Educational Administration: Theory and Practice
2024, 30(1), 3685 - 3692
ISSN: 2148-2403
https://kuey.net/

Review Article

Testing And Training Considerations For Kettlebell Sport – Snatch

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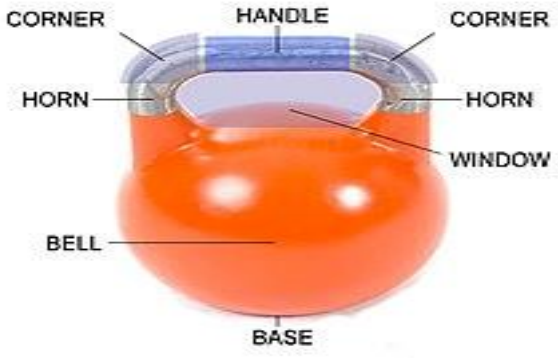
Citation: Devimeena Sundaram (2024) Testing and training considerations for kettlebell sport – Snatch, *Educational Administration: Theory and Practice*, *30*(1), 3685 - 3692
Doi: 10.53555/kuey.v30i1.7426

ARTICLE INFO

ABSTRACT

This study is aimed to analyze and understand the testing protocols and training considerations for kettlebell sports. The focal point of this article is kettlebell snatch. Although the popularity of kettlebells is increasing, fewer facts are known [6] about kettlebell testing protocols and training methodologies. The sport consists of three main lifts—the snatch, jerk and long cycle. A kettlebell snatch involves continuously swinging the kettlebell between the legs by extending the hips, knees, and ankles and using the momentum to take the kettlebell overhead [6]. It is generally performed for multiple repetitions with only one hand change. It is performed in a biathlon or as a standalone event in Girevoy competitions. The long cycle consists of 10 minutes [8] of clean & jerk, where the bells are cleaned from knee level to chest and then jerked overhead. It can be done with one or two kettlebells. Jerk is performed by grasping two kettlebells in each hand, swinging to the rack position at chest level, and then jerking above the head. A judge determines if the repetitions are performed correctly and allocates a point accordingly. Kettlebell lifting is a highly technical sport [6,8] that involves the technicality of snatch, clean, and jerk. For a person to compete at the national/international level, strength and aerobic capacity with explosiveness are imperative. To improve performance, it is prudent to focus on complex training, an essential aspect of post-activation potentiation. Needs analysis based on biomechanics and injury epidemiology is discussed in this article. Individual athlete assessment is necessary. Mobility must be prioritised to prevent injury, as kettlebell moves are highly ballistic. [1]

Prelude to kettlebells



A kettlebell is a cannon ball-shaped equipment with a handle made of cast iron and can be used for various exercises [7]. It is ballistic and can be used widely to improve endurance, fundamental strength and flexibility. The Russian girya was a type of metal weight primarily used to weigh crops and used by circus strongmen during the 19th century. Russian girya [7] is traditionally weighed by pood, corresponding to 16kgs. Unlike traditional dumbbells, a kettlebell's centre of mass is extended beyond the hand and facilitates ballistic and swinging movements. Kettlebell exercises build strength and endurance [6], particularly in the lower back, legs, and shoulders, increasing grip strength. Exercises can be performed with either one or two kettlebells. Swing, push press, clean and jerk, snatch, and Turkish getup (TGU) are the various exercises that can be done with

kettlebells. All the exercises usually involve high repetitions, unlike traditional weight training, and they are holistic, working on different muscle groups simultaneously. Since it focuses on large volumes and is explosive, it combines aerobic and high-intensity interval training. Kettlebell is inherently not dangerous or comes with a risk factor. However, poor technique, weak core, or shoulder issues can cause injuries to athletes. Proper progression and a good GPP support kettlebell training and can benefit health and help improve flexibility, cardiovascular endurance, mental toughness, and strength.

Needs Analysis

Kettlebell training programs follow specificity, overloading, and progression principles, such as resistance training. Specificity is nothing but SAID, specific adaptation to imposed demands [4]. The demand placed dictates the adaptation. Overloading and progression refer to the intensity placed and, when appropriately applied, promote long-term training benefits.

Needs analysis [4] includes movement analysis, physiological analysis, and injury analysis. It's essential to assess an athlete's profile by evaluating training/injury status, conducting various tests, and assessing the results.

Movement analysis

The biomechanical movement of kettlebell snatch involves upward and downward phases within each repetition [5]. Using the overhead lockout position as the starting and finishing position for descriptive purposes is helpful. The overhead lockout position is termed fixation. Successful fixation is essential for scoring a point within GS (Girevoy sport). Fixation requires the athlete to stop and briefly control the kettlebell motion overhead. During the fixation, the kettlebell handle rests diagonally across the palm, and the bell rests on the back of the wrist and forearm [8]. From the overhead position, the downward phase is initiated with the drop. The kettlebell moves from the palm into the fingers before moving into the back swing, where the kettlebell passes between the legs. In contrast, the upward phase starts with the forward swing, then the acceleration pulls and lastly, the hand insertion phase.

The downward phase of kettlebell snatch covers fixation, drop, re-gripping and back swing, while the upward phase includes forward swing, acceleration pull, hand insertion and fixation.

The downward phase of the kettlebell snatch starts from the fixation; the drop takes place often with a countermovement away from the kettlebell. As the shoulder extends, moving the kettlebell away and downwards, the elbow supinates, flexes, and then the lifter's arm straightens. During the re-gripping phase, the elbow is extended as the athlete manoeuvres the handle from across the palm into the fingers. The backswing phase begins once the elbow extends and the handle is in the fingers. At the start of the backswing, the torso remains upright until the kettlebell passes between the legs. At this point, hips start to flex, and knees extend slightly. The backswing comes to an end and moves into the forward swing [8].

The upward phase of the kettlebell snatch starts with the forward swing, with the kettlebell moving between the legs by extending the hips and slightly flexing the knees. The acceleration pull begins as the kettlebell passes through the knees and ends when the handle moves out of line with the arm. This is the most influential motion in the snatch and is described as having a rapid contraction. The acceleration pull involves knee and hip extension, ipsilateral torso rotation and elbow flexion. The last part of the upward phase includes hand insertion by moving the handle from the fingers to the palm while the elbow is extended and the torso rotates contralaterally. The kettlebell rests diagonally across the palm and comes to rest in the overhead position whilst in fixation, and the process is repeated.

Many physical characteristics are required for kettlebell sport, and the ways to develop them are summarised below.

Physical Demands	Needs or requirements	Related exercises to meet the demands of the sport
Lower body strength >=85% 1RM <=6 reps	Lower body strength is crucial to power hip and knee extension while accelerating the kettlebell forward.	All types of squats, deadlift, glute & hamstring strengthening exercises
Upper body strength >=85% 1RM <=6 reps	Upper body strength includes the shoulder, trapezius, bicep, triceps, chest, and all upper body muscles, which are involved in powerful lockout during the upward trajectory.	All pushing exercises, including shoulder press, close grip bench press, targeting triceps, rows and dips.
Relative strength	Body weight exercises like pushups and abdominal exercises are essential for good relative strength.	Pushup, plank and its variations
Core strength	Core strength is vital for any ballistic exercise to maintain a stable and robust midsection to withstand the explosive nature of the sport.	All abdominal exercises, including body weight and external loads
Power	Kettlebell is a ballistic training requiring SEC activities and muscle spindle activation that uses mechanical and neurological models for its explosiveness.	All kinds of plyometrics emphasise the stretch-shortening cycle with a countermovement phase.
Flexibility and mobility	Flexibility refers to the elastic properties of a muscle, while mobility refers to the range of motion of a joint. Both are vital to prevent injury.	Dynamic stretches are done as a part of warmup that starts from low intensity and typically mimics the sport moves before the actual training or competition. Static stretches don't invoke stretch reflexes, elicit great flexibility responses and are performed during the cool-down period. Mobility exercises are crucial for allowing the joints to move in their fullest range. Drills like full squats and overhead squats with the knees over the toes and hands closer to the ear should be done to fulfil the requirement when viewed from the frontal plane.

Physiological analysis

Kettlebell places a high demand on both aerobic [3] and anaerobic. It also works on muscle strength. Kettlebell exercise may elicit cardiovascular, neuromuscular, and metabolic responses sufficient to improve strength, aerobic power and overall physical fitness. Several findings support that kettlebell training could improve cardiorespiratory and muscular fitness. Evidence suggests a significant increase in blood lactate levels during training, which indicates high-intensity work involved in the training. Kettlebells are great for improving vo2 max and should not be used for muscle hypertrophy, primarily as in resistance training. In typical resistance training, the eccentric part of the TUT, time under tension is long enough to damage the muscle, which is imperative for muscle growth. Maximal oxygen uptake [3] is crucial for kettlebell training, but the lactate

threshold significantly differs between individuals. An athlete with a high lactate threshold is expected to perform at higher intensities without fatigue than an athlete with less LT. Also, it's essential to work on MLSS, maximal lactate steady state, which is an absolute marker for aerobic activities and refers to the rate at which the lactate clearance is greater than accumulation; the athlete performs better without fatigue. It's important to work close to or greater than vo2 max to elicit this response. This response is associated with a rapid increase in anaerobic metabolism, contributing to the energy cost of exercise.

Injury epidemiology

Kettlebell sport doesn't possess any inherent risk. [7]. However, faulty technique, poor body strength, and not wearing good weight-lifting shoes can all hamper progress and may cause injury. Since kettlebell sport is based on a maximum number of repetitions in 10 minutes and is compared between different athletes competing at the same weight category and lifts, it puts pressure on the athlete to increase the speed at any time of the competition and training. This repetitive stress can lead to any microtrauma injury, including bone and tendon. Careful monitoring and proper programming can help reduce or prevent this. The major joints, like the hip and knee, essential for powerful extension, can go under stress because of repeated flexion and a forceful extension for a good lockout. Also, the pull should happen after the hip extension so that the hips come into play [5], saving the shoulder. An early pull can put shoulder joints at risk, resulting in rotator cuff tears and may not be optimal [5]. Too much flexing during the insertion phase might cause stress on the forearm muscles and result in lactic accumulation, which might cause an athlete to decrease the snatch speed. Improper hand insertion might cause callouses on the palm because of constant friction and will dampen the speed, leading to a decrease in the number of repetitions required for the 1st place.

Low back injuries are common with kettlebell sports when performed improperly using a poor-quality hip hinge movement. In addition, lifting too much or too soon the wrong way can lead to muscle strains. The ballistic nature of the sport means that the training program must focus on achieving good core strength and endurance alongside flexibility and mobility to create the power to attain the required reps.

Assessment of Athlete–Training Protocols

An ideal testing protocol for kettlebell athletes doesn't exist. Veteran athletes do some basic assessments, and they are widely followed. However, per the strength and conditioning guidelines, testing helps athletes and coaches assess athletic talent and identify physical abilities and areas needing improvement. In addition, testing helps set goals.

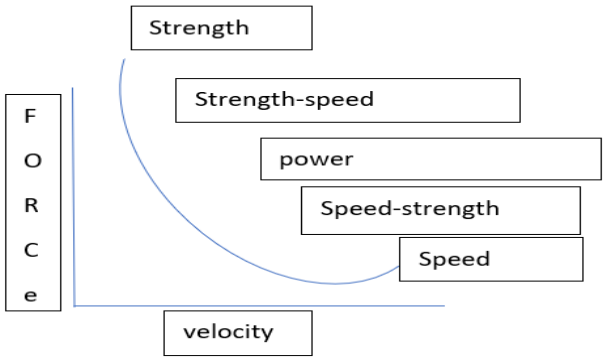
Athletic talent

Athlete's talent is based on their innate physical abilities and training status. While some physical skills can be improved through training, some are not amenable to change. The level of preparedness or current condition is an essential consideration in the design of training programs. Training status determines the capacity of an athlete and exercise technique experience. Athletes of advanced training age can take two lifts, like biathlon, or aim for higher reps and compete in the elite category.

Selection of tests

It is essential to consider sports specificity, including metabolic energy system specificity and biomechanical movement pattern, while also considering athletes' training age and experience for high levels of validity and reliability. A test must be reliable to be valid [4].

Kettlebell sport is highly endurance-based and ballistic, which means it is performed for 10 minutes and, in some cases, more than that for marathons. In both cases, it deploys explosiveness to achieve maximum reps. The force-velocity curve for kettlebells is performed at a point where it uses submaximal force and velocity [2], which continuously stresses the vo2 max and power output. Understanding the different energy systems (Phosphagen, Glycolytic, and oxidative)[4] It is imperative to apply specificity when designing valid tests and their interrelationships.



Sports differ in their physical demands. Some demands are very specific to certain sports and less relevant to other sports. In kettlebell sport, athletes require high oxidative support without getting fatigued and not much accumulating lactic for optimal performance [3]. It is wholly based on the glycolytic pathway, which works to improve the lactate threshold as the intensity increases. Athletes require a good range of motion and flexibility to ensure zero compensation. They require vo2 max testing to ensure their current level of oxidative capacity and to identify the point or % of oxygen consumption at which they get tired. This helps improve lactate threshold (LT) and better lactate clearance. Vo2 max is a lab test, whereas 1.5-mile run, 12-minute run, or yoyo intermittent tests are field tests that enable the coach to determine the athlete's oxygen consumption capacity and also the % at which they get tired and start working in elevating LT levels. This is an important test protocol in any endurance sport, as improving vo2 max and LT are proven to show great results. In addition, it's essential to assess the flexibility. An overhead squat test should be included to ensure a well-rounded testing regime. Muscular endurance tests like pushups and curls should be counted as well. Finally, the kettlebell is an endurance sport judged throughout the competition among athletes of the same weight category. An athlete who weighs less than their counterparts will be on the beneficial side. Non-fatiguing tests like weight and flexibility should be checked before the aerobic test. Having a note on the weight at the start will give an insight into how to take the training and help decide the weight category to compete for. Having known their weight, athletes either work to reduce the scale to fit into a particular weight category or maintain the same weight. However, in both scenarios, they keep improving strength and stamina, which is the solid underpinning of kettlebell sport.

Test protocols [4]

1. Non-fatiguing tests – weight and flexibility. Weight can be checked with any good standard scale. Weighing before ingestion of food and fluids and after excretion is essential. Minimal clothing is advised during weighing.
2. Flexibility – wooden dowel/ PVC/ barbell can be used. The wooden dowel or PVC is held overhead with the shoulders fully flexed and elbows locked. The grip is twice shoulder width and feet approximately shoulder width with toes slightly pointing out or forward. The athlete then squats down by flexing hips and knees while the heels remain in contact with the floor. The squat's depth continues until the hip's crease is below the top of the knee. An upright torso should be maintained for a minimum of five reps.
3. Muscular endurance – The pushup test can be done with knees on the floor; women and men assume the standard pushup starting position with hands shoulder-width apart and elbows and body straight. The test should be done to check the maximum number of good reps where the upper arms are parallel to the ground.
4. Aerobic tests – A 1.5-mile run is a field test, and each athlete warms up and stretches before the test. Athletes are instructed to complete the run as quickly as possible at a steady pace that they can barely maintain over the distance. On an auditory signal, the athletes start running and cover the course quickly.

Implementation of the needs analysis

Sport evaluation [4]	**Athlete's profile**	**Primary In-season training goal**
Movement Analysis Sport – Repetitive swing followed by upward trajectory with full lockout overhead. Muscles involved – all lower body muscles, while pull and press involve the back and shoulders.	Training background 1. Training age (training status) 2. Technique experience and skill 3. Training frequency	Muscular endurance while also working on power to amplify explosivity.
Physiological analysis Endurance/power	Training status decides the training frequency and then comes the sports season.	Endurance sport primarily follows reverse linear periodization.

Program Configuration

The goal of the testing battery is to identify the demands of the sport and the athlete's training readiness or level of preparedness. [4]. Testing gives an idea of baseline measurements, and goals are set based on that. Based on test results, it is evident that a strength and conditioning program for kettlebells should aim to improve vo2 max, LT and muscular endurance while also working on power to maintain explosiveness.

The strength and condition program for kettlebell snatch follows reverse linear periodization. A reverse linear periodization plan [1] It works well for any endurance sport as the sport's emphasis, or the primary goal during in-season is the volume, unlike the intensity of a linear periodization plan. A kettlebell athlete's Off-season, Pre-season strength and conditioning program typically starts with low volume, high intensity to moderate volume, moderate intensity to high volume and low intensity towards the season or competitive period. [1]. Planned progressions and regressions are to be made to avoid fatigue and injury, and an unloading week is added at the end of a mesocycle.

Before diving into the strength and conditioning program, it is essential to understand how the sports season influences an athlete's presence in the weight room and his training status. The strength and conditioning

program discussed here focuses on an athlete whose training age is > two years, falls under the advanced category and possesses high exercise technique experience and skill [4].

Off-season training plan
- Follows reverse linear periodization
- Low-to-volume, high intensity
- Strength focus

Pre-season training plan
- Moderate volume, moderate to high intensity
- Hypertrophy focus

In-season training plan
- High volume, low to moderate intensity
- Muscular endurance focus

Off-season training sample (Mesocycle 1, 4 weeks) – Low volume, High intensity (80 to 90% 1RM, 2-5 sets, 3-6 reps) [4]

Athlete name:
Goal:

Session - 1

Exercise	Sets	Reps	Week 1	Week 2	Week 3	Week 4	Unloading week 5
Back Squat	3	5	80% 1RM	83% 1RM	85% 1RM	87% 1RM	75% 1RM
Military press	2	5	80% 4RM	85% 4RM	87% 4RM	90% 4RM	70% 4RM
Chest press	3	5	80% 4RM	80% 4RM	85% 4RM	87% 4RM	70% 4RM
Tricep dip	3	15	BW	BW	BW	BW	BW
Bent over row	3	5	82% 5RM	85% 5RM	87% 5RM	90% 5RM	72% 5RM
Romanian Deadlift	3	6	85% 3RM	90% 3RM	93% 3RM	95% 3RM	75% 3RM

Session - 2e

Exercise	Sets	Reps	Week 1	Week 2	Week 3	Week 4	Unloading week 5
Incline chest press	3	5	75% 4RM	77% 4RM	80% 4RM	82% 4RM	70% 4RM
Push press	3	4	70% 6RM	75% 6RM	77% 6RM	80% 6RM	75% 6RM
Sumo Deadlift	3	6	75% 3RM	78% 3RM	80% 3RM	85% 3RM	80% 3RM
Push up	3	15	BW	BW	BW	BW	BW
Pull up	3	15	BW	BW	BW	BW	BW
Front squat	3	4	67% 3RM	70% 3RM	75% 3RM	80% 3RM	70% 3RM

Pre-season training sample (Mesocycle 1, 4 weeks) - moderate volume, Moderate to High intensity (67% - 85% 1RM, 3-6 sets, 6-12 reps)

Exercise	Sets	Reps	Week 1	Week 2	Week 3	Week 4	Unloading week 5
Good mornings	3	10	70% 8RM	72% 8RM	75% 8RM	80% 8RM	72% 8RM
Dumbbell chest press	3	10	75% 10RM	77% 10RM	80% 10RM	85% 10RM	72% 10RM
Pull up	4	15	BW	BW	BW	BW	BW
Close grip bench press	4	10	72% 8RM	77% 8RM	80% 8RM	82% 8RM	75% 8RM
Lunges	4	10	70% 6RM	75% 6RM	77% 6RM	80% 6RM	72% 6RM
Shoulder press	3	10	72% 8RM	75% 8RM	80% 8RM	82% 8RM	75% 8RM

Session - 1

Session - 2

Exercise	Sets	Reps	Week 1	Week 2	Week 3	Week 4	Unloading week 5
Pendley rows	3	10	67% 10RM	70% 10RM	72% 10RM	77% 10RM	75% 10RM
Push up	4	15	BW	BW	BW	BW	BW
Loaded squat jumps	4	20	40% 8RM	45% 8RM	50% 8RM	50% 8RM	45% 8RM
Stiff leg deadlift	3	10	70% 10RM	72% 10RM	75% 10RM	80% 10RM	75% 10RM
Seated rows	3	12	67% 8RM	70% 8RM	72% 8RM	77% 8RM	72% 8RM
Plank & Variations	3	Time in secs	45s	45s	60s	60s	45s

In-season training sample (Mesocycle 1, 2 weeks, Strength endurance phase 1) & (Mesocycle 2, 2 weeks, endurance phase 2) - high volume, low to moderate intensity (50 – 70% 1RM, 3-6 sets, 8 – 20 reps)

Strength endurance phase 1 – Mesocycle 1, 2 weeks
Days – Monday/Friday

	Week 1			Week 2		
Exercise	Sets	Reps	Intensity	Sets	Reps	Intensity
Bench press	3	12	60% 5RM	3	12	65% 5RM
Back squat	3	12	65% 8RM	3	12	70% 8RM
Shoulder press	3	10	65% 10RM	3	10	70% 10RM
Romanian deadlift	3	10	70% 8RM	3	10	75% 10RM
Abs roller	3	15		3	20	
Tricep dips	3	20	BW	3	20	BW

Days – Wednesday

	Week 1			Week 2		
Exercise	Sets	Reps	Intensity	Sets	Reps	Intensity
Close grip bench press	3	15	50% 5RM	3	15	55% 5RM
Squat jumps	3	30	BW	3	30	BW
Good Mornings	3	10	60% 10RM	3	10	65% 10RM
Push up	3	15	BW	3	20	BW
Plank	3	45secs	BW	3	45secs	BW
Dumbbell rows	3	15	60% 5RM	3	15	65% 5RM

Friday's workout should be 10% less than Monday's
*BW – Body weight, *5RM/8RM/10RM – Training loads based on those RMs

Strength endurance phase 2 – Mesocycle 2, 2 weeks
Days – Monday/Friday

	Week 1			Week 2		
Exercise	Sets	Reps	Intensity	Sets	Reps	Intensity
Pull up	3	30	BW	3	50	BW
BW squat	3	50	BW	3	70	BW
Military press	3	15	30% 10RM	3	15	35% 10RM
Close grip bench press	3	20	30% 8RM	3	30	40% 10RM
Farmers walk	3	45secs	Two heavy dumbbells	3	45secs	Two heavy dumbbells
Tricep pushup	3	20	BW	3	20	BW

Days – Wednesday

	Week 1			Week 2		
Exercise	Sets	Reps	Intensity	Sets	Reps	Intensity
Squat jumps with countermovement	3	50	BW	3	100	BW
Good morning	3	15	30% 10RM	3	15	40% 10RM
Tricep dip	3	20	BW	3	30	BW
Romanian deadlift	3	30	40% 10RM	3	50	40% 10RM
Squat	3	20	30% 8RM	3	40	40% 8RM
Tricep dips	3	20	BW	3	20	BW

*Friday's load should be 10% less than Monday's
5RM/8RM/10RM – training loads are based on those RMs
*BW – body weight

Practical application

Because variables like loads, reps, sets, and their interplay influence kettlebell sports success, it is essential to understand and incorporate interval runs and several explosive bodyweight exercises to improve quickness and vo2 max capacity. Short interval runs of 3 to 5 mins with a 1:1 work-to-rest ratio work close to vo2 max helps increase vo2 max. Some days, it adds high-intensity interval runs, which target intensity greater than vo2 max aids to elicit anaerobic glycolysis responses. This is particularly important during the last stages of an anaerobic endurance event when the push is needed to pass a competitor or set a record. Kettlebell sport is highly ballistic, and it should be noted that it depends on the countermovement and how quickly the energy is released during the concentric phase. Loading of the hips before extension is essential for performance. It's advisable to include

plyometric exercises with countermovement jumps, which are vital for both stored elastic energy in the tendons and potentiation by using stretch reflexes in the muscle spindles. For example, the training protocol of back squat, eight reps @ 80% 3RM immediately followed by body weight squats or loaded squat jumps @ 30% 10RM results in post-activation potentiation, meaning the high threshold motor units or type 2 muscle fibres recruited in the back squat exercise helps in greater activation of muscle when immediately followed by a plyometric exercise, squat jump. This is also known as complex training. To have a well-rounded approach, a strength and conditioning program for kettlebell sports should focus on all aspects of training.

Summary

Kettlebells are used for both general athletic training and competitive sports. They facilitate whole-body dynamic movement for strength, endurance and power training. This article discusses on evidence-based needs analysis and physiological and injury analysis. I have discussed snatch, including needs analysis, testing protocol, and program considerations. Strength and conditioning coaches should aim to develop strength, power and endurance. Various plyometric and body weight explosive exercises should be added to the routine to help enhance the power to meet the kettlebell's ballistic demands. Testing becomes indispensable to diagnose the weakness and realise the strength. The program is built on the test result's outcome and helps develop the needed skills for the sport. Regarding injury, kettlebell is inherently not a dangerous sport but is highly fallible. This may be due to a lack of strength, faulty technique, or both. Strength coaches should focus on all error-prone areas. Strengthening of shoulders and upper body muscles helps prevent glenohumeral injuries. The same principle applies to the lower body as well. Strengthening of hips and knees helps achieve flawless technique and free from injury. Other considerations, such as interval runs and high-intensity training, are discussed. Plyometrics should not be neglected in the training. A dogmatic approach to strength and conditioning programs is always wise, but being practical regarding progression and regression is crucial. Kettlebell sport is becoming widespread worldwide, and it is suggested that many strength coaches consider athletes' body weight, training age, previous training history, injury status, technique experience, and maturity while designing the program.

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