International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2025: 7.089

# Effect of High-Intensity Circuit Training on Aerobic Capacity and Muscular Endurance among Male Recreational Cricket Players

Running Title: High-Intensity Circuit Training in Recreational Cricket Players

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**Abstract:** ***Background: Cricket is an intermittent sport requiring repeated high-intensity actions interspersed with lower-intensity activity. Adequate aerobic capacity and muscular endurance are important for sustaining performance and recovery during prolonged participation. High-Intensity Circuit Training (HICT) combines aerobic and resistance exercises within a time-efficient training format. However, limited research has examined HICT among male recreational cricket players. Aim: To determine the effect of HICT on aerobic capacity and upper-body muscular endurance among male recreational cricket players. Methods: A pre-experimental one-group pre-test and post-test design was used. Thirty male recreational cricket players aged 18–25 years were recruited using convenience sampling. Participants completed an 8-week supervised HICT programme, three sessions per week on non-consecutive days, with each session lasting approximately 45 minutes. Aerobic capacity was assessed using the 12-minute Cooper run test, and upper-body muscular endurance was assessed using the 1- minute push-up test. Pre-test and post-test values were compared using a paired t-test. Results: Aerobic capacity improved significantly, with the mean Cooper run distance increasing from 2436.00 ± 291.93 m at pre-test to 2633.33 ± 320.70 m at post-test ($t = 16.28$, $p < 0.001$). Upper-body muscular endurance also improved significantly, with the mean push-up score increasing from 21.83 ± 7.18 repetitions to 26.50 ± 8.87 repetitions ($t = 13.33$, $p < 0.001$). Conclusion: An 8-week HICT programme was associated with significant improvements in aerobic capacity and upper-body muscular endurance among male recreational cricket players. HICT may provide a practical and time-efficient conditioning approach for this population.***

**Keywords:** High-Intensity Circuit Training, recreational cricket players, aerobic capacity, muscular endurance, 12-minute Cooper run test, push-up test

## 1. Introduction

The physical demands of cricket differ according to playing role and match format. Batters may perform repeated short accelerations and changes of direction, while fielders must respond quickly to the ball and sustain activity across an innings. These demands make general physical conditioning relevant even for players who participate recreationally rather than in professional training environments. The physiological and movement demands described in cricket literature provide a rationale for assessing fitness components that support repeated activity.

The exact demands vary with the duration of play, pitch conditions, fielding position, and individual playing role. Even at recreational level, players may need to sustain attention and movement over an extended period while repeatedly producing short bursts of activity. Conditioning should therefore address both the ability to sustain activity and the ability to repeat movements after incomplete recovery. The present study focused on two field-based components of fitness rather than attempting to represent every physical demand of cricket.

Aerobic capacity is important in intermittent sports because recovery between intense efforts occurs alongside continued low- to moderate-intensity activity. Better aerobic fitness may support the ability to sustain participation and recover between repeated efforts; however, aerobic capacity alone does not represent all the physical requirements of cricket. It is therefore useful to examine aerobic capacity alongside a separate measure of muscular endurance.

Aerobic fitness is not the only determinant of cricket performance, and a field test of running distance cannot directly quantify technical skill, tactical decision-making, or match performance. Nevertheless, aerobic capacity is a relevant general fitness component because it supports sustained activity and recovery between more demanding efforts. In this study, the 12-minute Cooper run test was selected as a practical field assessment that could be administered before and after the training period under similar conditions.

Muscular endurance refers to the ability of a muscle group to perform repeated contractions or maintain a submaximal effort over time. Upper-body endurance can be relevant to repeated physical tasks and general conditioning, although a push-up test does not directly measure cricket-specific skill or performance. In this study, the one-minute push-up test was selected as a practical field measure of upper-body muscular endurance.

The one-minute push-up test was selected because it provides a simple count-based measure that can be repeated without specialised laboratory equipment. The score reflects performance of a coordinated movement involving the upper limbs and trunk, and it should be interpreted as a task-specific measure rather than a direct measurement of endurance in every individual upper-body muscle. Standardising instructions and counting only correctly performed repetitions are important for making pre-test and post-test scores comparable.

High-intensity circuit training combines multiple exercises in sequence with planned work and recovery intervals. A circuit can include both whole-body and upper-body tasks and can be delivered with minimal equipment, which may make it feasible in community or college-based settings. The training stimulus depends on exercise selection, work duration, recovery periods, number of circuits, session frequency, and progression across the programme. These variables should be reported clearly so that the intervention can be understood and reproduced.

Circuit-based training may also offer a practical way to organise several exercise tasks within a limited session. In a body-weight format, the exercises can be arranged to alternate movement patterns and involve different regions of the body. However, the actual training stimulus depends on exercise technique, effort, work duration, rest duration, progression, and adherence. For that reason, the current protocol specified the work and rest intervals, number of circuits, weekly frequency, and perceived-intensity target.

The present programme used body-weight exercises and a progressive increase in circuit volume while maintaining three sessions per week. The selected exercises included jump squats, push-ups, mountain climbers, plank, high knees, and squat thrusts. The programme was designed to provide a structured conditioning stimulus rather than cricket technical training. Its effects were evaluated using the same field tests before and after the intervention.

The study was designed to examine changes in two selected outcomes after a defined training period in recreational male players. It did not include a control group, and it did not measure match statistics, laboratory-derived maximal oxygen uptake, or strength in isolated muscle groups. The findings should therefore be understood as pre-test to post-test changes observed during participation in the programme, rather than definitive evidence that the intervention alone caused all observed changes.

Cricket is an intermittent sport characterized by alternating periods of lower-intensity activities with short periods of high-intensity activities including sprinting, bowling, batting, and fielding. These repeated changes in activity place demands on the cardiovascular and musculoskeletal systems and require players to repeatedly perform high-intensity efforts throughout participation.1–3 Adequate physical fitness is therefore important for sustaining performance, delaying fatigue, and facilitating recovery during prolonged match play.

Recreational cricket players may have fewer opportunities than professional players to follow systematic physical conditioning programmes and regular fitness assessment. Participation in cricket alone may not provide sufficient exposure to structured aerobic and resistance conditioning required to develop multiple components of physical fitness. Practical conditioning strategies may therefore be useful for improving exercise tolerance and the ability to repeatedly perform sport-related activities.

Aerobic capacity represents the ability of the cardiovascular and respiratory systems to deliver oxygen to working muscles and support sustained physical activity.4,15 It is relevant to intermittent sports because players require adequate aerobic fitness both to sustain prolonged activity and to recover between repeated high-intensity efforts. Muscular endurance is the ability of a muscle or muscle group to perform repeated contractions or sustain force production over time without excessive fatigue.5 Upper-body muscular endurance is relevant to batting, bowling, throwing, and fielding.

HICT combines aerobic and resistance exercises within a single training session and can be performed using body-weight or simple resistance exercises with relatively short recovery periods.6 Previous research has demonstrated beneficial effects of HICT on physical fitness. Yunus et al. reported significant improvements in physical fitness following an 8-week HICT programme performed three times per week among healthy young males.7 Ho et al. reported improvements in muscle mass and muscular performance following an 8-week HICT intervention among sedentary workers.8 Systematic review evidence has also reported beneficial effects of high-intensity multimodal training on several components of physical fitness.9

The 12-minute Cooper run test is a practical field-based assessment used to estimate aerobic capacity, with evidence supporting its validity for estimating maximal oxygen uptake in healthy individuals.11,12 The 1-minute push-up test provides a simple field-based measure of upper-body muscular endurance and requires minimal equipment.13 Despite evidence supporting HICT and practical field-based outcome measures, limited research has specifically examined the combined effects of HICT on aerobic capacity and upper-body muscular endurance among male recreational cricket players. Therefore, the present study investigated the effect of an 8-week HICT programme on these outcomes.

## 2. Aim and Objectives

### Aim

Although circuit training and high-intensity training have been examined in different populations, findings from other groups cannot automatically be assumed to apply to recreational cricket players. The present study addressed this practical question by applying an eight-week body-weight HICT programme and assessing two accessible outcomes: distance covered in the 12-minute Cooper run test and repetitions completed in the one-minute push-up test. This focus may be useful for settings where advanced exercise-testing equipment is not readily available.

To determine the effect of HICT on aerobic capacity and upper-body muscular endurance among male recreational cricket players.

**Objectives**

- To assess pre-test and post-test aerobic capacity using the 12-minute Cooper run test.
- To assess pre-test and post-test upper-body muscular endurance using the 1-minute push-up test.
- To determine the effect of HICT on aerobic capacity among male recreational cricket players.
- To determine the effect of HICT on upper-body muscular endurance among male recreational cricket players.

## 3. Materials and Methodology

### 3.1 Study Design and Participants

The study employed a pre-experimental one-group pre-test and post-test design. Thirty male recreational cricket players aged 18–25 years were recruited using convenience sampling. The study was conducted at the College of Physiotherapy, SVIMS, and the Department of Physical Education, Sri Venkateswara University, Tirupati.

The study compared each participant with his own baseline score. This approach allowed within-participant change to be examined over the intervention period, but it did not provide a comparison with usual activity or another exercise programme. Convenience sampling was used; consequently, the sample may not represent all recreational cricket players. The results should be generalised cautiously beyond men of a similar age and recreational participation profile.

A single-group design was used, with outcome measures recorded before the training programme and again after completion of the eight-week intervention. Because no parallel control group was included, the findings describe changes observed within the participants over time and should not be interpreted as definitive proof that the intervention alone caused all observed changes.

Participants were eligible if they were male recreational cricket players aged 18–25 years, apparently healthy, regularly participating in recreational cricket activities, and willing to participate throughout the study period. Participants were excluded if they had a history of cardiovascular, neurological, or musculoskeletal disorders; recent injury or surgery affecting physical activity; contraindications to high-intensity exercise; participation in structured high-intensity or resistance training during the study period; or inability/unwillingness to complete the intervention or assessment procedures.

Before participation, players were informed about the study purpose, testing procedures, training schedule, and their role in completing the intervention. Participation was voluntary, and written informed consent was obtained as stated in the study records. The manuscript should retain the exact ethics committee approval number and approval date only if these are available in the official approval documentation; these details should not be inferred or fabricated.

The study was initiated after obtaining approval from the Institutional Ethics Committee of Sri Venkateswara Institute of Medical Sciences, Tirupati. The purpose and procedures were explained to all participants, and written informed consent was obtained before enrolment.

**Outcome Measures**

Aerobic capacity was assessed using the 12-minute Cooper run test. Participants were instructed to cover the maximum possible distance within 12 minutes on a standard 400-m athletic track. The total distance covered was recorded in metres.11,12

For interpretation, the recorded distance was treated as the primary observed result of the Cooper test. Although Cooper-test distance can be used to estimate aerobic fitness in appropriate populations, the present study reports distance covered rather than a directly measured value of maximal oxygen uptake. The same test name and unit are used for both assessment occasions.

Upper-body muscular endurance was assessed using the 1-minute push-up test. Participants performed the maximum number of correctly executed push-ups within one minute, and the total number of repetitions was recorded.13

The push-up count was recorded as the number of valid repetitions completed within the one-minute period. Because push-up scores can be influenced by technique, pacing, and familiarity with the test, consistent instructions and the same counting criteria at both assessment points are important. The result is reported as repetitions and is not converted into a separate physiological estimate.

The same test procedures and outcome units were used at pre-test and post-test to support comparison across assessment points. The Cooper run test result was recorded as distance covered in metres, while the push-up test result was recorded as the number of correctly performed repetitions completed within one minute. Test performance can be influenced by participant effort and test-day conditions; therefore, consistent instructions and supervision are important when administering field-based measures.

**Intervention Protocol**

Participants underwent a supervised HICT programme for 8 weeks, with three training sessions per week on non-consecutive days. Each session lasted approximately 45 minutes and consisted of a 10-minute warm-up, 30-minute HICT session, and 5-minute cool-down. Exercise intensity was monitored using the modified Borg RPE scale (0–10), with a target intensity of RPE 8–9. All sessions were supervised by the investigator.

Sessions were scheduled on non-consecutive days to provide time between training exposures. The warm-up and cool-down were included as part of the planned session structure. The six exercise stations were performed in the same circuit sequence, while the work interval and number of circuits changed according to the planned progression. No additional equipment-dependent exercise stations are described in this protocol.

The HICT programme consisted of six body-weight exercises performed consecutively in a circuit format: jump squats, push-ups, mountain climbers, plank, high knees, and squat thrusts. Training volume progressed over the intervention period while maintaining the prescribed intensity and exercise technique.

The selected movements represented a mixture of lower-body dynamic exercise, upper-body pushing, whole-body repeated movement, trunk stabilisation, and rapid stepping or running-in-place activity. The circuit was intended as general physical conditioning rather than a technical cricket-skills session. Exercise performance and perceived effort should be interpreted in the context of the stated protocol; the study did not separately quantify the physiological load of each exercise station.

Training intensity was targeted at a rating of perceived exertion of 8–9 on the modified 0–10 scale, as specified in the study protocol. Participants were supervised during the sessions, and the exercise sequence and progression were kept consistent with the planned intervention.

The work-to-rest structure was progressed by increasing the number of circuits during the early weeks and then increasing the work interval in the later weeks. During weeks 1–2, participants performed two circuits with 30 seconds of work and 15 seconds of rest for each exercise. During weeks 3–4, the work and rest intervals remained the same while the programme increased to three circuits. During weeks 5–8, participants completed three circuits with 40 seconds of work and 15 seconds of rest. A two-minute recovery period was provided between circuits. The planned session also included approximately 10 minutes of warm-up, 30 minutes for the circuit component, and 5 minutes of cool-down.

Progression was volume-based: participants first completed two circuits, then three circuits, and later retained three circuits while increasing the work interval. The rest interval remained 15 seconds between stations, with a two-minute recovery between circuits. The schedule was intended to increase total work while keeping the weekly frequency at three sessions. The protocol description should be checked against the approved intervention sheet before submission to ensure that the final manuscript matches the programme actually delivered.

**Table 1:** HICT training progression

| Weeks | Work duration | Rest between exercises | Circuits | Rest between circuits |
|---|---|---|---|---|
| 1–2 | 30 s | 15 s | 2 | 2 min |
| 3–4 | 30 s | 15 s | 3 | 2 min |
| 5–8 | 40 s | 15 s | 3 | 2 min |

**Statistical Analysis**

Data were entered into Microsoft Excel and analysed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were expressed as mean ± standard deviation (SD). The Shapiro–Wilk test was used to assess normality. The paired t-test was used to compare pre-test and post-test values of aerobic capacity and upper-body muscular endurance. A p-value $< 0.05$ was considered statistically significant.

Pre-test and post-test means were compared using a paired-samples t-test because both measurements were obtained from the same participants. Statistical significance was set at $p < 0.05$. The reported p-values were below this threshold for both outcomes. Results are presented as mean ± standard deviation to show the central value and variability within the sample.

The paired-samples analysis was appropriate to the repeated-measures structure because the pre-test and post-test scores belonged to the same participants. The p-value indicates the statistical evidence against a null hypothesis of no mean change under the test assumptions; it does not by itself describe the practical importance of the change. Mean differences are therefore also reported to make the magnitude of observed change transparent.

## 4. Results

Thirty male recreational cricket players completed the study. The mean age was 20.90 ± 2.05 years, mean height was 173.20 ± 4.72 cm, and mean body weight was 70.80 ± 4.85 kg.

**Table 2:** Demographic characteristics of participants (n = 30)

| Variable | Mean | SD |
|---|---|---|
| Age (years) | 20.90 | 2.05 |
| Height (cm) | 173.20 | 4.72 |
| Weight (kg) | 70.80 | 4.85 |

**Table 3:** Pre-test and post-test outcome measures

| Outcome | Pre-test Mean ± SD | Post-test Mean ± SD | t-value | p-value |
|---|---|---|---|---|
| Cooper run distance (m) | 2436.00 ± 291.93 | 2633.33 ± 320.70 | 16.28 | <0.001 |
| Push-up score (repetitions) | 21.83 ± 7.18 | 26.50 ± 8.87 | 13.33 | <0.001 |

Aerobic capacity improved significantly after the 8-week HICT programme. The mean distance covered in the 12-minute Cooper run test increased from 2436.00 ± 291.93 m at pre-test to 2633.33 ± 320.70 m at post-test ($t = 16.28$, $p < 0.001$).

The mean increase in distance was 197.33 m. This value describes the difference between the reported group means and should not be interpreted as an identical improvement for every participant. Individual responses may vary, but individual-level response data are not presented in the current summary tables.

Upper-body muscular endurance also improved significantly. The mean 1-minute push-up score increased from 21.83 ± 7.18 repetitions at pre-test to 26.50 ± 8.87 repetitions at post-test ($t = 13.33$, $p < 0.001$).

The mean increase was 4.67 repetitions. As with the Cooper run result, this is a group-level difference between assessment occasions. It does not establish that every participant improved by the same number of repetitions, and it should not be taken as evidence of improvement in all dimensions of upper-body strength or endurance.

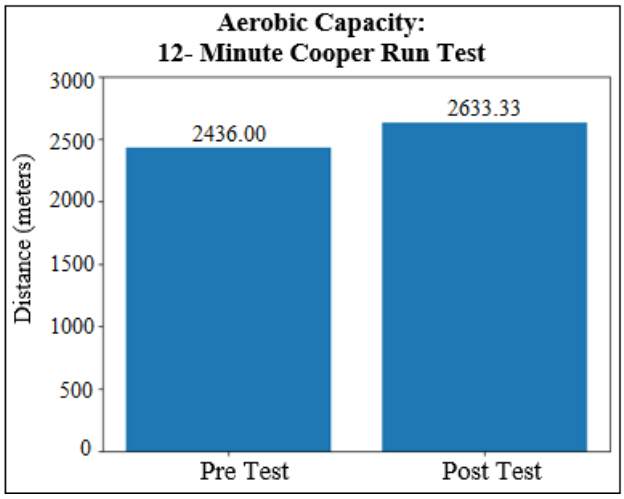



**Figure 1:** Pre-test and post-test mean distance in the 12-minute Cooper run test

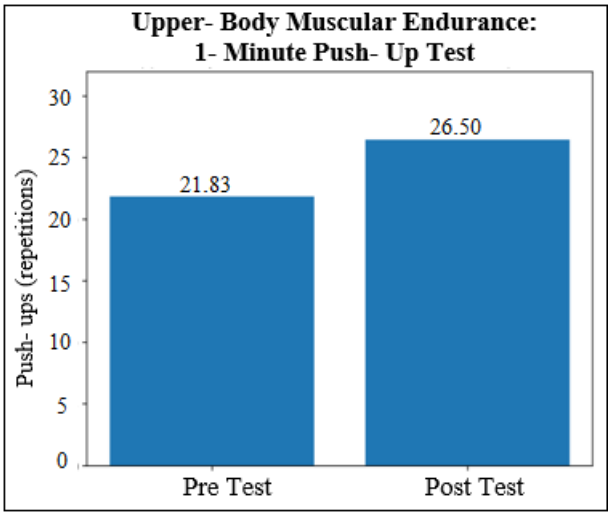



**Figure 2:** Pre-test and post-test mean repetitions in the one-minute push-up test

Note: Graphs display group means only. Error bars are not shown.

## 5. Discussion

The increase in mean Cooper run distance indicates that participants covered a greater distance during the 12-minute test after the intervention. The change in the group mean was 197.33 m, from 2436.00 m at baseline to 2633.33 m after eight weeks. This result is consistent with an improvement in performance on the selected field test. The Cooper test is practical for group assessment because it requires a measured running area and timing, although performance reflects effort and running ability as well as aerobic fitness.

A possible explanation is that repeated exposure to dynamic whole-body exercises and progressively increased circuit volume may have provided a conditioning stimulus. This explanation is plausible but was not directly tested: the study did not measure training heart rate, oxygen uptake, lactate response, or the contribution of individual exercise stations. Accordingly, the mechanism should be presented as an interpretation rather than a measured finding.

The improvement in the one-minute push-up score indicates an increase in the number of repetitions completed under the test conditions. The mean score increased by 4.67 repetitions, from 21.83 to 26.50. Push-ups involve repeated upper-body and trunk muscle activity, making the test relevant to the study's operational measure of upper-body muscular endurance. Nevertheless, the result should be interpreted as a change in push-up test performance rather than a direct measure of all upper-body muscle groups or cricket-specific performance.

Repeated push-ups within the circuit may have provided task-specific practice, while trunk-stability and whole-body exercises may have contributed to the overall training demand. However, because the push-up test is itself a repeated movement task and there was no control group, the observed change may reflect a combination of training adaptation, test familiarity, and other influences. The study design cannot determine the relative contribution of these factors.

The intervention combined lower-body, upper-body, trunk-stability, and whole-body movements within a single circuit. This combination provided a structured session with both repeated dynamic tasks and a sustained trunk exercise. The progressive increase in circuit volume and work duration was intended to increase the training demand across the eight-week period while retaining the planned frequency of three sessions per week. The results should be interpreted in the context of this specific programme rather than assumed to apply to every HICT protocol.

The use of a consistent weekly schedule and a planned progression is a practical feature of the intervention. For clinicians or coaches considering a similar programme, the results support the feasibility of examining body-weight circuit training with field-based outcome measures, but they do not establish an optimal exercise selection, intensity, or progression for all cricket players. Any application should take account of baseline fitness, exercise technique, symptoms, and individual tolerance.

Although both outcomes improved statistically, the study design limits causal interpretation. Without a control group, it is not possible to separate the contribution of HICT from other influences such as normal activity, familiarisation with the tests, motivation, or changes in training outside the study. The findings are therefore best described as improvements observed after participation in the programme. Future controlled studies would help establish whether similar changes occur relative to usual activity or another conditioning approach.

The absence of a control group is the principal interpretive limitation. Other explanations for pre-test to post-test changes include concurrent physical activity, changes in cricket participation, variation in testing conditions, and familiarity with the tests. The study also did not report a separate measure of adherence or systematically monitored external training load in the summary available for this manuscript. These gaps should be acknowledged rather than addressed through assumptions.

The present study evaluated the effect of an 8-week HICT programme on aerobic capacity and upper-body muscular endurance among male recreational cricket players. Table 3 shows that aerobic capacity significantly improved, with the mean Cooper run distance increasing from 2436.00 ± 291.93 m to 2633.33 ± 320.70 m ($t = 16.28$, $p < 0.001$). The finding is consistent with HICT as a time-efficient conditioning method capable of producing cardiorespiratory adaptations.6 Yunus et al. also reported significant improvements in physical fitness following an 8-week HICT programme performed three times per week in healthy young males.7 The improvement observed in the present study may be related to repeated high-intensity exercise involving large muscle groups, which provides a cardiovascular training stimulus and may improve oxygen transport and utilization and exercise efficiency.

Table 3 also demonstrates a significant improvement in upper-body muscular endurance, with the mean push-up score increasing from 21.83 ± 7.18 to 26.50 ± 8.87 repetitions ($t = 13.33$, $p < 0.001$). This finding is consistent with Vadivel and Maniazhagu, who reported significant improvements in muscular strength endurance following circuit training and circuit weight training.14 The improvement may be attributed to repeated body-weight loading and progressive training volume, which can provide a repeated stimulus to the muscles of the upper limbs and trunk and improve neuromuscular coordination and resistance to fatigue.

The present findings are also supported by Yunus et al., who reported improvements in multiple components of physical fitness after 8 weeks of HICT, and Ho et al., who reported improvements in muscle mass and muscular performance after an 8-week HICT intervention.7,8 The combination of aerobic and resistance exercises within the present HICT programme may therefore have provided simultaneous cardiovascular and muscular stimuli. However, because the present study used a one-group pre-test and post-test design without a control group, the observed changes should be interpreted in the context of the study design.

## 6. Limitations and Recommendations

The findings should be interpreted within the boundaries of the sample and design. Recruitment from a single setting using convenience sampling may limit external validity, and the sample included only male recreational players aged 18–25 years. The eight-week intervention provides information about short-term changes but does not establish whether improvements persist after training stops or translate into improved match performance.

- The sample size was relatively small and included only 30 male recreational cricket players, which may limit generalizability.
- The intervention duration was limited to 8 weeks.
- The study used a one-group pre-test and post-test design without a control group.
- Dietary intake and physical activity outside the intervention were not controlled.

The study also relied on field-based tests, which are practical for recreational settings but do not directly measure laboratory-based maximal oxygen uptake or isolate muscular endurance in every upper-body muscle group. The findings should be considered within the selected outcomes and sample characteristics.

Only aerobic capacity and upper-body muscular endurance were assessed; other fitness components were not evaluated.

## 7. Conclusion

From a practical perspective, the programme used body-weight exercises and field-based tests, which may be easier to organise than laboratory-based training and assessment. However, coaches and physiotherapists should not interpret the findings as proof that the programme is superior to other conditioning methods. A controlled study with a larger and more diverse sample, documented attendance, monitoring of training load, and follow-up assessment would help clarify the magnitude and durability of change.

An 8-week supervised HICT programme was associated with statistically significant improvements in aerobic capacity and upper-body muscular endurance among male recreational cricket players. The programme combined body-weight aerobic and resistance exercises and was delivered three times per week in approximately 45-minute sessions. HICT may therefore provide a practical and time-efficient conditioning approach for recreational cricket players.

Future studies may include larger samples, female cricket players and different age groups; incorporate a control group or comparison intervention; use longer intervention periods; and evaluate additional physical fitness outcomes such as agility, speed, muscular strength, power, flexibility, and balance.

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