Strength and Conditioning for Cricket Fielding: A Narrative Review

Julian Lim, MSc, CSCS*D,[1] Sing Wong, MSc, CSCS,[2,3] Stuart A. McErlain-Naylor, PhD,[4] Aaron Scanlan, PhD,[5] Luke Goggins, PhD,[6] Rob Ahmun, MSc,[6] Paul Comfort, PhD, CSCS*D,[7,8,9] and Anthony Weldon, PhD, CSCS[10]
[1]National Youth Sports Institute, Singapore, Singapore; [2]The Technological and Higher Education Institute of Hong Kong, Chai Wan, Hong Kong; [3]Cricket Hong Kong, Causeway Bay, Hong Kong; [4]School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, United Kingdom; [5]Human Exercise and Training Laboratory, School of Health, Medical and Applied Sciences, Central Queensland University, Rockhampton, Queensland, Australia; [6]England and Wales Cricket Board, National Cricket Performance Centre, Loughborough, United Kingdom; [7]Human Performance Laboratory, Directorate of Psychology and Sport, University of Salford, Salford, United Kingdom; [8]School of Medical and Health Sciences, Edith Cowan University, Joondalup, WA, Australia; [9]Institute for Sport, Physical Activity and Leisure, Carnegie School of Sport, Leeds Beckett University, Leeds, United Kingdom; and [10]Centre for Life and Sport Sciences (CLaSS), Faculty of Health, Education and Life Sciences, Birmingham City University, Birmingham, West Midlands, United Kingdom

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (http://journals.lww.com/nsca-scj).

ABSTRACT

The main aim of cricket fielding is to minimize runs scored by the opposing batting team. This is achieved through (a) collecting a batted ball and returning it to the wicket-keeper to prevent runs from being scored, (b) dismissing a batter by catching a batted ball, (c) running a batter out by throwing the ball to strike the stumps, or 4) preventing a batted ball from hitting the boundary. These tasks require various physical fitness attributes, which can be developed through progressive strength and conditioning programming. To support strength and conditioning coaches in developing tailored programs for fielding, this narrative review provides comprehensive information, including a needs analysis, match demands, and injury epidemiology. Furthermore, programming considerations are given for physical testing, program design, and youth fielders. It is recommended to design and implement a well-rounded training program for fielding, focusing on developing a broad range of physical fitness attributes (e.g., aerobic fitness, speed, acceleration, change of direction speed, agility, and upper-body and lower-body strength and power). A combination of traditional weight training exercises and cricket-specific drills can be implemented to achieve this target. This approach allows the training program to meet the specific needs for high- performance fielding.

Address correspondence to Julian Lim, limjulian83@gmail.com.

INTRODUCTION

Cricket has grown in popularity over the past 2 decades, with 100 nations now recognized by the International Cricket Council (ICC) (37). Professional cricketers can participate in different match formats (i.e., Twenty20, one-day, and multiday) (60) and concurrently play for their club, franchise, and international teams (96). The aim of cricket is for each batting team to score as many runs as possible against an opposing team that attempts to restrict runs through bowling and fielding (73). Cricketers have various roles within a team, including batter, bowler, wicket-keeper, and all-rounder, with all cricketers required to field during matches (40). With participation continuing to increase, there is a growing focus on enhancing physical performance to help mitigate injury risk in cricketers (17,80), with strength and conditioning (S&C) coaches commonly employed to achieve this target (96). Therefore, S&C coaches

KEY WORDS:
injury prevention; program design; resistance training; speed; power; team sports; throwing

require a detailed understanding of the physical demands imposed for each role in cricket so that they can design appropriate S&C programs specific to the needs of each cricketer (96).

Competence in fielding is an underpinning attribute for teams to successfully compete across all cricket formats (62) because both preventing runs and taking wickets contribute to winning matches (68,71). Compared with batting and bowling, there is a paucity of research investigating the physical demands of fielding, with only time-motion analysis studies of cricket fielding available for reference in the literature (40,59–61,87). These studies used Global Navigation Satellite System (GNSS) technology to track fielding movements during the different match formats of cricket to quantify time spent and distances covered at different exercise intensities. The authors reported positional differences (i.e., outer circle, inner circle, and close fielding positions) in cricket fielding, indicating that the different fielding positions require competency in various fielding skills and physical attributes. Although time-motion analyses can provide physiological information, which is useful for S&C coaches to develop training programs based on quantified match demands, it does not provide all performance-related information about the position-specific demands of fielding (40). However, there is empirical evidence of relevant throwing (10,33) and sprinting (13,33,42) training methods in other athletic samples, which may translate to fielding performance in cricket. Therefore, from the available evidence, this narrative review aims to provide a comprehensive needs analysis for cricket fielding, including match demands and injury epidemiology. Hereafter, S&C programming considerations are given for fielding performance, including approaches to testing, program design, and youth fielders.

NEEDS ANALYSIS

TECHNICAL AND BIOMECHANICAL ANALYSIS

The cricket field has nonuniform dimensions and spans a minimum of 137 m from boundary to boundary, with the shorter of the boundaries being a minimum of 59 m and the straight boundary at both ends of the pitch being a minimum of 64 m (all distances are measured from the center of the pitch) (36). The placement of fielders (Figure 1) influences the demands faced and skills required, with most fielding ball contacts occurring with the wicket-keeper (21%), cover (12%), mid-off (10%), and mid-on (9%) positions during multiday matches (76).

Fielding performance can be categorized into 3 distinct phases: (a) movement preparation, (b) multidirectional movement, and (c) throwing (16,28,101).

Movement preparation is an important premovement phase for close and inner circle fielding (16). A "trigger" movement is performed by adopting a balanced stance with the fielder's body weight equally distributed over both feet (i.e., drop squat into an athletic position) (101). Developing lower-body and reactive strength can aid in executing this movement preparation phase (2) and enable fielders to be ready for movement in all directions to obtain the ball by sprinting, jumping, or diving.

Multidirectional movement involves different techniques (i.e., catching, chasing [running or sprinting], and ball retrieval) depending on the match scenario. A jump or dive may be needed to retrieve a ball beyond an arm's reach. Fielders in the outer field may also have to sprint and perform a sliding stop to intercept or retrieve a ball before it reaches the boundary (91). These dynamic techniques may enable a quicker ball return to prevent runs or run out the batter (1). Therefore, a greater ability to accelerate, decelerate, change direction, and jump may be advantageous in fielding scenarios.

Throwing technique underpins a fielder's ability to throw a ball over various distances with speed and accuracy

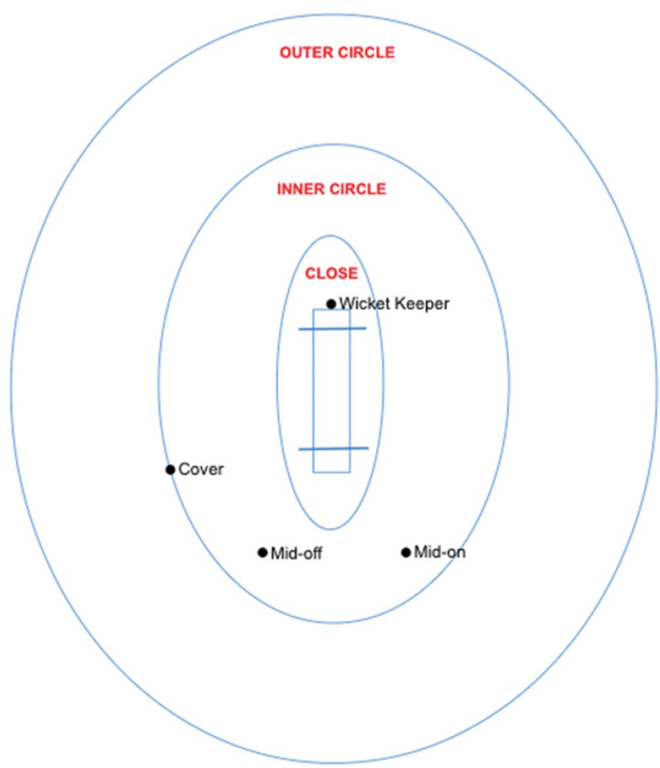


Figure 1. Cricket field illustrating the different fielding positions.

(28). The demands of throwing tasks are specific to the various field positions (Table 1). An effective throwing technique can support fielding performance and mitigate throwing-related injury risk (27).

Cricket throwing has been categorized into 3 distinct biomechanical phases that help to identify key performance variables for consideration: (a) preparatory, (b) arm acceleration, and (c) follow-through (15,21,25,65) (Figure 2).

Preparatory phase. When transitioning from a ball retrieval to a throw, the fielder initiates the throwing preparatory phase with the torso musculature prestretched, the throwing shoulder externally rotated and elevated, and the elbow flexed (15,21). The ipsilateral hip is in approximately neutral flexion/extension, with slight abduction and external rotation (21). There is also thoracolumbar extension and rotation toward the throwing arm, with minimal lumbopelvic movement (21). This phase enables the sequential coordination of the pelvis and upper-torso rotation to transfer energy toward the throwing arm (25).

Arm acceleration phase. As the preparation phase ends at maximum shoulder external rotation point, the acceleration phase subsequently starts (35). The trunk continues to rotate and tilt medially, and energy is transferred through the upper extremity in a proximal to distal manner (23). During this phase, the shoulder moves into horizontal adduction and internal rotation, with the elbow extending rapidly just before ball release (23). This movement velocity peaks slightly before wrist flexion at the end of the throwing motion (4,23). This position is the point at which the ball is released from the dominant hand toward the target. Compared with the preparatory phase, there is greater shoulder elevation and glenohumeral internal rotation, with the elbow in a more extended position (21). There is also thoracolumbar flexion toward the contralateral side, with accompanying hip flexion (21). The phase ends as the ball is released from the hand toward the target.

Follow-through phase. The follow-through is defined as the short time from ball release to maximum shoulder internal rotation. The arm horizontally adducts across the trunk to decelerate (25), resulting in less shoulder elevation and greater elbow flexion at the end position. The thoracolumbar is neutral and rotated toward the contralateral side, with lumbopelvic flexion, dominant hip flexion, and external rotation (21). The follow-through phase is completed with the arm swinging across the body, and the fielder is in a balanced position (25).

MATCH DEMANDS

Cricket fielding includes intermittent bursts of short, high-intensity efforts (e.g., running, striding, and sprinting) interspersed throughout longer periods of low-intensity exercise and recovery periods (e.g., standing, walking, and jogging), with these demands differing between match formats (37,60). Using GNSS technology, data show that international male fielders, on average, cover 6.62 ± 0.97 km over 1.68 ± 0.25 hours, 11.9 ± 2.73 km over 3.4 ± 0.62 hours, and 34.5 ± 9.10 km over 13.3 ± 3.38 hours while fielding during Twenty20 (6), one-day (6), and multiday cricket matches (5), respectively. More recently, the demands experienced in different fielding positions across match formats have been investigated, including outer circle, inner circle, and close fielding positions. These are presented in Table 2 and further elaborated on below (87).

OUTER CIRCLE

When positioned in the outer circle, fielders often execute rapid movements such as diving or jumping to field the ball and sprint the greatest distance of all fielding positions (up to 40 m in a single bout) (40). The distances covered per hour by the fielders can vary by 30–35% across the different match formats (Twenty20 = 3,549 ± 615 m; one-day = 2,635 ± 741 m; and multiday = 2,018 ± 290 m) (87). Furthermore, high-intensity running (i.e., striding, high-speed running, and sprinting at speeds of 5.56–6.94 m/s) has shown to be greater in one-day (930 ± 1085 m) compared with multiday (889 ± 435 m) professional matches among outer circle fielders (87). By contrast, professional fielders covered only 244 ± 158 m in the Twenty20 match format at similar speeds (5.8–7.2 $m \cdot s^{-1}$) (77).

INNER CIRCLE

When positioned in the inner circle, fielders execute rapid movements such as diving and sprinting to cover ground and retrieve a batted ball (40). A greater number of sprints across 16 innings of play were reported in this position compared with other fielding positions in professional one-day matches (inner circle = 33, outer circle = 30, and close = 4) (40). These increased sprinting requirements include support runs

Table 1
Fielding requirements of different fielding positions (1,15,22)

Field position	Fielding requirements
Outer circle	Fielders cover a larger distance compared with other positions (up to 40 m) Sprinting ability Accurately throw over long distances
Inner circle	Cricketers catch a ball falling from above the head Good reactive ability Strong over-arm throwing ability
Close	Quick reflexes to intercept a ball coming off the bat edge Reaching for the ball below chest height

Figure 2. Throwing phases in cricket. (A) Preparatory, (B) arm acceleration, and (C) follow through.

(fielding the ball in tandem or preparing to perform the return throw if the primary fielder failed in their attempt) (40). When fielding in the inner circle, no significant differences were observed for the number of high-intensity running actions per hour across different match formats among professional fielders (87).

CLOSE

Close fielders display skills such as catching and stopping the ball from its original position near the batter. They are rarely required to cover considerable distances at speed (40). The total distance covered per hour while fielding is higher in one-day (1,644 ± 234 m) compared with multiday (1,361 ± 93 m) matches among professional close fielders. However, no significant differences in the distance covered performing high-intensity running per hour between match formats (~13 m) were observed (87). The peak running velocity reached while fielding was significantly higher in Twenty20 ($8.00 \pm 0.69\ m \cdot s^{-1}$) and multiday ($7.56 \pm 1.50\ m \cdot s^{-1}$) matches when compared with those observed in one-day ($4.66 \pm 0.57\ m \cdot s^{-1}$) matches for professional close fielders (77,87).

The requirement for all cricketers to be highly competent at fielding is essential, as poor fielding performance can result in extra runs given to the opponents (77). Thus, fast bowlers are now given more fielding training to cover this position in the inner circle/close (77). These insights demonstrate the differences experienced between specialist fielding positions, which support the S&C coach's decision-making when tailoring training programs to match positional fielding demands (60).

PHYSICAL, TECHNICAL, AND PHYSIOLOGICAL RESPONSES TO FIELDING

The physiological responses to fielding activities in cricket matches have received little attention in the literature (20,59–61). Throughout a cricket match, there is an interchange of low-intensity activities (i.e., stationary, walking, jogging, and low-intensity fielding) and high-intensity activities (i.e., shuffling, running, and high-intensity fielding) (67). In professional multiday cricket, high-intensity activity contributed to 1.60 ± 0.80% of match time, with a mean frequency of 5.00 ± 3.50 high-intensity bouts every 10 overs among professional male fielders (20). The mean work duration was 1.30 ± 0.30 seconds, and the mean recovery duration was 100 ± 95 seconds, resulting in a work-to-rest ratio of 1:84 ± 65 (20). This low work-to-rest ratio resulted in the mean heart rates of male fielders rarely exceeding 60–70% of the maximal heart rate (51). The ratio between high-intensity and low-intensity activities also varies between match formats, with values of 1:43, 1:62, and 1:90 observed for Twenty20, one-day, and multiday professional matches, respectively, in nonbowling male fielders (60). The available data provide insight for S&C coaches to develop position-specific conditioning programs and recovery periods based on match demands (59). However, further investigation is needed to understand the broader physiological demands better (e.g., core temperature, ratings of perceived exertion, energy expenditure, and blood lactate concentration) during matches (70).

INJURY EPIDEMIOLOGY

To reduce the occurrence of injuries in team sports, a 3-phase cycle is proposed. The first phase involves sports injury epidemiology research to assess the current injury situation (i.e., types, prevalence, and severity) in any given context (54). Once the injury epidemiology has been established, injury risk factors and mechanisms can be identified in the second phase (54). The third phase informs preventative strategies, such as developing adequate physical preparedness, aided by S&C coaches (54). In this regard, a review of the injuries commonly sustained while fielding is important to inform appropriate training approaches.

Although bowling and batting result in more injuries than fielding (56,80), a 9-season (2010–2018 inclusive) longitudinal injury surveillance study among domestic cricketers in England and Wales identified fielding as having the second-highest (behind bowling) match injury incidence among tasks across all match formats combined (27 injuries/1,000 days of match play; 95% CI: 24–30) (32). In turn, when exploring Twenty20 matches specifically, fielding exhibited the greatest match injury incidence among tasks (49 injuries/1,000 days of match play; 95% CI: 41–59) (32). An overview of the common injuries sustained by fielding is shown in Table 3.

Table 2 Fielding demands of cricketers among different cricket match formats (mean ± standard deviation) (Adapted with permission from (87))						
	Distance covered per hour (m)					
Format and position	Walking ($\leq$7 km·h^{-1})	Jogging (7–15 km·h^{-1})	Striding (15–20 km·h^{-1})	High-speed running (20–25 km·h^{-1})	Sprinting ($>$25 km·h^{-1})	Total distance
Twenty20						
Outer circle (n = 13)	1788 ± 379	1259 ± 305	354 ± 263	95 ± 73	53 ± 62	3,549 ± 615
Inner circle (n = 11)	2015 ± 413	866 ± 435	114 ± 114	17 ± 29	4 ± 8	3,016 ± 643
Close (n = 0)						
One-day						
Outer circle (n = 24)	1604 ± 333	765 ± 396	173 ± 231	72 ± 67	20 ± 30	2,635 ± 741
Inner circle (n = 31)	1808 ± 332	567 ± 234	66 ± 39	29 ± 65	15 ± 21	2,485 ± 418
Close (n = 9)	1042 ± 236	537 ± 188	65 ± 99	—	—	1644 ± 234
Multiday						
Outer circle (n = 17)	1322 ± 252	558 ± 205	112 ± 76	26 ± 17	10 ± 10	2018 ± 290
Inner circle (n = 19)	1605 ± 429	406 ± 207	60 ± 36	20 ± 15	19 ± 15	1988 ± 608
Close (n = 13)	966 ± 114	336 ± 125	40 ± 37	13 ± 21	10 ± 8	1361 ± 9

Most fielding injuries occur during high-intensity actions, including sprinting, throwing, catching, and diving, with most injuries sustained to the lower limbs (49.8%) (58). Of these lower-limb injuries, the most common sites include hamstring (18%) or quadriceps (10%) strains during repeated high-intensity sprinting or knee (19%) and ankle (11%) strains when diving to stop a ball (58). Other injuries may occur due to direct ball impacts, with balls traveling at speeds greater than 160 km·h^{-1} through the air or bouncing off the pitch in an unpredictable manner (24). Furthermore, anterior cruciate ligament injuries can occur during poor execution of the sliding stop technique, resulting in a large torque at the knee (1,91) and movements requiring quick changes of direction (i.e., decelerating to collect a batted ball while crouching down to collect the ball and performing a rapid throw back to the wicket-keeper) (58).

Among all positions, injuries to the upper limbs (26%) are most frequently sustained while fielding (24). Most upper-limb injuries in fielding involve a bruise or distal interphalangeal joint dislocation to the hand (12%) from ball impact, valgus strain to the elbow (no % available) from the repetitive whip-like throwing motion of the arm, and rotator cuff tendinopathy in the shoulder (14%) sustained from the abnormal torque observed in overhead throwing. The shoulder is exposed to high eccentric loads during the decelerative portion of arm acceleration and follow-through phases of the throwing action, which may lead to rotator cuff lesions (from the midsupraspinatus to the mid-infraspinatus) (1). Throwing-related pain has been attributed to a lack of strength, mobility, and/or exposure to specific throwing-based conditioning (e.g., interval throwing program gradually increasing in quantity, distance, and intensity of throws) (98). Therefore, it has been proposed that previous injury epidemiology research may underestimate the true extent of throwing-related injuries, as there is usually a relatively low number of shoulder injuries compared with other body regions and activities (32,57). Hence, injury epidemiology research has typically focused on injuries that result in time lost from match participation, so it does not account for non-time loss injuries (49). Throwing-related shoulder pain rarely causes cricketers to miss matches as they can be placed in alternative fielding positions to avoid throwing (66). The start of a competitive season or transitioning from longer (i.e., one-day) to shorter (i.e., Twenty20) match formats are periods where throwing load per hour can increase (17). Such spikes in athlete loads have been identified as an important risk factor for match injuries in cricketers (49,55,89), which highlights the need for training load monitoring (31,96).

PROGRAM DESIGN CONSIDERATIONS

TESTING APPROACH

A survey of cricketers, coaches, and S&C practitioners highlighted the various physical fitness attributes deemed important for successful high-performance fielding, including agility, core strength, and lower-body strength and power (16). Therefore, regular testing of these physical fitness attributes is essential to assess the efficacy of fielding-specific training programs, allowing S&C coaches to proactively adjust program variables and delivery as necessary (Table 4) (97).

Cricketers require moderate-to-high aerobic fitness levels with GNSS and match analysis data showing that they cover up to 15 km per day in the field with intermittent high-intensity efforts required (37,60). Aerobic fitness in professional cricketers has previously been determined using the multistage fitness test, with professional cricketers being reported to achieve 12.4 $\pm$ 0.9 completed levels, end-test heart rates of 190 $\pm$ 11 beats$\cdot$min^{-1}, and predicted maximal oxygen uptakes ($\dot{V}O_2max$) of 54.9 $\pm$ 3.7 mL$\cdot$kg$^{-1}\cdot$min^{-1} (37). The Yo-Yo Intermittent Recovery Test Level 1 has also been commonly used to assess the aerobic fitness of international cricketers (34,95), with the senior England men's team covering mean distances of 2,426 m (equating to an estimated $\dot{V}O_2max$ of 56.8 mL$\cdot$kg$^{-1}\cdot$min^{-1}) (72).

Speed among cricketers is typically assessed using sprint tests (10–40 m) (41), with 5–15 m sprint distances being measured to specifically gauge fielding performance (37). However, variation in the sprint distances tested has made it difficult to compare data reported between studies. Although linear speed assessments are applied in cricket performance assessment, fielders also move in various directions, requiring a multidirectional assessment to test movement ability (41). Accordingly, common change of direction (COD) tests such as the 5-0-5 test and T test have predominantly been adopted to assess COD speed in fielding (26). These tests allow for the measurement of key attributes (acceleration and deceleration) over distances (5, 10, and 15 m) applicable to the movements performed in fielding during matches (26). To investigate the ability to change direction, the COD deficit is recommended to provide an isolated measure of physical performance than the 5-0-5 test time alone, as the test eliminates the effect of linear sprinting speed within the COD performance (50). This attempt will allow the S&C coach to tailor a fielder's training to focus on linear speed or COD ability.

Lower-body force production is essential to enhance linear (14,74,81) and COD speed (78,79), which are attributes required for the multidirectional activities typically performed during fielding (41). Researchers have assessed lower-body strength (e.g., 1 repetition maximum [1RM] squat, deadlift tests, and isometric midthigh pull [IMTP]) (16,86), ballistic force production (e.g., countermovement jump) (37,62), and reactive strength (e.g., repeated vertical jumps) (37), as performance measures deemed most important for professional and academy cricketers. In addition to lower-body assessments, upper-body strength requirements may differ between fielding positions (e.g., the throwing distance required by an outer circle fielder versus a close fielder). Previous research has assessed upper-body strength (e.g., 1RM bench press and bench pull tests) (16), ballistic force production (e.g., medicine ball throw) (37), and strength endurance (e.g., timed push-ups) (37), as

Table 3
Common injuries sustained during cricket fielding (24,58,73)

Site	Prevalence	Examples of injury	Cause of injury
Lower-limb	50%		
Knee	19%	Includes anterior cruciate ligament injuries	Diving/change of direction
Hamstring	18%	Muscular strains	Sprinting
Ankle	11%	Muscular strains	Diving
Quadricep	10%	Muscular strains	Sprinting
All	NA	Contusions	Direct ball impact
Upper-limb	26%		
Shoulder	14%	Rotator cuff tendinopathy	Throwing
Hand	12%	Contusions/interphalangeal joint dislocation	Direct ball impact

Table 4 Physical fitness testing battery to assess fielding performance	
Physical fitness attribute	**Field-based tests**
Aerobic capacity	Yo-Yo Intermittent Recovery Test Level 1 and 2 (34,37) Maximal aerobic speed (73)
Anaerobic capacity	Speed: 10–40 m linear sprints (41) Change of direction speed: 5-0-5 test and T test (16,26) Change of direction deficit (50)
Power and reactive strength	Lower-body: countermovement jump (jump height, time to take-off, and countermovement depth) and repeated vertical jump (reactive strength index, ground contact time, and leg stiffness) (3,16,37,62) Upper-body: medicine ball throw (16,37)
Strength	Lower-body: 1 repetition maximum (1RM) squats and deadlifts (16,37,62) and isometric midthigh pull (IMTP) (relative peak force and force at 150, 200, and 250 ms) (45) Upper-body: 1RM bench press and bench pull (16,37)
Anthropometry	Standing height, body mass, and 7-site skinfold measurement (52)

performance measures regarded as most relevant in professional cricket.

Modern cricket scheduling necessitates professional cricketers be on tour for up to 11 months per year, sometimes making physical fitness testing challenging (96). Ideally, testing can be incorporated as part of the physical warm-up or within gym training sessions. For instance, sprints through timing gates can be assessed as cricketers finish their warm-ups on the field, with high-intensity sprints of varying distances commonly used toward the end of warm-up phases (46). In the gym, countermovement jumps may be monitored using force platforms or mobile applications to obtain desired measures at the start of the session (12).

TRAINING APPROACH

The sections below highlight various physical fitness attributes critical for high-performance fielding, including recommended exercises (Table 5) for training programs. It is advised that programming strategies are continually adapted using appropriate exercise progressions and regressions (i.e., load, stability, range of motion, tempo, and contraction type) depending on the cricketer's physical and exercise performance, positional needs, injury history, and training age (73). For video playbacks of Figures 3–7, refer to Supplemental Digital Content (see Videos 1 and 2, http://links.lww.com/SCJ/A348; http://links.lww.com/SCJ/A349).

CONDITIONING

Fielders can compete for up to 6–7 hours per day, with GNSS and match analysis data demonstrating that moderate to high levels of aerobic fitness are required, with anaerobic pathways providing a small contribution to overall energy demands (1). This aerobic dependence is exacerbated in multiday cricket, where matches can take place over 5 days (1). A well-developed aerobic capacity can help cricketers cope with the physiological stress of match activities and expedite recovery between matches and acute intermittent running efforts when fielding (60,67). Although the precise physical fitness attributes of different fielding positions have not been researched, it may be assumed, based on match movement demands, that outer and inner fielders require focused anaerobic conditioning to sprint and cover ground (up to 40 m) to retrieve the ball when fielding (40). These 2 fielding positions were reported to perform ~30 sprints across 16 innings during one-day international cricket matches (40). Cardiovascular endurance can be improved by implementing long slow distance training and repeated shuttle runs with shorter work-rest ratios (i.e., anaerobic threshold intervals) (30). Short sprint performance can be improved by implementing interval training consisting of 5, 10, and 20 m sprints with longer rest intervals (75). Given the duration of the international cricket season and the tour demands placed on cricketers, incorporating precise work-to-rest ratios with appropriate sprint frequencies should assist cricketers in sustaining performance at a high level. The challenge for S&C coaches is to effectively plan the conditioning program for fielders throughout the demanding competition season (i.e., congested match schedules, a high number of matches/minutes played, and reduced recovery times between matches) (31).

SPEED AND AGILITY

The ability to change direction rapidly is also an important physical fitness attribute required in fielding, with professional cricketers specializing in various fielding positions requiring different expressions of agility (i.e., COD movement in response to a stimulus) (62). Accordingly, a comprehensive agility program should seek to develop the

Table 5
Summary of proposed physical fitness attributes and exercises to include in the training program for cricket fielders

Physical fitness attribute	Rationale for including each attribute	Exemplar exercises to develop each attribute	Training variables (75)
Warm-up and neural activation	Movement preparation: a balanced stance with weight equally distributed over both feet and ready to move in all directions (i.e., athletic position).	Drills: drop squat (Figure 3) and base pogos	10–15 min Not reaching volitional fatigue
Maximum lower-body strength	Catching: lower-limb force production is needed to project one's body in jumping, diving, and sliding stops. Running: initial phases of acceleration 0–5 and 0–10 m require high force production in the lower limbs (39).	Squat: back, front, and Bulgarian split Deadlift: barbell, hex bar, and Romanian Lunge: forward, backward, angled, offset, front or rear foot elevated, and lateral	≥ 85% 1RM 3–4 sets ≤ 6 repetitions
Maximum upper-body strength	Throwing: increase release velocity and possibly accuracy while maintaining strength and neuromuscular control of the scapulohumeral joint (98).	Bench press: flat, incline, decline, unilateral, staggered, or kneeling stance cable press Shoulder press: military and landmine press in standing, split, and/or kneeling stance Row: bent over, bench pull, staggered, and kneeling stance cable pull Pull-up/over: bodyweight/weighted pull-up and dumbbell pullover	≥ 85% 1RM 3–4 sets ≤ 6 repetitions
Core strength, stability, and rotational power	Throwing: develop a stiff trunk that can transfer momentum generated in the lower body to the distal segments without energy leakage (17,29). Rotational power simulates the quickness of the back-leg drive and trunk rotation, taking advantage of the "serape effect" during the acceleration phase of the throwing motion (17,29).	Strength/stability: Landmine Cossack squat (Figure 4), rotatory/stability chops (Figure 5), anti-rotation push-pull, Pallof press, and landmine rotations (all can be performed standing, split stance, or kneeling) Rotational power: Parallel/perpendicular medicine ball throw (Figure 6), rotational medicine ball slam	Stability: light load (3–5 kg resistive load) 2–3 sets ≥ 12 repetitions (till volitional fatigue) Power: Light load (2–3 kg medicine ball) 2–3 sets 3–5 repetitions
Power and reactive strength	Power and reactive strength training can improve the rate of force production, which is advantageous during acceleration (39).	*Power* Loaded jumps: squat and hexagonal bar Weightlifting: derivatives (e.g., jump shrug, high pull, push press, hang clean, and hang snatch) (96) *Reactive strength* Drop jumps: 30–45 cm drop (34)	Nonweightlifting multijoint power exercises: 0–30% 1RM 2–3 set3–5 repetitions Weightlifting-derived exercises: 75–90% 1RM 2–3 sets 3–5 repetitions
Acceleration and change of direction speed	Specific movements and distances applicable to fielding (e.g., positioning to catch and sprinting to the boundary). Such training also attenuates eccentric loads during the deceleration phase of change of direction (39).	Acceleration: 5, 10, and 20 m sprint (resisted, assisted, and free) (34) Change of direction: lateral shuffle/cut and cross-over step Technical: acceleration, deceleration, and change of direction wall drills (Figure 7)	Distance covered is kept to < 20 m in line with the mean sprint distance covered when fielding (60)

Table 5 (continued)

Conditioning	Improves match conditioning to complete periodic sprints across relatively large distances to field the ball.	Interval sprints, simulating match pace and rest periods.	> 75% of HRmax
Mobility and stability	Aids in easy movement transitions (e.g., from sprinting to diving on the ground or picking up the ball from the ground and throwing).	Assessment of asymmetry of strength and/or range of motion between opposing limbs, with corrective exercises prescribed to address imbalances.	

RM = 1 repetition maximum, HRmax = maximum heart rate.

movement patterns (e.g., COD, shuffle, backpedal, and crossover) and movement sequences (e.g., cut to crossover to acceleration) through nonreactive means while also applying these movement skills within progressive and reactive contexts involving suitable stimuli (e.g., isolated match-specific scenarios) (73). The integration of nonreactive and reactive agility supports the development of good decision-making on the back of effective and efficient movement capacity (73). COD speed is underpinned by force production as it relies on developing sufficient impulse to perform the required acceleration or deceleration (19). To develop acceleration, deceleration, and speed, S&C coaches in professional cricket commonly use plyometrics, sprinting, and weightlifting activities within fielding and gym-based settings (96).

STRENGTH AND POWER

A well-rounded S&C program should focus on developing muscular strength to enhance force production characteristics (e.g., rate of force development and external mechanical power) (84). Adequate development of force production characteristics has been shown to aid general sport skill performance (e.g., jumping, sprinting, and COD speed), which can translate to the specific skills required in fielding (e.g., sprinting, diving, catching, and throwing) (62). The greatest strength adaptations are observed using bilateral, eccentric, and variable resistance exercises, with the supplementation of bodyweight exercises, isolation exercises, plyometric exercises, and unilateral exercises to challenge time-constrained force expression and motor demands (83).

Strength and ballistic training programs specific to throwing movement patterns have been reported to increase throwing velocity in professional baseball pitchers (99,100). A specific focus on improving throwing performance should include pressing (vertical and horizontal), pulling (vertical and horizontal), throwing, and whole-body movement patterns (17). Performing these movements ensures that the entire scapulohumeral complex is robust, and the contribution of key muscles along the kinetic chain is accounted for when performing high-volume throwing to offer protection against shoulder injuries (58).

High force eccentric actions are performed during repeated, high-intensity efforts requiring decelerations and accelerations throughout cricket matches (51). The high ground reaction forces associated with the COD speeds seen in matches may result in neuromuscular fatigue and tissue damage, leading to diminished coordinative proficiency and increased injury risk among fielders (43). These negative outcomes can be regulated by strategically using the repeated bout effect, whereby initially introducing low volumes of eccentric training provides a protective effect against muscle damage from the subsequent performance of the same exercise (44). Eccentric weight training can be supplemented with bodyweight exercises such as the Nordic hamstring exercise, which may reduce the risk of hamstring strain injuries through an increase in eccentric force production and the shifting of the force-length curves of the hamstrings (biceps femoris short head and semitendinosus) to longer muscle lengths (8,90).

Core training (including isometric and rotational loading of the rectus abdominis, transversus abdominis, and external/internal oblique muscles) supports overhead throwing through the transfer of energy from the lower extremities through the trunk musculature to the upper extremities (18). Thus, greater trunk stiffness and transfer of momentum from the lower to upper limbs is an important contributing factor to throwing performance (85). Therefore, rotational training can take advantage of the "serape effect", whereby the trunk's musculature is stretched in a diagonal pattern to maximize force production between the shoulder and contralateral hip (17). In addition to improving trunk stability and mobility (82), core training also contributes to protecting and reducing

Figure 3. Drop squats.

lower back pain in cricketers competing across all levels (i.e., professional, state-level, and club) (47).

MONITORING

Load monitoring helps sports science and medicine practitioners ensure cricketers are adequately prepared physically to cope with the varying and unpredictable match demands (6). Furthermore, by measuring internal (e.g., heart rate and rating of perceived exertion) and external (e.g., duration and distance) loads, training load monitoring may help identify cricketers at a higher risk of sustaining an injury by detecting any "spikes" in acute training loads (7). However, there is a paucity of literature linking workload to performance in cricket, with most of the research focusing only on professional fast bowlers (11). A recent survey of S&C practices by cricket coaches in South Africa showed that the most common monitoring practices included the number of deliveries bowled, the load lifted, running intensity and distance, number of throws, average heart rate, as well as training load through session ratings of perceived exertion (sRPE) and duration (64).

Specifically for fielding, load monitoring can be an effective strategy for identifying throwing thresholds (load exposure > load tolerance) that heighten the risk of sustaining injuries (4,96). In professional cricket, it was reported that higher throwing workloads had been linked to increased upper-limb injuries, which was supported by the objective data from video footage of matches and training (69). The authors reported that the injuries were sustained when cricketers completed more throws (more than 75 throws per week) during phases of the season. They also had fewer rest days the week before the injury occurred (69). Although there is an association between "spikes" in load and injury risk, research has highlighted the highly individualized nature of this relationship, reinforcing the point that training modifications should be based on individualized rather than team-based approaches (94).

PERIODIZATION

Traditional periodization practices may be applied for the physical training throughout the season of amateur and youth fielders. However, as one progresses through the ranks to the professional stage (e.g., international fixtures), a stark contrast in the number of matches is observed. The higher volume of matches does not allow the traditional periodization approach to be implemented, especially within the in-season period. As such, an alternative strategy applied for professional fielders is suggested, where the frequency of physical training opportunities is highly influenced by the type of match (i.e., Twenty20, one-day, and multiday) (73). A sample periodized physical training plan to enhance fielding performance for fielders during the off-season, preseason, and in-season is outlined in Table 6.

Preseason allows for a more traditional approach to training, encompassing the general preparatory phase of high-volume, low-intensity training, focusing on anatomical adaptation and injury risk reduction (75). As the season progresses, exercises with greater specificity to fielding movement patterns and throwing speed should be used (48). During the in-season, the volume of match time and technical work should increase with a match typically being played every 3–4 days (i.e., Twenty20 format) and fielders

Figure 4. Landmine Cossack squats.

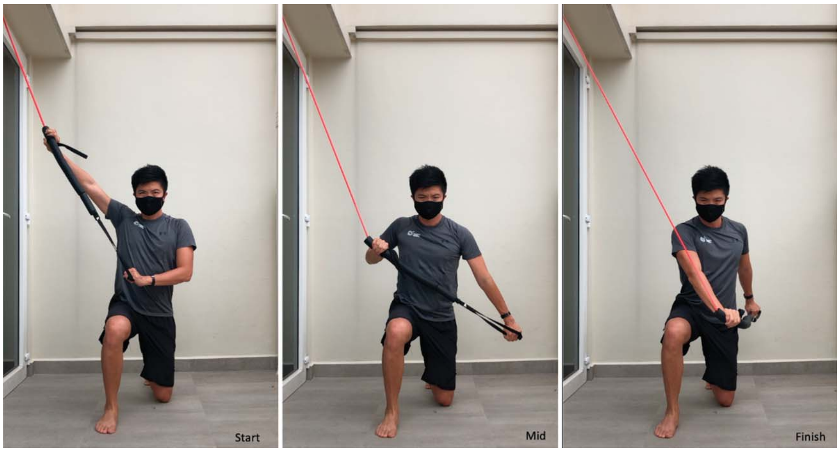


Figure 5. Rotatory/stability chops.

fielding for up to 6–7 hours in a single day (i.e., multiday format) (73). Accordingly, specific competition preparatory phases focusing on high-intensity, low-volume training can be strategically implemented in this period while ensuring cricketers get adequate rest (24–48 hours) between training and matches (17,96). It was suggested to use a priming strategy to enhance match-day performance while ensuring that the strength/power attributes of cricketers are maintained through the in-season (73). For example, professional cricketers can microdose a strength or sprint session 3–6 hours before the start of a Twenty20 competition (53). Akin to the training practices of professional soccer players (92), post-match top-up training sessions can also be implemented based on the cricketers' match involvement (e.g., cricketer was allocated 12th man and did not get any playing time). These suggested training approaches help to bridge the gap between traditional in-season training programs and match loading, with match demands in isolation being insufficient to maintain physical fitness throughout the cricket competition period (48).

CONSIDERATIONS FOR YOUTH AND DEVELOPMENTAL FIELDERS

As fielders transition from youth to senior teams, they must develop a strong physical foundation to prepare them for higher performance fielding and injury reduction (38,88). Youth cricketers (aged 10–19 years) experience a high incidence (48–55%) of match fielding injuries to the head, upper limbs, and lower limbs through being struck by the ball (63,80,93). The high incidence of such injuries coincides with the age range where there are changes to spatial awareness postpuberty and different handling skills (i.e., catching, retrieving, and throwing) with the introduction of the hard ball (93). In youth cricketers, a high volume of repeated throwing can place repetitive valgus strain on the elbow (medial epicondylar apophysitis), which can be reduced by implementing prehabilitation and therapy exercises (e.g., resisted forearm pronation/supination) within the main physical training program (58). To mitigate injury risk in youth cricketers, a pathway program that includes physical, technical, and mental performance profiling for age groups can also assist in the longitudinal tracking of player development and enable an evidence-based approach to increase each cricketer's performance potential (62). For example, Cricket Australia Centre of Excellence developed a national standards fitness program to monitor cricketers' progress through the pathway (e.g., State U19 side, Futures League, Centre of Excellence, Australia U19, Australia A) (62). The program longitudinally tracked the performance metrics to establish a normative data set, creating developmental benchmarks for aspiring professional cricketers (62).

FUTURE RESEARCH

This narrative review has highlighted several areas needing research attention specific to cricket fielding. First, there is a need to address knowledge gaps regarding the physical demands of cricket fielding during matches. A more comprehensive, multidirectional force-velocity-power profile with suitable tests investigating different

Figure 6. Parallel (A) and perpendicular (B) medicine ball throws.

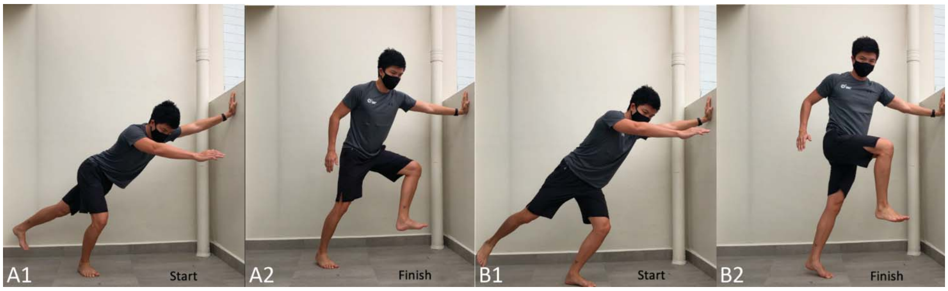


Figure 7. Change of direction wall drills using a lateral shuffle/cut (A) or crossover step (B).

directions of force application (e.g., unilateral jumps in multiple planes) and accompanying dynamic correspondence should be developed (9). Second, a stronger understanding of the mechanisms causing injury and fatigue in fielding is required to better identify the risk factors specific to this activity, which can inform preventative strategies. This suggestion may also tie in with further investigations on the best practices in monitoring throwing loads during fielding. Third, increased data reporting the normative training practices for different competition levels and age groups in cricket is needed, which will provide greater insight into the physical demands of fielding at each developmental stage, which can assist in talent identification and enhance overall player development. Fourth, longitudinal research demonstrating the long-term applicability of the above prescribed methods on fielding performance is required.

PRACTICAL APPLICATION

The need for rapid, responsive movements in cricket fielding highlights the important role the S&C coach can play in developing the physical fitness attributes that underpin these movements. Alongside maximal strength and power training, an S&C program emphasizing cricket-specific throwing and multidirectional movements should be included. Upper-body prehabilitation exercises should also be implemented to ensure adequate shoulder stability to cope with the high throwing demands in fielding. Accordingly, this narrative review has recommended a series of exercises to aid in the physical preparation and development for cricket fielding, focusing on modifying programs using appropriate progressions/regressions depending on cricketers' physical competency levels. A sample periodized physical training plan (off-season, preseason, and in-season phases) is provided for S&C coaches to refer to, with programming strategies to navigate the packed competition calendar experienced by the professional cricketer.

SUMMARY

The development of cricket has led to increased competitive demands and greater focus placed on practices to test and train cricketers, to enhance performance. It is important to improve performance across the various fielding positions and different match formats by recognizing and evaluating the technical requirements and match demands of fielding. The different match formats also influence match demands with varying cycles of intermittent short, high-intensity efforts throughout longer, low-intensity recovery periods. These demands have contributed to fielding having the second-highest match injury incidence among tasks across all match formats combined. As part of a testing protocol, regular testing of aerobic fitness, speed, acceleration, COD speed, agility, and upper-body and lower-body strength and power are necessary to assess the efficacy of training programs, allowing S&C coaches to proactively adjust program variables and delivery when necessary.

A sample periodized conditioning, speed, agility, strength, and power training plan is outlined in this narrative review for S&C coaches to reference during the various phases of a competition season. Aerobic and anaerobic conditioning will enhance a cricketer's capacity to sprint and retrieve the ball while fielding. Developing COD patterns and sequences through nonreactive and reactive drills will aid cricketers in being agile in ball retrieval. Enhancing force production (through bilateral, unilateral, eccentric, variable resistance, and core training) and rate of force production (through plyometric, weightlifting derivatives, and rotational training) characteristics will aid general sport skill performance of jumping, sprinting and COD speed, which can translate to enhanced performance of fielding skills such as sprinting, sprinting, diving, catching, and throwing. The program design is advised to be modified to match a cricketer's current physical and training competency level.

Certain adjustments are needed when implementing the program recommendations for youth and developmental cricketers, as they should invest more time in enhancing multidirectional movements and throwing skills. Thus, a pathway program that includes physical, technical, and mental performance profiling for age groups is suggested to assist in the longitudinal tracking of player development. Currently, there is a lack of fielding-focused research, with more evidence needed to bridge the knowledge gap for this position. This narrative review provides S&C coaches with guidance on selecting suitable testing,

Table 6
Sample periodized physical training plan for cricket fielders (session variables referenced from (75))

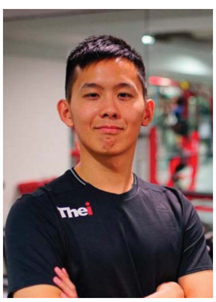
Competition phase	**Off-season**		**Preseason**		**In-season**	
Training phase	**General preparation**	**Session variables**	**Specific preparation**	**Session variables**	**Competition**	**Session variables**
Power	Jump shrugs	3–6 sets 75–85% 1RM 3–5 reps	High pull (snatch)	3–4 sets 75–85% 1RM 3–5 reps	Power/hang snatch (BB, single arm DB)	2–3 sets 75–85% 1RM 3–5 reps
	Box jumps (45–60 cm) Plyometric push-ups	3–6 sets 0–30% 1RM 3–5 reps	Countermovement jumps Medicine ball power drop	3–4 sets 0–30% 1RM/2–3 kg medicine ball 3–5 reps	Drop jump (30–45 cm) Medicine ball rotatory slam	2–3 sets 0–30% 1RM/2–3 kg medicine ball 3–5 reps
Strength	Back squat Romanian deadlifts Bodyweight pull-ups Half kneeling single arm shoulder press	3–6 sets 6–8 RM Stopping each set with 2 repetitions in reserve	Hex bar deadlifts Weighted pull-ups Military press Nordic hamstring exercise	2–5 sets 3–5 RM Stopping each set with 2 repetitions in reserve	Landmine Cossack squat Reactive step-ups DB pullovers	2–5 sets 3–5 RM Stopping each set with 2 repetitions in reserve
Speed and agility	10–20 m linear sprints COD drills (e.g., cut and shuffle, crossover step)	8–10 sets 80–100% maximum	10–20 m linear sprints COD drills Reactive agility drills	7–8 sets 80–100% maximum	10–20 m linear sprints Reactive agility drills	5–6 sets 80–100% maximum
Conditioning	Metabolic strength circuits (e.g., stair lunges and farmer's walk) Interval training Repeated shuttle runs	W:R 1:1, 2:1	Interval training Repeated shuttle runs	W:R 1:2	N/A	N/A

RM = repetition maximum, BB = barbell, DB = dumbbell, COD = change of direction, W:*R* = work-to-rest ratio.

training, and monitoring practices that may assist in maintaining and enhancing fielding performance among their teams.

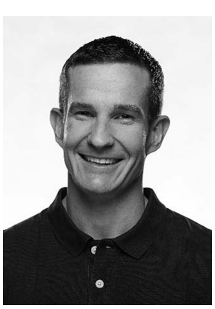
Conflicts of Interest and Source of Funding: The authors report no conflicts of interest and no source of funding.

Julian Lim *is the Senior Performance Pathways Scientist (Strength and Conditioning) at National Youth Sports Institute, Singapore.*



Sing Wong *is the Physical Education Officer at The Technological and Higher Education Institute of Hong Kong, Hong Kong.*

Stuart A. McErlain-Naylor *is a Lecturer (Sport and Exercise Biomechanics) at School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, UK.*



Aaron Scanlan *is an Associate Professor in Exercise and Sport Sciences in the School of Health, Medical and Applied Sciences, Central Queensland University, Rockhampton, Queensland, Australia.*

Luke Goggins *is an Injury Surveillance Officer at England and Wales Cricket Board, National Cricket Performance Centre, Loughborough, UK.*

Rob Ahmun *is the Head of Performance Science and Medicine at England and Wales Cricket Board, National Cricket Performance Centre, Loughborough, UK.*

Paul Comfort *is the Programme Leader for the MSc Strength and Conditioning and the Sport and Exercises Research Theme Lead at the University of Salford, UK.*

Anthony Weldon *is a Lecturer (Sport and Exercise) at Birmingham City University, Birmingham, UK.*

REFERENCES

1. Bartlett RM. The science and medicine of cricket: An overview and update. *J Sports Sci* 21: 733–752, 2003.
2. Beattie K, Carson BP, Lyons M, Kenny IC. The relationship between maximal strength and reactive strength. *Int J Sports Physiol Perform* 12: 548–553, 2017.
3. Bishop C, Turner A, Jordan M, et al. A framework to guide practitioners for selecting metrics during the countermovement and drop jump tests. *Strength Cond J* 44: 95–103, 2022.
4. Black GM, Gabbett TJ, Cole MH, Naughton G. Monitoring workload in throwing-dominant sports: A systematic review. *Sports Med* 46: 1503–1516, 2016.
5. Bliss A, Ahmun R, Jowitt H, et al. Variability of test match cricket and the effects of match location on physical demands in male seam bowlers. *Int J Perform Anal* 22: 291–301, 2022.
6. Bliss A, Ahmun R, Jowitt H, et al. Variability and physical demands of international seam bowlers in one-day and Twenty20 international matches across five years. *J Sci Med Sport* 24: 505–510, 2021.
7. Bourdon PC, Cardinale M, Murray A, et al. Monitoring athlete training loads: Consensus statement. *Int J Sports Physiol Perform* 12: 161–170, 2017.
8. Bourne MN, Duhig SJ, Timmins RG, et al. Impact of the Nordic hamstring and hip extension exercises on hamstring architecture and morphology: Implications for injury prevention. *Br J Sports Med* 51: 469–477, 2017.
9. Brughelli M, Cronin J, Levin G, Chaouachi A. Understanding change of direction ability in sport: A review of resistance training studies. *Sports Med* 38: 1045–1063, 2008.
10. Chelly MS, Hermassi S, Shephard RJ. Relationships between power and strength of the upper and lower limb muscles and throwing velocity in male handball players. *J Strength Cond Res* 24: 1480–1487, 2010.
11. Christie CJ, Barnard DV, Pote L, Munro CE. Workload monitoring in team sports: Using elite cricket as an example. *Indian J Orthop* 54: 271–274, 2020.
12. Claudino JG, Cronin J, Mezêncio B, et al. The countermovement jump to monitor neuromuscular status: A meta-analysis. *J Sci Med Sport* 20: 397–402, 2017.
13. Comfort P, Bullock N, Pearson SJ. A comparison of maximal squat strength and 5-10-and 20-meter sprint times, in athletes and recreationally trained men. *J Strength Cond Res* 26: 937–940, 2012.
14. Comfort P, Haigh A, Matthews MJ. Are changes in maximal squat strength during preseason training reflected in changes in sprint performance in rugby league players? *J Strength Cond Res* 26: 772–776, 2012.
15. Cook DP, Strike SC. Throwing in cricket. *J Sports Sci* 18: 965–973, 2000.
16. Cronin JB, MacDonald D. A survey of the performance demands of cricket fielding and wicket-keeping. *J Athl Enhanc* 2: 1–6, 2013.
17. Cronin JB, Sharp AP, Stronach B, et al. Strength and conditioning for throwing in cricket. *Strength Cond J* 38: 1–9, 2016.
18. Dale RB, Smith DM. Incorporating kinetic-chain integration, part 2: Functional shoulder rehabilitation. *Athl Ther Today* 11: 63–65, 2006.
19. Dos'Santos T, Thomas C, Comfort P, Jones PA. Role of the penultimate foot contact during change of direction: Implications on performance and risk of injury. *Strength Cond J* 41: 87–104, 2019.
20. Duffield R, Drinkwater EJ. Time–motion analysis of test and one-day international cricket centuries. *J Sports Sci* 26: 457–464, 2008.
21. Dutton M, Gray J, Prins D, Divekar N, Tam N. Overhead throwing in cricketers: A biomechanical description and playing level considerations. *J Sports Sci* 38: 1096–1104, 2020.
22. Elliott B, Anderson G. Age-related differences in high-performance overarm throwing patterns. *J Hum Mov Stud* 18: 1–24, 1990.

23. Escamilla RF, Andrews JR. Shoulder muscle recruitment patterns and related biomechanics during upper extremity sports. *Sports Med* 39: 569–590, 2009.
24. Finch CF, Elliott BC, McGrath AC. Measures to prevent cricket injuries: An overview. *Sports Med* 28: 263–272, 1999.
25. Fleisig GS, Barrentine SW, Escamilla RF, Andrews JR. Biomechanics of overhand throwing with implications for injuries. *Sports Med* 21: 421–437, 1996.
26. Foden M, Astley S, Comfort P, et al. Relationships between speed, change of direction and jump performance with cricket specific speed tests in male academy cricketers. *J Trainol* 4: 37–42, 2015.
27. Freeston J, Ferdinands R, Rooney K. Throwing velocity and accuracy in elite and sub-elite cricket players: A descriptive study. *Eur J Sport Sci* 7: 231–237, 2007.
28. Freeston J, Rooney K. Progressive velocity throwing training increases velocity without detriment to accuracy in sub-elite cricket players: A randomized controlled trial. *Eur J Sport Sci* 8: 373–378, 2008.
29. Freeston JL, Carter T, Whitaker G, Nicholls O, Rooney KB. Strength and power correlates of throwing velocity on subelite male cricket players. *J Strength Cond Res* 30: 1646–1651, 2016.
30. Gibala MJ, McGee SL. Metabolic adaptations to short-term high-intensity interval training: A little pain for a lot of gain?. *Exerc Sport Sci Rev* 36: 58–63, 2008.
31. Goggins L, McKay C, Peirce N, Stokes K, Williams S. You come up with different theories every year": Practitioner perceptions of injury risk factors and player monitoring practices in elite men's domestic cricket. *Int J Sports Sci Coach* 16: 804–814, 2021.
32. Goggins L, Peirce N, Ranson C, et al. Injuries in England and Wales elite men's domestic cricket: A nine season review from 2010 to 2018. *J Sci Med Sport* 23: 836–840, 2020.
33. Hermassi S, Chelly MS, Tabka Z, Shephard RJ, Chamari K. Effects of 8-week in-season upper and lower limb heavy resistance training on the peak power, throwing velocity, and sprint performance of elite male handball players. *J Strength Cond Res* 25: 2424–2433, 2011.
34. Herridge R, Turner A, Bishop C. Monitoring changes in power, speed, agility, and endurance in elite cricketers during the off-season period. *J Strength Cond Res* 34: 2285–2293, 2020.
35. Hussain I, Bari MA. Mechanical analysis of overhead throwing in cricket. *Int J Sports Sci Eng* 5: 163–168, 2011.
36. International Cricket Council Cricket Rules and Regulation. *Men's Playing Conditions*, 2021. Available at: https://www.icc-cricket.com/about/cricket/rules-and-regulations/playing-conditions. Accessed August 16, 2022.
37. Johnstone JA, Ford PA. Physiologic profile of professional cricketers. *J Strength Cond Res* 24: 2900–2907, 2010.
38. Lloyd RS, Cronin JB, Faigenbaum AD, et al. National Strength and Conditioning Association position statement on long-term athletic development. *J Strength Cond Res* 30: 1491–1509, 2016.
39. Lockie RG, Murphy AJ, Knight TJ, Janse de Jonge XA. Factors that differentiate acceleration ability in field sport athletes. *J Strength Cond Res* 25: 2704–2714, 2011.
40. MacDonald D, Cronin JB, Macadam P. Key match activities of different fielding positions and categories in one-day international cricket. *Int J Perform Anal* 18: 609–621, 2018.
41. MacDonald D, Cronin JB, Mills J, McGuigan M, Stretch R. A review of cricket fielding requirements. *S Afr J Sports Med* 25: 87–92, 2013.
42. McBride JM, Blow D, Kirby TJ, et al. Relationship between maximal squat strength and five, ten, and forty yard sprint times. *J Strength Cond Res* 23: 1633–1636, 2009.
43. McBurnie AJ, Harper DJ, Jones PA, Dos'Santos T. Deceleration training in team sports: Another potential 'vaccine' for sports-related injury? *Sports Med* 52: 1–12, 2022.
44. McHugh MP. Recent advances in the understanding of the repeated bout effect: The protective effect against muscle damage from a single bout of eccentric exercise: Repeated bout effect. *Scand J Med Sci Sports* 13: 88–97, 2003.
45. McMaster DT, Gill N, Cronin J, McGuigan M. A brief review of strength and ballistic assessment methodologies in sport. *Sports Med* 44: 603–623, 2014.
46. Morin J-B, Le Mat Y, Osgnach C, et al. Individual acceleration-speed profile in-situ: A proof of concept in professional football players. *J Biomech* 123: 110524, 2021.
47. Morton S, Barton CJ, Rice S, Morrissey D. Risk factors and successful interventions for cricket-related low back pain: A systematic review. *Br J Sports Med* 48: 685–691, 2014.
48. Mukandi I, Turner A, Scott P, Johnstone JA. Strength and conditioning for cricket fast bowlers. *Strength Cond J* 36: 96–106, 2014.
49. Newton L, McCaig S. The effect of a cricket fielding session on glenohumeral range of motion and active joint position sense. *Phys Ther Sport* 31: 52–57, 2018.
50. Nimphius S, Callaghan SJ, Spiteri T, Lockie RG. Change of direction deficit: A more isolated measure of change of direction performance than total 505 time. *J Strength Cond Res* 30: 3024–3032, 2016.
51. Noakes TD, Durandt JJ. Physiological requirements of cricket. *J Sports Sci* 18: 919–929, 2000.
52. Noorbhai H, Khumalo A. Anthropometric and physical fitness characteristics of male university cricket club players in accordance to player position and height categories. *J Community Health* 10: 784, 2021.
53. Nutt F, Hills SP, Russell M, et al. Morning resistance exercise and cricket-specific repeated sprinting each improve indices of afternoon physical and cognitive performance in professional male cricketers. *J Sci Med Sport* 25: 162–166, 2022.
54. O'Brien J, Finch CF, Pruna R, McCall A. A new model for injury prevention in team sports: The team-sport injury prevention (TIP) cycle. *Sci Med Footb* 3: 77–80, 2019.
55. Opar DA, Williams MD, Shield AJ. Hamstring strain Injuries: Factors that lead to injury and re-Injury. *Sports Med* 42: 209–226, 2012.
56. Orchard JW, James T, Portus MR. Injuries to elite male cricketers in Australia over a 10-year period. *J Sci Med Sport* 9: 459–467, 2006.
57. Orchard JW, Kountouris A, Sims K. Incidence and prevalence of elite male cricket injuries using updated consensus definitions. *Open Access J Sports Med* 7: 187–194, 2016.
58. Pardiwala DN, Rao NN, Varshney AV. Injuries in cricket. *Sports Health* 10: 217–222, 2018.
59. Petersen C, Pyne D, Portus M, Dawson B. Validity and reliability of GPS units to monitor cricket-specific movement patterns. *Int J Sports Physiol Perform* 4: 381–393, 2009.
60. Petersen CJ, Pyne D, Dawson B, Portus M, Kellett A. Movement patterns in cricket vary by both position and game format. *J Sports Sci* 28: 45–52, 2010.
61. Petersen CJ, Pyne DB, Portus MR, Dawson BT. Comparison of player movement patterns between 1-Day and Test cricket. *J Strength Cond Res* 25: 1368–1373, 2011.
62. Portus M, Kellett A, Karppinen S, Timms S. Physiological protocols for the assessment of athletes in specific sports: Cricket players. In: *Physiological Tests for Elite Athletes. Tanner RK and Gore CJ* (2nd ed). Champaign, IL: Human Kinetics, 2013. pp: 289–297.
63. Pote L, Christie CJ. Injury prevention strategies in cricket. *Strength Cond J* 40: 34–43, 2018.
64. Pote L, King G, Christie C. Strength and conditioning practices of franchise-level cricket trainers. *S Afr J Sports Med* 32: 1–5, 2020.
65. Putnam CA. Sequential motions of body segments in striking and throwing skills: Descriptions and explanations. *J Biomech* 26: 125–135, 1993.
66. Ranson C, Gregory PL. Shoulder injury in professional cricketers. *Phys Ther Sport* 9: 34–39, 2008.
67. Rudkin ST, O'Donoghue PG. Time-motion analysis of first-class cricket fielding. *J Sci Med Sport* 11: 604–607, 2008.
68. Saikia H, Bhattacharjee D, Lemmer HH. A double weighted tool to measure the fielding performance in cricket. *Int J Sports Sci Coach* 7: 699–713, 2012.
69. Saw R, Dennis RJ, Bentley D, Farhart P. Throwing workload and injury risk in elite cricketers. *Br J Sports Med* 45: 805–808, 2011.
70. Scanlan AT, Berkelmans DM, Vickery WM, Kean CO. A review of the internal and external physiological demands associated with batting in cricket. *Int J Sports Physiol Perform* 11: 987–997, 2016.
71. Scholes R, Shafizadeh M. Prediction of successful performance from fielding indicators in cricket: Champions League T20 tournament. *Sports Technol* 7: 62–68, 2014.
72. Scott P, Ahmun R, de Weymarn C, et al. Evolution of anthropometric and physical performance characteristics of international male cricketers from 2014 to 2020 in a World Cup winning nation. *Int J Sports Sci Coach* 1–8: 2022.
73. Scott P, Herridge R. Team sports: Cricket. In: *Routledge Handbook of Strength and Conditioning: Sport-specific Programming for High Performance*. Tuner A, ed. New York, NY: Routledge, 2020, 194–297.
74. Seitz LB, Reyes A, Tran TT, de Villarreal ES, Haff GG. Increases in lower-body strength transfer positively to sprint performance: A systematic review with meta-analysis. *Sports Med* 44: 1693–1702, 2014.
75. Sheppard JM, Triplett NT. Program design for resistance training. In: *NSCA's Essentials of Strength Training and Conditioning* (4th ed). Haff GG and Triplett NT, eds. Champaign, IL: Human Kinetics, 2016. pp: 439–469.
76. Shilbury D. An analysis of fielding patterns of an "A" grade cricket team. *Sports Coach* 13: 41–44, 1990.
77. Sholto-Douglas R, Cook R, Wilkie M, Christie CJ-A. Movement demands of an elite cricket team during the Big Bash League in Australia. *J Sports Sci Med* 19: 59–64, 2020.
78. Spiteri T, Cochrane JL, Hart NH, Haff GG, Nimphius S. Effect of strength on plant foot kinetics and kinematics during a change of direction task. *Eur J Sport Sci* 13: 646–652, 2013.
79. Spiteri T, Nimphius S, Hart NH, et al. Contribution of strength characteristics to change of direction and agility performance in female basketball athletes. *J Strength Cond Res* 28: 2415–2423, 2014.
80. Stretch RA. Cricket injuries: A longitudinal study of the nature of injuries to South African cricketers. *Br J Sports Med* 37: 250–253, 2003.
81. Styles WJ, Matthews MJ, Comfort P. Effects of strength training on squat and sprint performance in soccer players. *J Strength Cond Res* 30: 1534–1539, 2016.
82. Subramanian A. Investigation of core strength training induced adaptations on selected

physical and physiological parameters of cricket players. *Int J Phys Educ Fit Sports* 3: 65–70, 2014.

83. Suchomel TJ, Nimphius S, Bellon CR, Stone MH. The importance of muscular strength: Training considerations. *Sports Med* 48: 765–785, 2018.

84. Suchomel TJ, Nimphius S, Stone MH. The importance of muscular strength in athletic performance. *Sports Med* 46: 1419–1449, 2016.

85. Talukdar K, Cronin J, Zois J, Sharp AP. The role of rotational mobility and power on throwing velocity. *J Strength Cond Res* 29: 905–911, 2015.

86. Thomas C, Dos'Santos T, Comfort P, Jones A. Relationship between isometric strength, sprint, and change of direction speed in male academy cricketers. *J Trainol* 5: 18–23, 2016.

87. Thomas T, Steve C, Rob D, Chris H, Carl P. Fielding specific walk/run patterns in English professional cricket. *J Sport Exerc Sci* 4: 11–17, 2020.

88. Till K, Lloyd RS, McCormack S, et al. Optimising long-term athletic development: An investigation of practitioners' knowledge, adherence, practices and challenges. *PLoS One* 17: e0262995, 2022.

89. Tysoe A, Moore IS, Ranson C, McCaig S, Williams S. Bowling loads and injury risk in male first class county cricket: Is 'differential load' an alternative to the acute-to-chronic workload ratio? *J Sci Med Sport* 23: 569–573, 2020.

90. Van Hooren B, Vanwanseele B, Rossom S, et al. Muscle forces and fascicle behavior during three hamstring exercises. *Scand J Med Sci Sports* 32: 997–1012, 2022.

91. Von Hagen K. The sliding stop: A technique of fielding in cricket with a potential for serious knee injury. *Br J Sports Med* 34: 379–381, 2000.

92. Walker GJ, Hawkins R. Structuring a program in elite professional soccer. *Strength Cond J* 40: 72–82, 2018.

93. Walker HL, Carr DJ, Chalmers DJ, Wilson CA. Injury to recreational and professional cricket players: Circumstances, type and potential for intervention. *Accid Anal Prev* 42: 2094–2098, 2010.

94. Warren A, Williams S, McCaig S, Trewartha G. High acute:chronic workloads are associated with injury in England and Wales Cricket Board Development Programme fast bowlers. *J Sci Med Sport* 21: 40–45, 2018.

95. Weldon A, Clarke N, Pote L, Bishop C. Physical profiling of international cricket players: An investigation between bowlers and batters. *Biol Sport* 38: 507–515, 2021.

96. Weldon A, Duncan MJ, Turner A, Christie CJ, Pang CM. Contemporary practices of strength and conditioning coaches in professional cricket. *Int J Sports Sci Coach* 16: 585–600, 2021.

97. Weldon A, Duncan MJ, Turner A, Lockie RG, Loturco I. Practices of strength and conditioning coaches in professional sports: A systematic review. *Biol Sport* 39: 715–726, 2022.

98. Wilk KE, Meister K, Andrews JR. Current concepts in the rehabilitation of the overhead throwing athlete. *Am J Sports Med* 30: 136–151, 2002.

99. Wilk KE, Obma P, Simpson CD, et al. Shoulder injuries in the overhead athlete. *J Orthop Sports Phys Ther* 39: 38–54, 2009.

100. Wilk KE, Yenchak AJ, Arrigo CA, Andrews JR. The advanced throwers ten exercise program: A new exercise series for enhanced dynamic shoulder control in the overhead throwing athlete. *Physician Sportsmed* 39: 90–97, 2011.

101. Woolmer B, Noakes T, Moffett H, Lewis F. *Art and Science of Cricket*. London: New Holland, 2008.