a slower pace and reduced intensity. A cool down is an essential part of your workout. A cool down can last for 3–10 minutes and includes stretches or gentle variations of the movements you did during your workout. The purpose of cooling down after exercise is to allow your heart rate and breathing to return to normal and to promote relaxation [35, 36]. Better psychophysiological recovery following exercise may attenuate or prevent performance decrements—or even enhance performance—during a subsequent training session or competition [37].

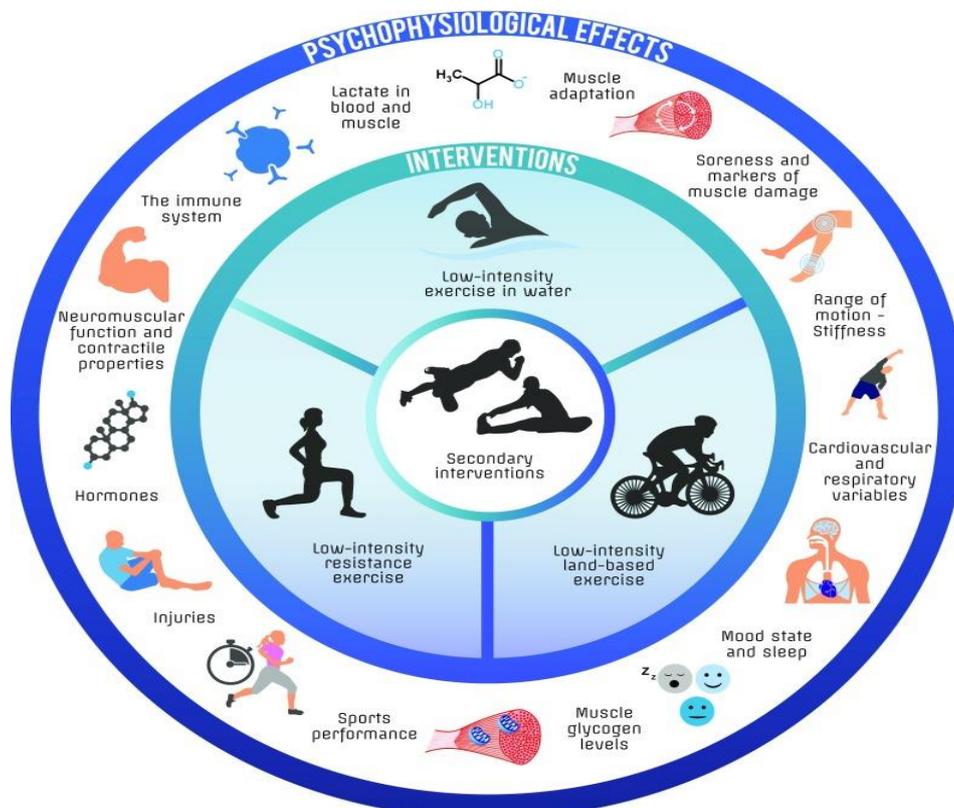
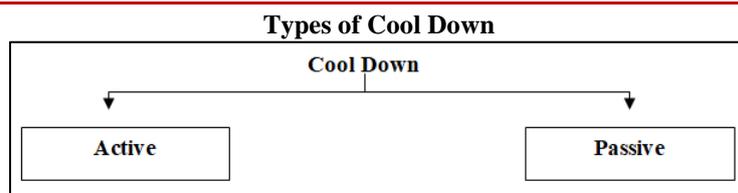


Figure 2: Psychological benefit of cool down (cited from Bas Van Hooren and Jonathan M. Peake, [38])

Important Benefits

- **Improves Relaxation: Effective cool down protocol is helpful to promote relaxation in body and mind after exhaustive exercises.**
- **Removal of Metabolic By-Products:** High-intensity exercises are facilitates to an accumulation of metabolic by-products in muscle such as lactate, which is related with fatigue [39]. Large body of research has shown that a variety of low- to moderate-intensity active cool-down protocols are more effective than a passive cool-down for removing lactate from blood [40,41] and muscle tissue [41, 42].
- **Delayed-Onset Muscle Soreness:** An active cool-down increases the blood flow to muscles and skin . This increase in blood flow may reduce the accumulation of metabolic by-products and factors associated with muscle soreness (e.g., cyclo-oxygenase and glial cell line-derived neurotrophic factor [43].
- **Indirect Markers of Muscle Damage:** Though an active cool-down is generally not effective for reducing delayed-onset muscle soreness, it may have beneficial effects on other markers of muscle damage [38].
- **Neuromuscular Function and Contractile Properties:** The research findings [44] indicate that an active cool- down does not significantly affect the recovery of neuromuscular function or contractile properties. Hence, active cool-down programme is highly recommended as they are related with other beneficial components.
- **Stiffness and Range of Motion:** The scientific evidence available suggests that an active cool-down does not significantly attenuate the decrease in range of motion and perceived physical flexibility, or attenuate the increase in musculo-tendinous stiffness up to 72 h after exercise [45, 46].
- **Muscle Glycogen Resynthesis:** High-intensity exercise can deplete muscle glycogen storage, and this can impair subsequent high-intensity exercise performance up to 24 h post-exercise [47]. An active cool-down may interfere with muscle glycogen resynthesis, particularly within type I muscle fibers [48], because these fibers are preferentially recruited during a low- to moderate-intensity active cool-down.
- **Recovery of the Immune System :** During the recovery period from high-intensity or prolonged exercise, there can be a temporary depression of the immune system (also referred to as an ‘open window’) during which microbial agents such as viruses have an increased chance to cause an infection or illness [49]. The research findings [50] suggest that an active cool-down able to partially prevent the depression of circulating immune cell counts immediately after exercise, but this effect is probably negligible >2 h after exercise.
- **Cardiovascular and Respiratory Variables:** The cardiovascular and respiratory systems are highly active during exercise to supply the exercising muscles with blood and oxygen. The cardio-respiratory system do not immediately return to resting levels after exercise, but remain activated for a considerable amount of time. An active cool-down is frequently performed in an attempt to restore normal activity of these systems after exercise [51]. An active cool-down has also been reported to lead to a faster recovery of respiratory variables such as minute expiratory ventilation, although this primarily occurred during the initial 20 s of the cool-down [52].
- **Sweat Rate and Thermoregulation:** Similar to the cardiovascular and respiratory systems, muscle and core temperature can remain elevated above resting levels up to 90 min after exercise. Sweat rate is higher after exercise to reduce the core temperature to resting levels [53]. Passive cool-down able to create decrease sweat secretion and faster normalize the core body temperature.
- **Mood State, Self-Perception, and Sleep:** The psychological effects are intimately linked to the physiological effects, and are also of major importance for performance. An active cool-down is seems to be more beneficial than a passive cool-down. Research reported for doing an active cool-down include relaxation, socializing and time to reflect on the training or match [54] and it also a matter of good mood and sleep.
- **Hormone Concentrations:** It is known that the rate at which hormone concentrations return to resting levels can be used to characterize physiological stress [55] and psychological recovery [56]. Findings suggest that an active cool-down may result in a slower recovery of hormone concentrations immediately after exercise, but does not significantly affect the recovery of hormonal concentrations beyond 30 min post-exercise compared with a passive cool-down.



A. Active Cool-Down

- Your cool-down should also be active, but it's not as crucial to your performance since the exercise has already been completed. Stretching can be part of your cool-down but it shouldn't replace the active part of your cool-down.
- Aim for 5-10 minutes for your warm-up and cool-down. But listen to your body. In cold weather, you may need to allow more time to warm-up and you may want to cool-down inside.
- As we age, both the warm-up and cool-down become even more important. Everything is slower to reach peak efficiency. In particular, it takes longer for the arteries to dilate and constrict.
- In people with heart disease, missing a warm-up or doing a short one may result in angina or chest pain. This is the result of the heart arteries not been given enough time to open to allow sufficient blood flow to the heart. If this happens, a longer warm-up is needed (if it persists, consult your doctor).

B. Passive Cool-Down

Passive cool down refers to reduce the core body temperature by means of external ways without much active participation of an athlete. The various modalities of passive cool-down are as follows :

1. Sitting, standing, or lying rest
2. Cold-water immersion
3. Sauna
4. Hot-water immersion
5. Massage
6. Contrast-water therapy
7. Pneumatic leg compression
8. Cryotherapy
9. Peristaltic pulse dynamic compression
10. Crycompression therapy
11. External counterpulsation therapy
12. Flotation Restricted Environmental Stimulation
13. Compression garments
14. Hyperbaric oxygen therapy
15. Intermittent negative pressure
16. Foam rolling
17. Vascular occlusion
18. Static stretching
19. Local or whole-body vibration therapy
20. Neuromuscular electrical stimulation
21. Ultrasound therapy Sustained heat treatment

Procedure of Cool-Down

The procedure of cool down protocol is as follows:

- Low intensity exercises
- Breathing exercises
- Slow jogging
- long-hold static stretching
- very gentle self-massage of major muscle groups
- Laying or savasana
- Re-hydrate or re fuel.

CONCLUSION

Warming up and cool down is very common phenomena for sports trainers and athletes. The scientific principles associate with warming up and cool-down is discussed here and the procedure to administer an ideal warming up session for 20 minutes of duration and cool down for 5-10 minutes of duration is discussed with evidence. The performance of an athlete is highly related with their preparedness just before the mega sporting events and for maintaining homeostasis and injury point of view the importance of cool down one cannot ignore.

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