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# The relationship between physical fitness and the physical demands of 50-Over Cricket in Fast-Bowlers.

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Running Head: Relationships between fitness and the demands of 50-Over Cricket

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Abstract:

Professional cricket is constantly evolving and resulting in increased physiological demand placed upon players. Fast-bowlers experience the greatest physical demand during match-play; despite this research has overlooked the importance of specific physical attributes to optimizing physical match performance. The aim of this study was to investigate the relationships between 50-Over physical match performance and tests of physical qualities in fast-bowlers. Fifteen professional male fast-bowlers (age = 23.8 ± 4.0 years; height = 183.4 ± 6.7 cm; body mass = 82.9 ± 9.2 kg) participated in the study. Subjects completed the following physical fitness tests; sum of skinfolds, countermovement jump (CMJ), 20-meter sprint and the YoYo intermittent recovery test level 1. Global positioning systems (GPS) data was collected during six professional 50-Over fixtures. Moderate correlations were established between CMJ height to total distance covered ($r = 0.585$; $p = 0.022$), sprinting distance ($\rho = 0.554$; $p = 0.032$) and maximal velocity ($r = 0.567$; $p = 0.027$); 20 m sprint time to total distance covered ($\rho = -0.519$; $p = 0.047$) and PlayerLoadTM ($\rho = -0.561$; $p = 0.03$); and YoYo distance to total match distance ($r = 0.520$; $p = 0.047$) and sprinting distance ($\rho = 0.524$; $p = 0.045$). These findings demonstrate the predictive importance of prolonged intermittent running ability, jump and sprint performance to match running performance of elite fast-bowlers in one-day cricket. Strength and conditioning coaches should use such information to design training to ensure fast-bowlers are adequately conditioned to meet the demands of match running performance.

**Key Words:** Physical attributes; match demands; global positioning system (GPS); jump height.

## INTRODUCTION

Professional cricket is an intermittent high-intensity activity requiring athleticism in the field, power for hitting, sprinting and repeated whole-body bowling actions (42,45). The introduction of new match formats has further increased these physiological demands (3,18). Cricket is unique as it is competed over three formats; First-Class, List-A and Twenty20 (T20) each with differing physiological demands (33). Players are further categorized into batters and bowlers, with bowlers either seam or spin (18). Fast-bowlers experience the greatest physical workload and resultant injury rates (19,33,34). Despite this, literature linking match-demands and physiological characteristics of fast-bowlers remains limited, to date no research links physical fitness to match demands.

During one-day fixtures each innings lasts up to 50-overs, in which bowlers deliver a maximum of ten overs (23). The implementation of new rules specifically power-plays which limit the number of fielders outside the inner ring has increased the physical demand, as fast-bowlers are required to bowl longer spells to limit a batters reaction time and are frequently used as deep fielders, thus covering increased fielding distance (18,33). The use of Global Positioning Systems (GPS) has been limited, although the field size and match duration means GPS provides an accurate, reliable and time-effective method of player monitoring (31,32). A cricketer covers 9.5-13.6 km during a 50-Over fielding innings with fast-bowlers covering greater total and high-intensity distance with the shortest recovery compared to other positions (33). This is apparent when comparing a fast-bowler who covers 10.2 km greater distance with a maximum heart rate of 52 bpm higher than a centurion batter (27,33), however opposition quality, ground dimensions, environmental factors (e.g., heat, humidity) and match magnitude could influence validity.

Match format also influences the physical demand, with one-day fast-bowlers recording similar high-intensity volume to hockey and soccer players, just with longer recovery periods (42). Although match duration means fast-bowlers cover greater total distance in multi-day fixtures, one-day fixtures require 27% greater sprinting distance with 13 seconds less recovery between high-intensity bouts, thus 50-Over cricket is more intense than multi-day cricket (33). Similarly, Petersen et al. (29) found scaled total distance, sprinting distance and time spent striding and sprinting to be greater in one-day cricket than first-class. Consequently, the tracking of fast-bowlers is essential, and GPS provides increased understanding of match-load and intensity to better monitor physical performance, training prescription and injury prevention (8).

Despite fast-bowlers undertaking the greatest workload and exhibiting the highest injury occurrence (27,33), literature has failed to establish a complete physical profile of fast-bowlers. Fast-bowlers deliver balls at 36.0-40.5 $m \cdot s^{-1}$, potentially in bouts of 60 whole-body actions (18,19), thus a solid athletic base with speed, strength, power and endurance may be important. Fast-bowlers are taller with greater mass than batters, thus providing a higher angle of release to optimize force production and the extraction of greater bounce (15,19). Stuelken et al. (41) elaborated on such anthropometrics by stating fast-bowlers not only have greater lengths, breadths and girths but have lower sum of seven skinfolds 62.3 ± 18.2 mm in comparison to batters (41), interestingly such results are superior to more recent research (18). Additionally, fast-bowlers have 30-meter sprints of 4.42 ± 0.7 seconds and run-3 times of 10.09 ± 0.44 seconds (22). Although drawing conclusions from such findings is challenging as previous research in 2010 and 2015 has typically utilized a 20-meter sprint and run-2 protocol (3,18). Finally, Johnstone and Ford (18) provided a physiological overview of fast-bowlers, finding a sum of seven skinfolds, predicted $VO_2$ Max, 20 m sprint time and counter-movement jump height of 72.5 ± 16.5 mm, 54.1 ± 2.8 $ml.kg^{-1}.min^{-1}$, 2.76 ± 0.6 s and 45.7 ± 5.8 cm, respectively. Such findings show superior 20-meter times (3), but inferior skinfolds (42) than other research. However, this was based on a low sample size (nine fast-bowlers). Consequently, establishing a broader database of normative values for professional fast-bowlers would aid conditioning coaches to establish specific and measurable goals.

Cricket has overlooked the relationship between tests of physical qualities and physical match performance, unlike in other sports. Professional rugby league players within the starting thirteen were leaner, quicker, had greater jump height and aerobic capacity than substitutes (12). Furthermore, positive correlations exist between prolonged, high-intensity running ability and both match total distance and high-intensity distance (13,14). Similarly, soccer players who perform better in a repeated-sprint test cover increased sprinting and high-intensity distances during competition (37), whereas Castagna et al. (5) found total distance and high-intensity distance positively correlated with yoyo test scores in junior soccer players. Interestingly, Gabbett (11) argued not all training should be match intensity and that optimal periodization should include conditioning and strength training to promote aerobic, neural, skeletal and tissue adaptations that will enable athletes to possess the physical attributes to repeatedly execute skills under fatigue and reduce injury. Despite this, no literature has examined the association between physical characteristics to cricket match play characteristics.

The study aimed to investigate the relationships between 50-Over physical match performance and tests of physical fitness qualities in fast-bowlers. To achieve this aim the following objectives were examined; (1) quantify and define the physical fitness characteristics of fast-bowlers through a physical testing protocol, (2) establish and examine GPS measured speed and distance match-play data for fast-bowlers in 50-Over cricket and, (3) explore the relationships between physical fitness characteristics and match demands. It is hypothesized greater counter-movement jump height and 20-meter sprint performance is associated with greater accumulated sprinting distances and higher maximal velocity achieved during match play, whilst better yoyo performance is associated with total, high-intensity and sprinting distances.

## METHODS

### Experimental Approach to the Problem

To investigate the relationships between tests of physical qualities and physical match performance of fast-bowlers in 50-Over cricket, an exploratory cross-sectional experimental design was used. A batch of sport-specific assessments were selected and assessed with each fast-bowler, whereas GPS data from six 50-Over fixtures were collected to provide an overview of typical one-day cricket match demands for fast bowlers. The relationship between physical qualities and physical match demands were examined through Pearson's and Spearman's correlations.

### Subjects

Fifteen professional male fast-bowlers (age = 23.8 ± 4.0 years; height = 183.4 ± 6.7 cm; body mass = 82.9 ± 9.2 kg) participated in the study. The subjects were made up of five fast (>140 km/hr.), seven medium-fast (135-140 km/hr.) and three fast-medium pace bowlers (130-135 km/hr.). All subjects received an explanation of the study, including a physical activity readiness questionnaire and a detailed explanation of any potential risks or benefits associated with participation, before signing an institutionally approved informed consent document. It must be noted all subjects were over 18 years of age (age range 19 - 35 years). The study was approved by the institution's ethics committee (HST1617-17 and HST1617-265). Fitness testing was conducted in pre-season post a five month periodized conditioning program in the indoor cricket center which had a full risk assessment; whereas one-day fixtures were played in accordance with the MCC Laws of Cricket (23). The collection of match data was taken oven a time range of three to six weeks post fitness testing in accordance with the first team fixture schedule. Each fast-bowler was accustomed to the indoor cricket center and familiarized themselves with GPS units during training.

Procedures

The study's procedure was two-fold; physical fitness tests and one-day matches. To optimize reliability and validity subjects completed the tests in a specific order all in one session to minimize the effect of sequencing, with a standardized warm-up implemented. The warm up comprised of five minutes jogging, a series of activations and mobilizations of the lower limbs before finishing with three sets of progressive forty meter strides. Subjects wore the same GPS unit throughout their sampled matches. Each player took part in six fixtures meaning a total sample of ninety files were collected. To be eligible each fielding innings had to last a minimum of 45 overs, notes of whether the innings was batting or fielding first were made and due to competitive constraints not every bowler completed their full allocation of ten overs per innings. Physical testing was performed in the following order; skinfold measurements, countermovement jump (CMJ), 20 m sprint and YoYo test. Prior to each test subjects were given clear instructions of how to execute the test but any encouragement was avoided. Subjects were requested to abstain from strenuous activity for 48 hours and arrive in a fed, hydrated state.

*Skinfolds*

Harpenden callipers (British Indicators Ltd, West Sussex) measured sum of eight skinfolds (tricep, bicep, subscapular, iliac crest, abdomen, supraspinale, front-thigh and medial-calf) to the closest 0.1 mm, in accordance with the ISAK protocol (28,41). The skinfold was collected by the pinching of the left thumb and index finger and raised perpendicular to the measurement site. The calliper was applied, ensuring the fold was grasped firmly and callipers remained at right-angles. The reading was taken two-three seconds following trigger release, once the dial had reached a set level. Three measurements were taken per site and the average recorded. A-priori test re-test reliability on 15 professional male fast bowlers revealed trivial differences ($p = 0.669$; $d = 0.02$) between sessions with good relative (ICC = 0.989 [95% CI = 0.966 – 0.996]) and absolute reliability (SEM = 0.91 mm (1.34%); CV = 12.8 [95% CI: 8.2 – 17.4]) for sum of eight skinfolds.

*Countermovement jump (CMJ)*

The Kinematic Measurement System and portable jump mat (FitTech, Australia) recorded flight time, with jump height calculated using the equation ($g \times FT^2$) / 8. Subjects stood feet shoulder width apart with hands on hips, before dropping into a semi-squat position and jumping as high as possible. If subjects tucked or piked in the air, removed hands from hips or held a squat position scores were disregarded. Each subject performed three jumps with one-minute recovery. A-priori test re-test reliability on 15 professional male fast bowlers revealed small differences ($p = 0.124$; $d = 0.10$) between sessions with good relative (ICC = 0.971 [95% CI: 0.913-0.99]) and absolute reliability (SEM = 0.49 cm (1.15%); CV = 6.8 [95% CI: 4.3 – 9.2]) for jump height.

*20 meter sprint*

Brower timing gates (Utah, USA) measured 20 m sprint times. The start line was positioned 0.5 m behind the first timing gate, to prevent early triggering. Subjects started in a two-point stationary stance that was held for three seconds. If feet left the floor or rocking motions occurred results were disregarded. The fastest of three trials was recorded to the nearest 0.01 seconds, interspersed by four minutes recovery. A-priori test re-test reliability on 15 professional male fast bowlers revealed trivial differences ($p = 0.546$; $d = 0.03$) between sessions with good relative (ICC = 0.983 [95% CI: 0.951-0.975]) and absolute reliability (SEM = 0.01 s (0.45%); CV= 3.0 [95% CI: 1.9 – 4.1]) for 20 m sprint times.

*Yoyo Intermittent Recovery Test Level 1*

The Yoyo Intermittent Recovery Test Level 1 measured aerobic capacity. A 20 m shuttle with a 5 m end zone was measured. Subjects began on the middle line and when prompted by the audible beep ran to the top cone, before turning and returning to the start, also in accordance with the beep. The subject then had ten seconds recovery to complete the 5 m end zone before returning to the start in a stationary stance. Warnings were administered for false starts and inability to complete a shuttle, two warnings led to elimination. Distance covered was recorded in meters. A-priori test re-test reliability on 15 professional male fast bowlers revealed trivial differences ($p = 0.697$; 0.02) between sessions with good relative (ICC = 0.984 [95% CI: 0.954-

0.995]) and absolute reliability (SEM = 63.02 m (2.60%); CV= 20.6 [95%CI: 13.2 - 28]) for distance covered during the Yoyo test.

*Global Positioning System Analysis*

Six 50-Over fixtures were used for GPS data collection. Movement was recorded using OptimEye S5 GPS units (Catapult, Melbourne, Australia) sampling at 10 Hz, in addition to a in-built tri-axial linear accelerometer, sampling at 100 Hz, encased in a vest on the upper back. This provided information on speed, distance, position and acceleration. Devices were switched on fifteen minutes prior to the fielding innings to establish a satellite lock and worn throughout fielding. Information was downloaded using Catapult OpenField Software, Version 1.12.0. Data recorded was total distance (meters), movement speed bands (meters) corresponding to low (0-7 km/hr), medium (7.1-15 km/hr.), high (15.1-20 km/hr.) and sprinting (>20 km/hr.), maximal velocity (km/hr.) and player load. PlayerLoadTM is an accelerometer-derived measurement of physical demand that represents the accumulated change of accelerations in the forward, lateral and vertical planes, thus providing a valid measure of external loading (39,44). McNamara et al. (24) explain PlayerLoadTM is recorded from the square root of the squared rate of change in acceleration in each of the three planes (X, Y and Z axis) divided by 100; with the resultant accelerometer calculated as $r = (x^2 + y^2 + z^2)0{\cdot}5$, roll (x-axis – lateral flexion during bowling) and yaw (z-axis – rotation at the thoracic spine during the bowling action). Velocity zones were derived from previous recommendations (5,32). These units have acceptable validity and reliability (16,38,39).

Statistical Analyses

Descriptive statistics were presented as mean ± standard deviations for physical qualities and match demands. The within subject coefficient of variation (then averaged for the group) expressed as a percentage (CV%) was calculated to provide an indication of variability in movement patterns across games. All further statistical analysis was conducted in SPSS for windows (Version 23, IBM). A Shapiro-Wilks test and examination of skewness and kurtosis for each variable was conducted to test the normality of data ($p < 0.05$). Normality was confirmed for all variables except 20 m sprints, high-intensity and sprinting distances, thus Spearman’s (ρ) correlations were used for these variables to examine the relationship between physical fitness and match physical performance; Pearson’s (R) correlations were used for all other variables. Correlation coefficients were interpreted as weak (0.1 - 0.3), moderate (0.4 - 0.6) and strong (>0.7) (7,17,18). Statistical significance was set as $p < 0.05$.

**RESULTS**

Table 1 presents descriptives for physical fitness characteristics, with physical match characteristics presented in Table 2. The CV for time motion data ranged from 6 to 18%, with medium and sprinting intensity distance proving the most variable characteristic (18%), whereas maximal velocity differed by 6% between matches (Table 2). Interestingly, 67% of total distance was at low-intensity (<7 km/hr.) with only 15% at high-intensities (>15km/hr.) (Figure 1).

<<INSERT TABLES 1 & 2 HERE>>

<<INSERT FIGURE 1 HERE>>

Several relationships between physical qualities and physical match performance variables emerged (Table 3). Superior physical qualities positively correlated to match running variables, although not all were statistically significant. Spearman's correlation coefficients demonstrated moderate statistically non-significant ($p > 0.05$) relationships between skinfolds and high-intensity distance, plus statistically non-significant inverse relationships between 20-meter sprints to high-intensity and sprinting distances (Table 3). Whereas Pearson's correlation coefficients revealed moderate associations with low-intensity distance to CMJ height and Yoyo scores (Table 3). Interestingly, improved physical performance on CMJ, Yoyo and 20-meter sprint tests had statistically significant ($p < 0.05$) correlations to physical match performance. CMJ height positively correlated to total distance, sprinting distance and maximal velocity, whereas yoyo distance positively correlated to total distance and sprinting distance (Table 3). Conversely an inverse relationship was found between 20-meter sprint times to total distance and player load (Table 4). Finally, strong and statistically significant correlations were found between PlayerLoadTM and running variables (Table 5).

<<INSERT TABLE 3 & 4 HERE>>

## DISCUSSION

The study aimed to produce a physical profile of professional fast-bowlers and establish the physical match demands of 50-Over fixtures, before examining relationships between physical qualities and physical match performance. In conjunction with the hypothesis it demonstrated superior physical qualities can be attributed to greater physical match performance.

Fast-bowlers had skinfolds of 68.1 ± 8.7 mm, comparable with previous findings of Johnstone and Ford (18) (72.5 ± 16.5 mm) and Stuelken et al. (41) (62.3 ± 18.2 mm), however given the later used a sum of seven protocol which explains the lower values. Understanding anthropometrics is crucial for injury prevention as five to nine fold bodyweight is propelled over the front knee during every delivery, however this is dependent on a range of factors such as front knee and hip angle at release, thus understanding and reducing fat-mass is essential (34). Furthermore CMJ performance (42.7 ± 2.9 cm) appeared similar to Carr et al. (3) score of 42.1 ± 5.3 cm. Whilst optimal lower-limb power has been used as a partial predictor of ball velocity (35), by minimizing knee flexion on front foot contact and creating high velocity momentum prior to ball release (3,35). Fast-bowlers achieved 20-meter sprint times of 2.96 ± 0.08 s, and such a level of sprinting ability may be important in generating faster run-ups to deliver balls at faster speeds. Finally, yoyo distance of 2419 ± 496 meters was higher than 1760-meters previously reported (42), providing fast-bowlers with the aerobic capacity to bowl long spells and meet the rigorous demands of fielding (30,31,33). Such measures provide normative data, allowing goals and thresholds to be established.

Fast-bowlers experience the greatest workload, including total distance and both the frequency and distance covered at higher intensities (30,31,33). Total distance covered was 10.92 km, significantly less than 12.83 km (29) and 13.63 km (32) previously reported, although both studies used international fast-bowlers, thus opposition quality and ground dimensions may explain the lower values. The CV for time motion data ranged from 6 to 18%, with medium and sprinting intensity distance proving the most variable characteristic (18%), whereas maximal velocity differed by 6% between matches. This was expected due to the uncontrollable nature of competitive fixtures but was lower than the 11-36% previously accepted (31,32,33). One noticeable trend was the percentage of low-intensity work with 67% of total distance at less than 7 km/hr., literature supports 70% of total distance in one-day cricket is at low-intensity (32,33). As fast-bowlers are required to create high-velocity momentum during run-ups (25), this low-intensity activity is crucial in ensuring fast-bowlers are fully recovered. Over 1.5 km was covered at high-intensity (>15 km/hr.) with maximal velocity 28.11 km/hr., thus fast-bowlers must be training at high-intensities. A PlayerLoadTM score of 811 represents the external load for the entire fielding innings. PlayerLoadTM calculates the accumulative physical load and includes total distance, accelerations and change of directions (4,6), as expected PlayerLoadTM positively correlated to all running variables. To date, no study has explored the use of PlayerLoadTM in cricket, with workload monitoring typically focusing on overs bowled. Despite this, player load can be explained through understanding the physical demands of fast-bowling with bowlers generating numerous accelerations (>20 km/hr.), repeated change of directions when fielding and delivering up to 60 balls during a one-day innings (19,41,42). Such information will enable conditioning coaches to optimize training and recovery specificity (6).

Tests of physical qualities were associated with increased physical match performance. Although non-significant, negative correlations were established between skinfolds to low-medium intensity, sprinting and total distances. Interestingly, other sports have found negative correlations between skinfolds to high-intensity and total distance with this trend becoming highlighted during the second half of matches (12,40). Thus, combined with the positive relationship between fat-mass increasing ground reaction forces on front foot contact and injuries in fast-bowlers (34), conditioning coaches must look to optimize skinfolds to improve performance and minimize injury.

Significant correlations were found between CMJ height to total distance, sprinting distance and maximal velocity. Such findings are supported by Buchheit et al. (2) who concluded CMJ height improved total and high-intensity distance (16-19 km/hr.) in adolescent footballers. Additionally Gabbett and Seibold (13) found positive correlations between vertical jump performance and total distance in rugby league players, although such studies lack external validity to cricket it can be proposed increasing potential total distances will allow fast-bowlers to bowl longer spells. Unsurprisingly a positive correlation is apparent between CMJ height and maximal velocity. A CMJ gives an indication of an athletes slow stretch shortening cycle performance (>0.25s) which is essential in initial accelerations when fielding (3). As cricket consists of repeated maximal intensity efforts over short distances the ability to generate velocity during the first few ground contacts is crucial (3,18). Similarly Waldron et al. (43) demonstrated positive associations between CMJ and ball carrying speed in rugby league, explaining coaches should incorporate triple extension exercises such as cleans and plyometrics to improve lower-limb power and subsequent match velocities. Although literature focuses on other sports the importance of CMJ height to fast-bowlers is clear, including the ability to create and maintain high velocity run-ups.

Sprint times negatively correlated to total distance and PlayerLoadTM. In footballers, 10-40 meter sprint times correlated to total and high-intensity distance (>16.1 km/hr.) (2), however such conclusions are position dependent and a 1-Hz GPS unit with a 11-30% variability in high-intensity distance reduces validity (16,17). Likewise Rampinini et al. (37) highlighted the importance of peak running velocity as a predictor of total distance and high-intensity activity, although drawing associations from a repeated sprint test means aerobic capacity could be masking speed. As expected speed correlated to player load. PlayerLoadTM has previously correlated to peak velocity (4) and the frequency of high-intensity efforts, including sprinting, accelerations and impacts (6); however no literature has analyzed player load in cricket.

Findings demonstrate a significant relationship between yoyo performance and total and sprinting distances. Performance during tests of prolonged high-intensity running ability correlate to high-intensity and total distance in rugby league (14), which is consistent with soccer in that superior yoyo distance results in greater high-intensity match distance (5,36,37). Yoyo performance has been used as a predictor of fatigue in soccer with superior aerobic capacity optimizing high-intensity distance in the second half of matches (21), such conclusions are transferable to fast-bowlers who are required to bowl the final overs of an innings. Furthermore, yoyo test better replicates the intermittent nature of fast-bowling (20). Unfortunately, the unpredictable nature of competitive sport means high-intensity distance varies depending on tactical limitations and motivation, thus large sample sizes are required before findings are generalizable (17). However, findings do highlight the importance of prolonged high-intensity running ability to match running performance, thus fast-bowlers should improve the ability to perform repeated high-intensity activity with minimal recovery.

This research outlines the physical fitness characteristics of fast-bowlers and the physical demands of one-day cricket. Relationships between tests of physical qualities and match performance highlighted the importance of lower-limb power, speed and prolonged intermittent running ability to enhance physical match performance. Therefore conditioning coaches must utilize such information to optimize training specificity and ensure players are conditioned for cricket.

However the authors do recognize potential limitations within the study. Firstly, sample size of fast-bowlers and number of fixtures is small, however this was unavoidable due to limited numbers of fast-bowlers selected per team and volume of one-day fixtures. Additionally the nature of professional cricket meant data was omitted due to player selection and injuries, with weather also hindering data collection through postponements (9). Finally, the study didn't attempt to quantify contextual factors such as opposition quality, match outcome or pitch conditions (37).

Future research should increase the number of fast-bowlers and match formats. As GPS has produced valid measures of distance, speed and accelerations, the next progression is to explore specific algorithms to automatically identify match events, including total deliveries. This is of significance as the majority of fast-bowling injuries are caused by overuse and currently training overs are self-reported thus lack accuracy, consequently an improved understanding, monitoring and modification of total workload will reduce injury (24). Research should look to identify bowling specific metrics, for example, run-up speeds and peak rotation, to explore the relationship between physical qualities and bowling performance with particular focus on the ability to maintain these throughout a spell. Finally, the physical variation between fielding positions should be identified, for example, a fast-bowler fielding at slip will experience significantly less physical load than a boundary fielder, which would allow captains to seek advantageous field placements.

## PRACTICAL APPLICATIONS:

The positive relationship between tests of physical qualities and physical match demands demonstrates the need to prepare fast-bowlers for competition. Fast-Bowlers undertake the greatest physical workload including, total distance and both frequency and distance of high-intensity activities, thus coaches should seek the most advantageous fielding positions to optimize recovery (30,31,32). However specialist skills for certain positions (slip catching) must be considered. Strength and conditioning coaches should deliver a multidimensional conditioning program to include optimizing body composition, speed, power and aerobic capacity to enhance physical match performance. The importance of lower-limb power and speed to total distance, sprinting distance and maximal sprinting velocities during competition suggests the need to develop these physical qualities with players (3,35). Although, future research is required to explore the efficacy of using plyometric and weightlifting exercises (the training strategies required to develop such qualities) to enhance fast-bowlers run-up velocities. Prolonged high-intensity running ability is important for fast-bowlers to cover high volumes at sprinting intensities, thus bowlers should be conditioned to bowl faster for longer (18,19). Finally, due to financial constraints limiting GPS in cricket, coaches should incorporate RPE as a cost-effective method of monitoring load. Such information will enable conditioning coaches to optimize training and recovery specificity to ensure fast-bowlers are optimally prepared.

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Figure 1. Percentage of Total Distance in Speed Zones.

Figure 1

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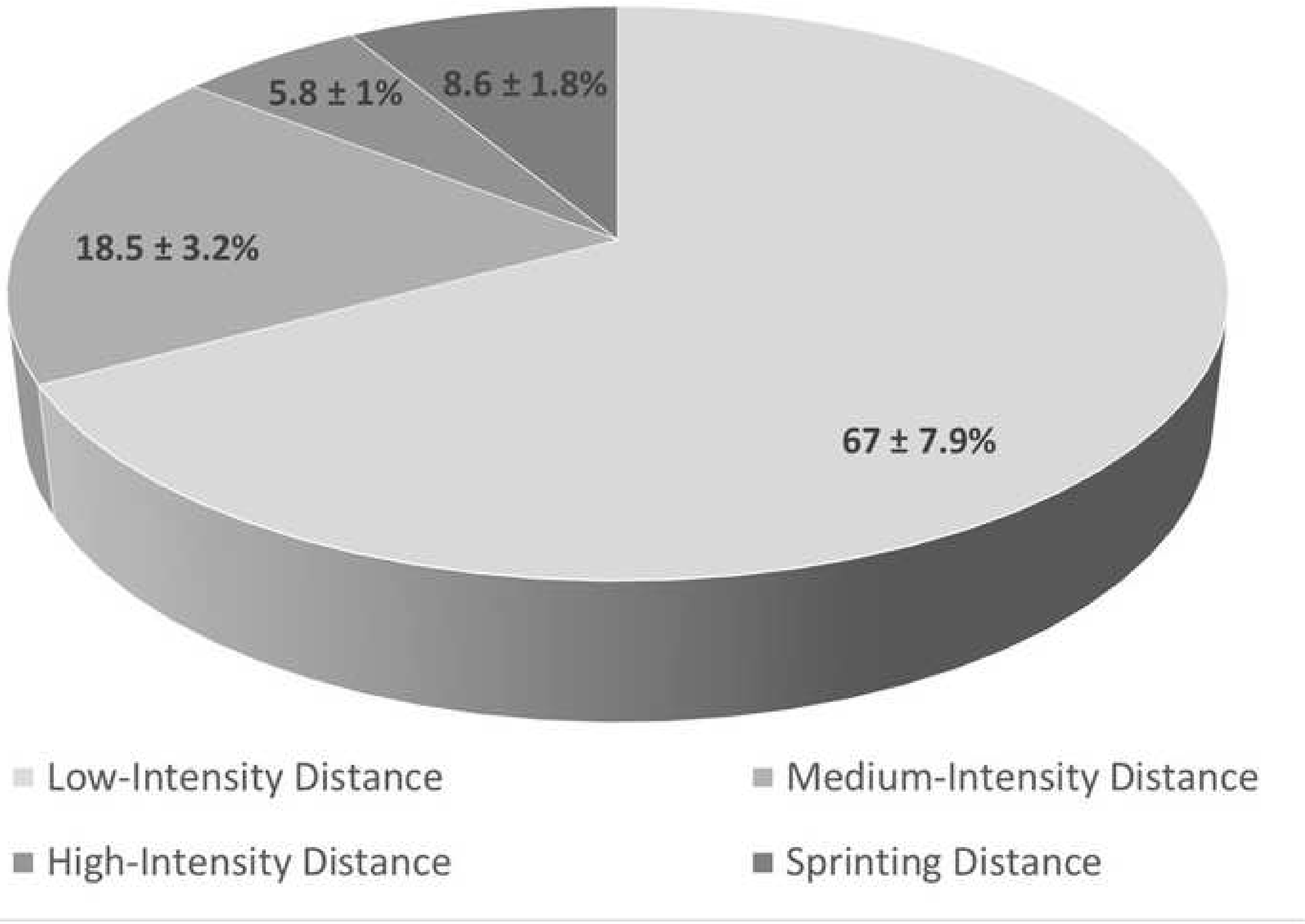

**Table 1.** Physical fitness characteristics for the cricket fast-bowlers (n = 15) participating in the study.

| Test | Mean ± SD |
|---|---|
| Skinfolds (mm) | 68.1 ± 8.7 |
| CMJ (cm) | 42.7 ± 2.9 |
| 20 m Sprint (s) | 2.96 ± 0.08 |
| YoYo (m) | 2419 ± 496 |

CMJ = Counter-Movement Jump, SD = Standard Deviation

**Table 2.** Time-motion variables for fast-bowlers (n = 15) in 50-Over Cricket.

| Workload Characteristic | Innings Mean/SD | Hourly Mean/SD | CV % (95% CI) |
|---|---|---|---|
| Low-Intensity (0-7 km/hr) (m) | 7,321 ± 864 | 2,440 ± 288 | 9.9 (8.1-11.7) |
| Medium-Intensity (7.1-15 km/hr) (m) | 2,022 ± 347 | 674 ± 116 | 17.8 (14.6-21.1) |
| High-Intensity (15.1-20 km/hr) (m) | 637 ± 114 | 212 ± 38 | 17.3 (14.2-20.5) |
| Sprinting (20.1+ km/hr) (m) | 941 ± 195 | 314 ± 65 | 18.0 (14.7-21.2) |
| Total Distance (m) | 10,920 ± 1,203 | 3,640 ± 401 | 11.0 (9 -13) |
| Maximal Velocity (km/hr) (m) | 28.11 ± 1.05 | | 5.9 (4.8 – 7.0) |
| Player Load (au) | 811 ± 105 | 270 ± 35 | 11.9 (9.8 – 14.1) |

SD = Standard Deviation, CV = Coefficient of Variation.

**Table 3.** Relationships with 95% Confidence Intervals between Physical Fitness and Physical Match Demands (R unless stated).

| | TD | LID | MID | HID | SD | MV | PL |
|---|---|---|---|---|---|---|---|
| Skinfolds | -0.126 | -0.030 | -0.296 | ρ = 0.470 | ρ = -0.261 | 0.190 | 0.121 |
| | [-0.60-0.41] | [-0.53-0.49] | [-0.70-0.26] | [-0.06-0.79] | [-0.68-0.29] | [-0.36-0.64] | [-0.42-0.60] |
| CMJ | 0.585* | 0.497 | 0.327 | ρ = 0.332 | ρ = 0.554* | 0.567* | 0.295 |
| | [0.10-0.84] | [-0.02-0.80] | [-0.22-0.72] | [-0.22-0.72] | [0.06-0.83] | [0.08-0.84] | [-0.26-0.70] |
| 20m Sprint | ρ = -0.519* | ρ = -0.377 | ρ = -0.262 | ρ = -0.468 | ρ = -0.442 | ρ = -0.387 | ρ = -0.561* |
| | [-0.82- -0.01] | [-0.75-0.17] | [-0.68-0.29] | [-0.79-0.06] | [-0.78-0.09] | [-0.75-0.16] | [-0.83- -0.07] |
| Yo-Yo | 0.520* | 0.444 | 0.357 | ρ = 0.382 | ρ = 0.524* | 0.214 | 0.360 |
| | [0.01-0.82] | [-0.09-0.78] | [-0.19-0.74] | [-0.16-0.75] | [0.02-0.82] | [-0.34-0.65] | [-0.19-0.74] |

* Correlation is Significant at the 0.05 Level

CMJ = Counter-Movement Jump, TD = Total Distance, LID = Low-Intensity Distance, MID = Medium-Intensity Distance, HID = High-Intensity Distance, SD = Sprinting Distance, MV = Maximal Velocity, PL = Player Load.

**Table 4.** Relationships with 95% confidence intervals between Player Load and Other Time-Motion Match Variables (R unless stated).

| | TD | LID | MID | HID | SD | MV |
|---|---|---|---|---|---|---|
| Player Load | 0.768** | 0.695** | 0.595* | ρ = 0.746** | ρ = 0.347 | 0.643** |
| | [0.42 - 0.92] | [0.28 – 0.89] | [0.12 – 0.85] | [0.38 – 0.91] | [-0.20 – 0.73] | [0.19 – 0.87] |

* Correlation is Significant at the 0.05 Level

** Correlation is Significant at the 0.01 Level

TD = Total Distance, LID = Low-Intensity Distance, MID = Medium-Intensity Distance, HID = High-Intensity Distance, SD = Sprinting Distance, MV = Maximal Velocity, PL = Player Load.