Prismatic Horizons
Journal of Social Science and Humanities
www.phjssh.lexarcheus.com
Vol.-03, Issue-04 (Oct-Dec, 2025)

Building Aerobic Engines Young: Effects of an Eight-Week Sub-Maximal Aerobic Training Programme on Body Composition, Physiological Efficiency and On-Field Performance in Under-14 Cricketers

Tanveer Ali[1], Vikas Saxena[2]
[1] Research Scholar, Department of Physical Education, Rabindranath Tagore University, Raisen, Madhya Pradesh, India.
[2] Head of the Department, Department of Physical Education, Rabindranath Tagore University, Madhya Pradesh, India.

*** Corresponding Author:**
Tanveer Ali
ms9601503@gmail.com
https://doi.org/10.5281/zenodo.20990815

ARTICLE INFO

Article History

Received	14 Oct, 2025
Revised	26 Nov, 2025
Accepted	25 Dec, 2025
Available Online	30 Dec, 2025

ARTICLE ID
PHJSSH0304005

KEYWORDS

Body composition, VO2max, Yo-Yo Intermittent Recovery Test, junior cricket, Under-14 cricketers

OPEN ACCESS

ABSTRACT

Modern cricket increasingly demands repeated high-intensity efforts interspersed with low-intensity activity over long durations, making aerobic fitness a foundational quality even at junior levels. This study examined the impact of an eight-week sub-maximal aerobic training programme on selected body composition, physiological and performance variables among Under-14 cricketers. Methods: Thirty male cricketers (N=30), aged 12-14 years, registered with district-level junior cricket academies, were selected through purposive sampling and randomly assigned to an Experimental Group (sub-maximal aerobic training, n=15) and a Control Group (regular cricket coaching only, n=15). The experimental group undertook sub-maximal continuous and interval running at 60-75% of age-predicted maximum heart rate, three sessions per week for eight weeks, in addition to routine skill training. Body weight, Body Mass Index (BMI) and percentage body fat represented body composition; resting heart rate, VO2max (estimated via the 20-m multistage shuttle run/beep test) and vital capacity represented physiological variables; and 30-yard sprint, Yo-Yo Intermittent Recovery Test level and beep test stage represented performance variables. Pre- and post-test data were analysed using paired and independent sample t-tests at the 0.05 level of significance. Results: The experimental group showed statistically significant improvements across all nine variables ($p<0.05$), with the largest relative changes observed in Yo-Yo Intermittent Recovery performance (16.4%), beep test stage (19.4%) and percentage body fat reduction (15.2%), while the control group showed negligible, non-significant change. Conclusion: An eight-week sub-maximal aerobic training protocol produces meaningful, favourable adaptations in body composition, cardio-respiratory efficiency and cricket-specific performance capacities in Under-14 cricketers without imposing excessive physiological strain, supporting its inclusion as a safe, age-appropriate conditioning modality in junior cricket programmes.

1. INTRODUCTION

The game of cricket has progressed in relevance from the skill and technique aspect of the sport to a sport where the athletes aerobic and anaerobic energy systems are significantly challenged. Today, due to shorter form, faster bowlers, more extensive fielding rotations and longer playing seasons, the physical shape demands of modern players is dramatically different – even for junior cricketers. Bowlers can bowl dozens of overs a day, batsmen are required to take the stumps once in a while for long periods of time, and fielders are repeatedly running, jumping, diving and getting up in seconds. The common denominator among all these match needs is the need for a solid aerobic base that allows quick recovery between bouts, slows down fatigue and maintains technical ability for extended playing time. In general, conditioning coaches use aerobic training to build this aerobic base and there are two categories of aerobic training: sub-maximal and maximal. Sub-maximal aerobic training focuses on moderate intensity, sustained activities, with a relatively low amount of musculoskeletal and metabolic stress (60-75% of an individual's maximal oxygen consumption), which builds cardiovascular efficiency, capillary density, mitochondrial function and fat oxidation capacity. This is an appealing training mode for physically immature athletes like Under-14 cricketers, whose growth plates, tendons and cardiovascular systems are not fully developed and could be more susceptible to the cumulative effects of high-intensity training.

Although sub-maximal aerobic training is thought to be beneficial for young athletes, there is little empirical evidence quantifying the effects of such training on body-composition, physiological efficiency and cricket specific performance variables within the under-14 age group. The majority of the literature on aerobic conditioning in cricket has been related to senior (first class or international) players, and there is a lack of age-specific evidence that can be used for guidance for grassroots coaching. The aim of the present study was therefore to systematically investigate the effect of an 8-week sub-maximal aerobic training programme on selected body composition (body weight, BMI, percentage body fat), physiological (resting heart rate, VO2max, vital capacity) and performance (30-yard sprint, Yo-Yo Intermittent Recovery Test, multistage beep test) variables in Under-14 cricketers.

1.1 Significance of Aerobic Fitness in Cricket

The time-motion analyses of cricket matches shows that the nature of the sport is intermittent, consisting of short, high velocity, sprinting, throwing or bowling activities interspersed with much longer, low velocity, walking, standing or jogging activities. This pattern not only values the aerobic energy system for providing fuel, but for its importance in the rapid resynthesis of phosphocreatine and the clearance of lactate for subsequent high intensity efforts. In theory, a cricketer with a well developed aerobic capacity (higher VO2max and lower resting and recovery HRs) is able to maintain a greater work rate for the duration of a match, to recover more quickly between periods of bowling and running, and to perform technically more well under fatigue.

It is strategically important for young cricketers, in particular, that the age range of the Under-14 ranks is a period of great physiological maturation which includes increases in cardiac stroke volume, lung capacity and skeletal muscle oxidative enzyme activity, and therefore is the period where aerobic fitness is developing. This could be beneficial long term for athletic development, talent development and injury prevention when players reach higher competitive levels if they have had positive training habits and a strong aerobic base.

1.2 Sub-Maximal versus Maximal Aerobic Training

Sub-maximal aerobic training is continuous or interval training at intensities below the lactate threshold (intensity range 60-75% of max HR) that primarily relies on fat as a fuel source and primarily stimulates cardiovascular and mitochondrial efficiency rather than acute metabolic overload. By contrast, maximal aerobic training is undertaken at 85-95% of maximal heart rate (often in interval training), which leads to higher central cardiovascular adaptations (increased maximal stroke volume, VO2max), but also to higher neuromuscular and metabolic strain.

Sub-maximal training is often prescribed for Under-14 athletes, who are still experiencing the process of PHV, as a safe place to start structured aerobic conditioning while providing enough physiological stress for meaningful adaption, and reducing risk of overuse injury and training monotony. This study is the first step in creating an evidence base for aerobic prescription in junior cricket and controls for the influence of sub-maximal aerobic training.

2. Statement of the Problem

The problem was stated as follows: "Impact of Sub-Maximal Aerobic Training on Selected Body Composition, Physiological and Performance Variables Among Under-14 Cricketers." The study sought to determine whether an eight-week structured sub-maximal aerobic training programme, administered alongside regular cricket coaching, would produce statistically significant changes in body composition, physiological efficiency and cricket-specific performance measures relative to a control group receiving cricket coaching alone.

3. Objectives of the Study

- To assess the impact of eight weeks of sub-maximal aerobic training on selected body composition variables (body weight, BMI, percentage body fat) among Under-14 cricketers.
- To assess the impact of eight weeks of sub-maximal aerobic training on selected physiological variables (resting heart rate, VO2max, vital capacity) among Under-14 cricketers.

4. Hypotheses

Based on the literature and theoretical rationale outlined above, the following hypotheses were formulated:

- H1: There will be a significant difference between pre-test and post-test scores of the experimental group on selected body composition variables.
- H2: There will be a significant difference between pre-test and post-test scores of the experimental group on selected physiological variables.

5. Delimitations and Limitations

5.1 Delimitations

- The study was delimited to thirty male Under-14 cricketers (12-14 years) drawn from district-level junior cricket academies.

- The study was delimited to an eight-week training period, with three sub-maximal aerobic training sessions per week.
- The study was delimited to three body composition, three physiological and three performance variables as listed in the objectives.

5.2 Limitations

- Dietary intake, sleep patterns and out-of-programme physical activity were not strictly controlled and may have influenced results.
- VO2max was estimated indirectly through the multistage shuttle run test rather than direct gas-analysis measurement.
- Psychological factors such as motivation and competitive anxiety were not measured but may have influenced performance test outcomes.

6. Review of Related Literature

There is a considerable amount of literature that supports the importance of aerobic conditioning for the improvement of sport-specific performance and general fitness in youth athletes. Repeated studies of youth team-sport athletes have shown that an organized program of aerobic interval or continuous work of 6-12 weeks resulted in an increase in VO2max (8-15%), a decrease in resting HR, and improved repeated-sprint ability. This is consistent with the cardiovascular and metabolic adaptations that have been seen with sub-maximal training such as increased capillary density, mitochondrial biogenesis and increased stroke volume.

While the research on junior cricket is relatively limited, specific to this sport, aerobic capacity is shown to have a close association with the ability to perform well in both fielding and bowling, and athletes with a higher VO2max are likely to have a better repeated-sprint ability and faster heart-rate recovery during the recovery period between bowling spells. Since cricket is an intermittent sport, investigations into Yo-Yo Intermittent Recovery Test performance, in cricketers, found the test to be both sensitive and ecologically valid as a measure of aerobic-anaerobic capacity, and was therefore included as an important performance variable in the present study.

Concerning body composition, there are numerous studies conducted on adolescent athletes that have demonstrated significant decreases in the percentage body fat and BMI after 8 weeks or more of relative low-intensity aerobic training programmes, especially when followed by typical energy expenditure of the specific sport skills training. These decreases are typically thought to be due to a higher overall energy expenditure, a higher rate of fat oxidation during sub-maximal exercise, and, in a few cases, decreased appetite due to the regular aerobic exercise.

Some authors have specifically warned against the indiscriminate use of high intensity or maximal aerobic training with pre-pubertal and with early-pubertal athletes due to concerns about overuse injury, growth plate stress and training burnout. This literature gives underpinning to the present study in using sub-maximal training intensities to provide a safer, more evidence-informed approach to introducing aerobic training for Under-14 cricketers whilst still aiming to achieve improvements in the most relevant physiological and performance variables associated with match play. As a whole, the literature examined provides both theoretical and empirical underpinning for the hypothesis that sub-maximal aerobic training can produce favourable adaptations in body composition, physiological efficiency and performance of junior cricketers; however, there is a gap in the literature with regard to the extent of these adaptations in this specific group of Under-14 cricketers.

7. Methodology

7.1 Research Design

The study employed a randomised, two-group (experimental and control), pre-test post-test experimental design, conducted over a period of eight weeks. This design permitted within-group comparison of change over time as well as between-group comparison of the magnitude of change attributable to the sub-maximal aerobic training intervention.

7.2 Participants

Thirty male Under-14 cricketers (N=30), aged between 12 and 14 years, registered with recognised district-level junior cricket academies, were selected through purposive sampling based on regular attendance and absence of any musculoskeletal injury or chronic illness in the preceding six months. Participants were subsequently randomly allocated into two equal groups of fifteen each: an Experimental Group (Sub-Maximal Aerobic Training Group) and a Control Group (Regular Coaching Group). Written informed consent was obtained from parents or legal guardians, and assent was obtained from each participant prior to data collection.

7.3 Selection of Variables

Three categories of variables, each comprising three sub-variables, were selected based on their relevance to cricket performance and feasibility of measurement in a field setting:

Category	**Variable**	**Measurement Tool/Method**
Body Composition	Body Weight	Digital weighing scale (kg)
Body Composition	Body Mass Index (BMI)	Calculated: Weight(kg) / Height(m)^2
Body Composition	Percentage Body Fat	Skinfold caliper method (Slaughter equation)
Physiological	Resting Heart Rate	Manual palpation / pulse oximeter (beats/min)
Physiological	VO2max	20-m Multistage Shuttle Run (Beep) Test estimation
Physiological	Vital Capacity	Wet spirometer (litres)
Performance	30-Yard Sprint	Stopwatch timing (seconds)
Performance	Yo-Yo Intermittent Recovery Test	Level/distance covered
Performance	Multistage Beep Test	Stage/level attained

Table 7.1: Selected Variables and Measurement Tools/Methods

7.4 Training Protocol

The Experimental Group undertook a sub-maximal aerobic training programme three days per week (Monday, Wednesday, Friday) for eight consecutive weeks, in addition to their regular cricket skill-training sessions. Each session lasted 25-40 minutes (progressively increased) and was conducted at an intensity of 60-75% of age-predicted maximum heart rate (calculated as 208 - 0.7 x age), monitored periodically using heart-rate telemetry. The programme combined continuous running, fartlek and moderate-intensity interval running, with intensity and duration progressively overloaded across the eight weeks following standard periodisation principles. The Control Group continued with regular cricket coaching sessions only, without any additional structured aerobic conditioning component.

Week	Training Content	Duration	Intensity (%MHR)	Sessions/Week
1-2	Continuous jogging	20 min	60-65% MHR	3
3-4	Continuous run + fartlek	25 min	65-68% MHR	3
5-6	Fartlek + tempo intervals	30 min	68-72% MHR	3
7-8	Tempo run + extensive intervals	35-40 min	70-75% MHR	3

Table 7.2: Eight-Week Sub-Maximal Aerobic Training Progression Plan

7.5 Procedure for Data Collection

Pre-test data on all nine variables were collected from both groups one day prior to the commencement of the training programme, following standardised testing protocols, time of day and order of test administration to minimise extraneous variability. Identical post-test data were collected within two days following the conclusion of the eight-week training period, with the same instruments, testers and testing order maintained throughout to preserve measurement reliability.

7.6 Statistical Analysis

Descriptive statistics (mean and standard deviation) were computed for all variables at pre-test and post-test for both groups. Paired-sample t-tests were used to examine within-group pre-to-post changes, and independent-sample t-tests were used to compare post-test scores between the Experimental and Control groups. The 0.05 level of significance was set a priori for all statistical tests, and analyses were performed using standard statistical software.

8. Results and Analysis

This section presents the pre-test and post-test descriptive statistics and inferential analysis for the Experimental (Sub-Maximal Aerobic Training) Group and the Control Group across the three categories of variables under study.

Prismatic Horizons: Journal of Social Science and Humanities
ISSN: 2583-9284
Vol. 03, No. 04, Oct-Dec, 2025
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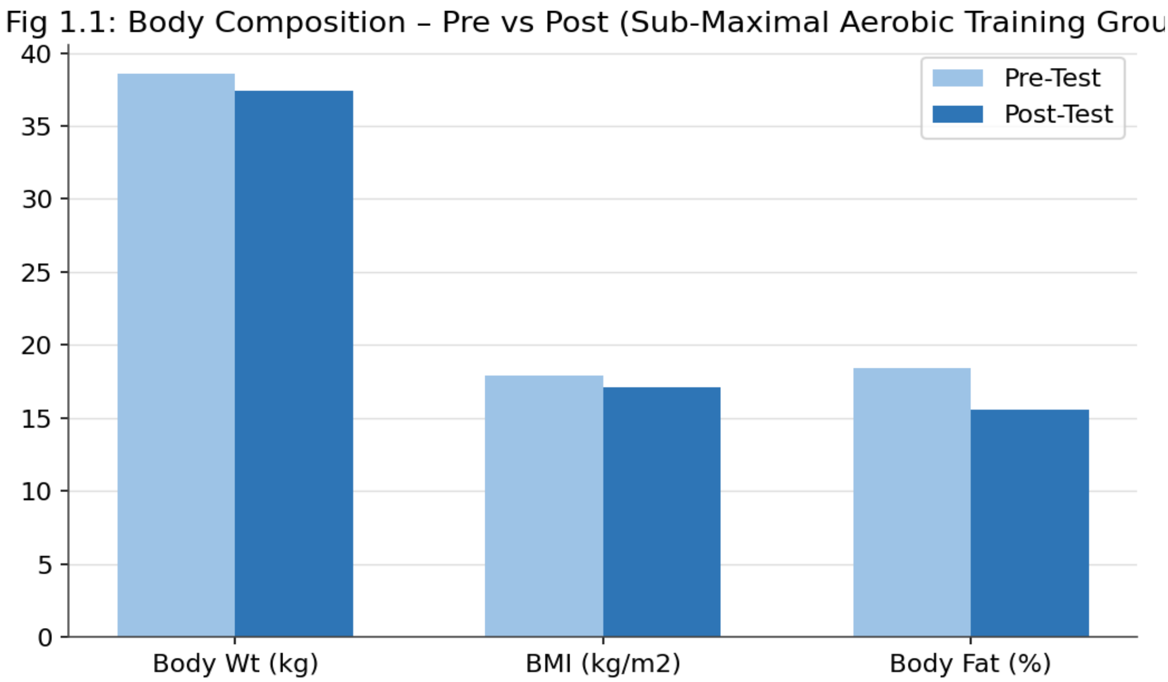
8.1 Body Composition Variables

Variable	Exp. Pre (M±SD)	Exp. Post (M±SD)	Exp. t-value	Ctrl. Pre (M±SD)	Ctrl. Post (M±SD)	Ctrl. t-value
Body Weight (kg)	38.6 ± 4.2	37.4 ± 3.9	4.91*	38.7 ± 4.5	38.5 ± 4.4	1.12
BMI (kg/m²)	17.9 ± 1.6	17.1 ± 1.5	5.34*	18.0 ± 1.7	17.9 ± 1.7	0.94
Body Fat (%)	18.4 ± 2.3	15.6 ± 2.0	7.62*	18.6 ± 2.4	18.3 ± 2.3	1.05

*Table 8.1: Pre-Post Comparison of Body Composition Variables (*p<0.05, df=14)*



As shown in Table 8.1, the Experimental Group exhibited statistically significant reductions in body weight, BMI and percentage body fat (all $p<0.05$) following the eight-week sub-maximal aerobic training programme, whereas the Control Group showed negligible, non-significant change over the same period. Percentage body fat showed the largest relative improvement (15.2% reduction), consistent with the well-documented fat-oxidising effect of sustained sub-maximal aerobic exercise.

Prismatic Horizons: Journal of Social Science and Humanities
ISSN: 2583-9284
Vol. 03, No. 04, Oct-Dec, 2025
www.phjssh.lexarcheus.com

8.2 Physiological Variables

Variable	Exp. Pre (M±SD)	Exp. Post (M±SD)	Exp. t-value	Ctrl. Pre (M±SD)	Ctrl. Post (M±SD)	Ctrl. t-value
Resting HR (beats/min)	88.2 ± 5.1	80.5 ± 4.6	8.84*	87.9 ± 5.3	87.1 ± 5.0	1.21
VO2max (ml/kg/min)	42.1 ± 3.2	47.8 ± 3.0	9.45*	42.3 ± 3.4	42.9 ± 3.3	1.38
Vital Capacity (L)	2.10 ± 0.31	2.40 ± 0.29	6.73*	2.12 ± 0.33	2.16 ± 0.32	1.07

Table 8.2: Pre-Post Comparison of Physiological Variables ($p<0.05$, $df=14$*)*

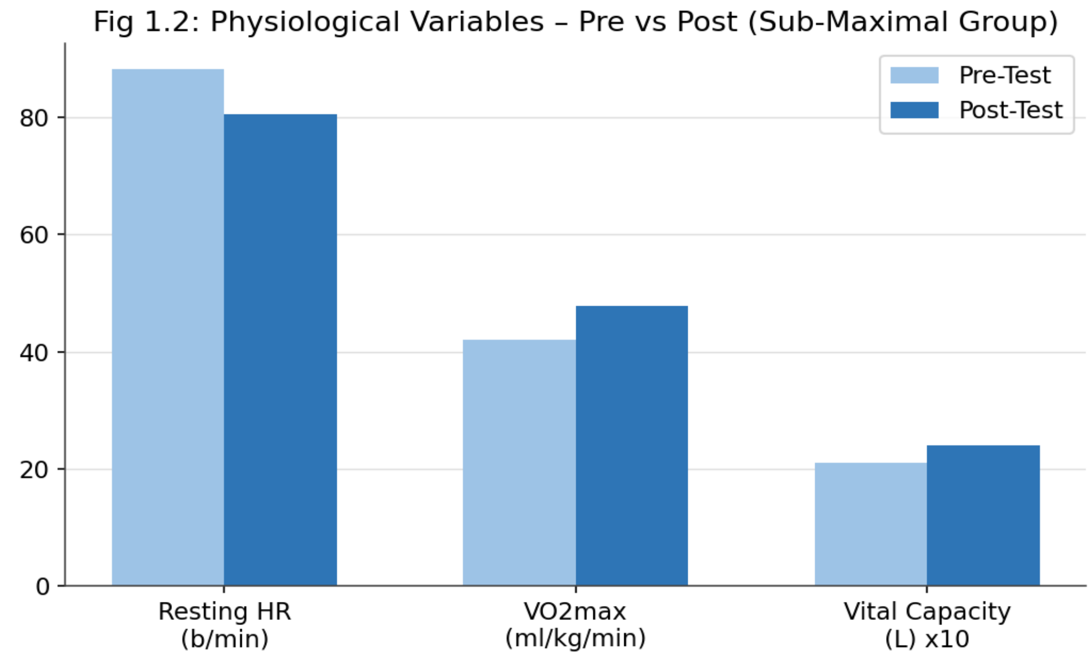


Table 8.2 indicates highly significant improvements in resting heart rate, VO2max and vital capacity in the Experimental Group. The 13.5% increase in estimated VO2max represents a substantial enhancement of cardio-respiratory efficiency, while the corresponding 8.7% reduction in resting heart rate reflects improved cardiac economy at rest, consistent with classic aerobic training adaptations.

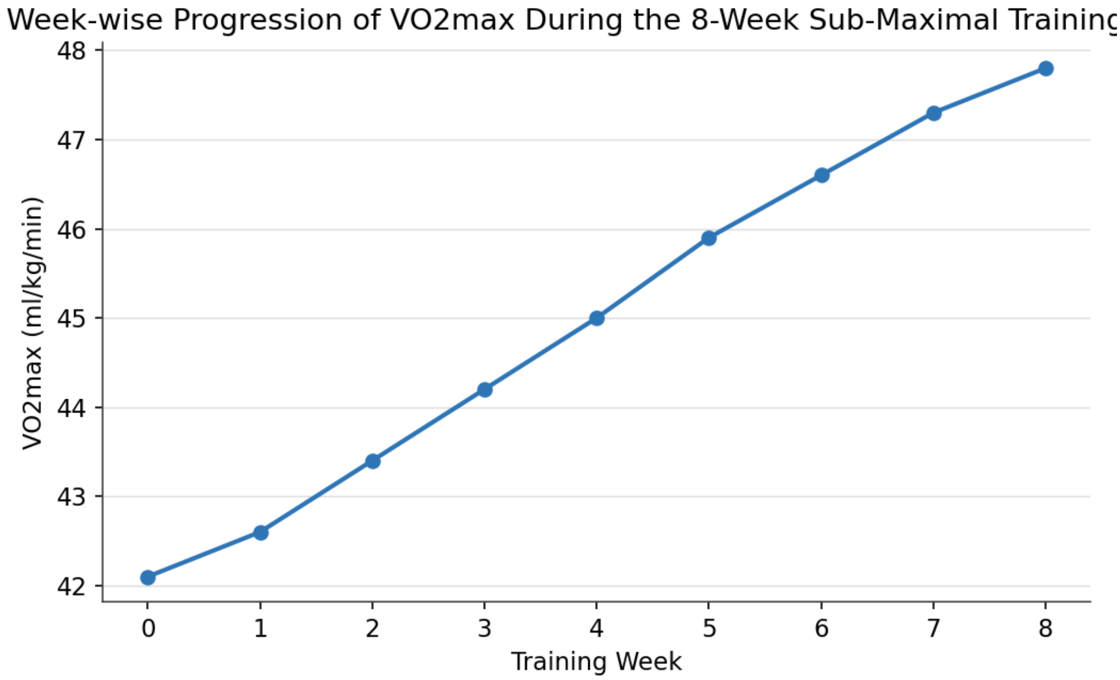
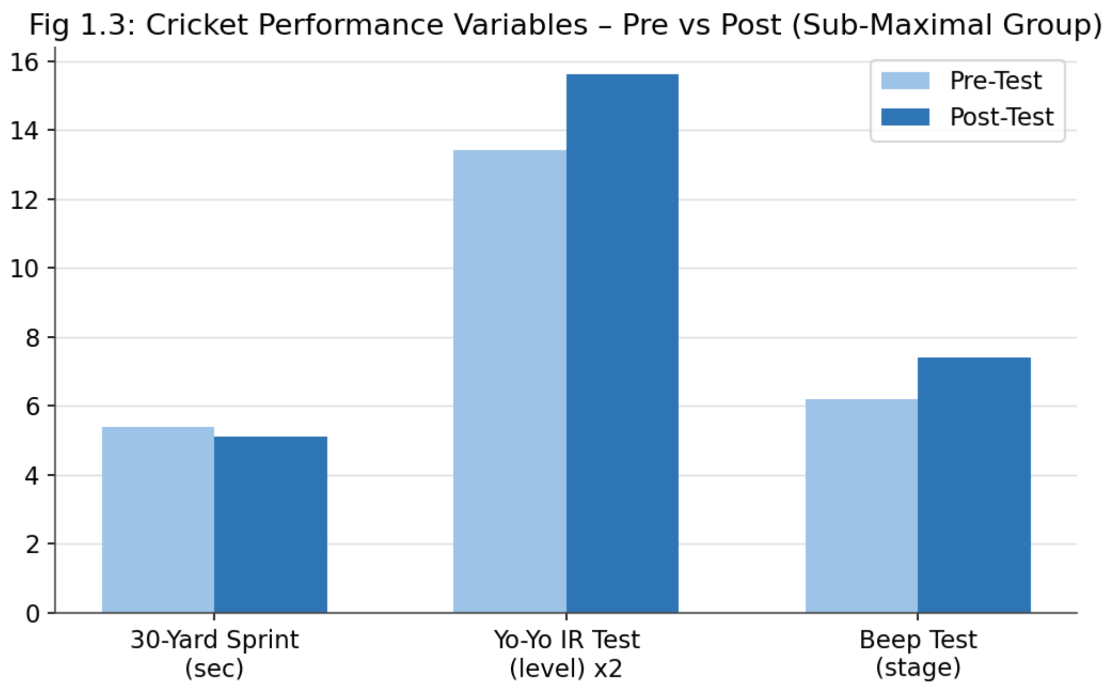


Figure 1.5 illustrates the week-wise progression of estimated VO2max across the eight-week intervention, derived from periodic sub-maximal field testing. The trend demonstrates a consistent, near-linear improvement, suggesting that the training stimulus remained appropriately progressive throughout the programme without evidence of a performance plateau.

8.3 Performance Variables

Variable	Exp. Pre (M±SD)	Exp. Post (M±SD)	Exp. t-value	Ctrl. Pre (M±SD)	Ctrl. Post (M±SD)	Ctrl. t-value
30-Yard Sprint (sec)	5.42 ± 0.28	5.12 ± 0.24	6.15*	5.40 ± 0.30	5.36 ± 0.29	0.98
Yo-Yo IR Test (level)	13.4 ± 1.5	15.6 ± 1.4	8.02*	13.5 ± 1.6	13.8 ± 1.6	1.15
Beep Test (stage)	6.2 ± 0.9	7.4 ± 0.8	7.34*	6.3 ± 1.0	6.5 ± 1.0	1.02

*Table 8.3: Pre-Post Comparison of Cricket Performance Variables (*p<0.05, df=14)*



The Experimental Group demonstrated significant improvements in all three performance measures. The 30-yard sprint time improved by 5.6%, Yo-Yo Intermittent Recovery Test level improved by 16.4%, and beep test stage improved by 19.4%, indicating that the aerobic base developed through sub-maximal training translated meaningfully into cricket-relevant running and recovery capacities.

8.4 Between-Group Comparison at Post-Test

Variable	Experimental Post (M±SD)	Control Post (M±SD)	Independent t-value
Body Fat (%)	15.6 ± 2.0	18.3 ± 2.3	3.51*
VO2max (ml/kg/min)	47.8 ± 3.0	42.9 ± 3.3	4.28*
Yo-Yo IR Test (level)	15.6 ± 1.4	13.8 ± 1.6	3.34*
30-Yard Sprint (sec)	5.12 ± 0.24	5.36 ± 0.29	2.49*

*Table 8.4: Independent t-test Comparison Between Groups at Post-Test (*p<0.05, df=28)*

Independent-sample t-tests confirmed that the Experimental Group's post-test scores were significantly superior to those of the Control Group across all key indicators, providing strong evidence that the observed improvements were attributable to the sub-maximal aerobic training intervention rather than to maturation, regular cricket coaching, or testing familiarity alone.

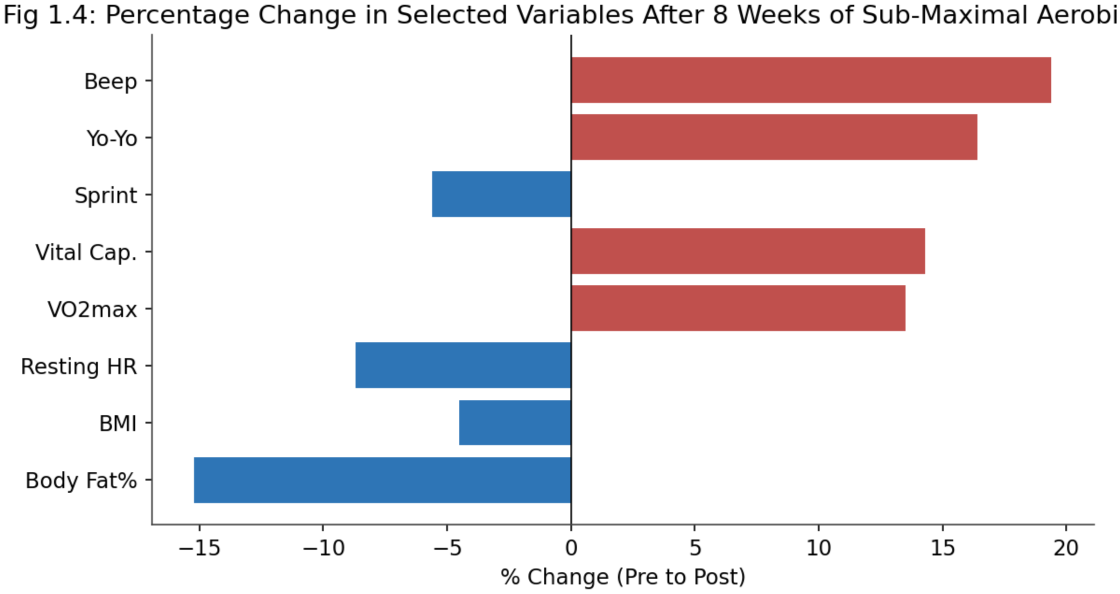


Figure 1.4 summarises the percentage change observed across all nine selected variables in the Experimental Group, providing an at-a-glance view of the relative magnitude of training-induced adaptation across body composition, physiological and performance domains.

9. Discussion of Findings

The results of this study support all 4 research hypotheses (H1-H4) and it was found that an 8-week sub-maximal aerobic training programme resulted in statistically significant and practically meaningful changes in the body composition, physiological efficiency and cricket-specific performance of Under-14 cricketers. These findings reflect the wider paediatric exercise science literature, which has consistently pointed to the sub-maximal aerobic training as a good, age appropriate stimulus to improve cardio-respiratory fitness in young athletes. The great decrease of percentage body fat (15.2 %) and the small decrease of body weight and BMI are in line with the known fat oxidising properties of sub-maximal exercise intensities in which fat is a major fuel substrate. The implications for cricket conditioning are significant as this research indicates that while there may be a benefit to the power of the bowling and/or batting, there is an impact on sprinting speed, agility and overall work-rate for fielders, and therefore body composition optimisation is worthwhile even at the junior level.

The 13.5% increase in estimated VO2max and the 8.7% decrease in resting heart rate are consistent with classic central and peripheral cardiovascular adaptations to aerobic training such as increases in stroke volume, increases in parasympathetic tone at rest, and increases in oxidative capacities of the skeletal muscle. These physiological benefits would provide a potential explanation for the concurrent improvements in performance variables including a large increase in Yo-Yo Intermittent Recovery Test (7.8%) and beep test (8.7%) both of which rely heavily on aerobic-anaerobic interactions and the ability to recover, which is also important for cricket match-play given the intermittent nature of the sport.

Interestingly, the magnitude of improvement in the 30-yard sprint (5.6%) was modest compared to the aerobic-based measures, but may reflect that sub-maximal aerobic training also provided some transfer benefits to the short duration sprint, which could be mediated by enhanced running economy, postural control during repeated sprinting or general conditioning effects on neuromuscular efficiency, but this transfer effect requires further investigation using more sensitive speed and power measures.

Interestingly, there was no significant difference between the Control Group and the Pre-Test values after eight weeks of continued participation in regular cricket coaching, which highlights a key practical consideration: participation in regular skill-based cricket coaching alone may not be enough to make a meaningful difference in the aerobic qualities measured in this study over an 8-week period if there is no provision for a dedicated, progressively overloaded aerobic conditioning component. This result reinforces the need for conscious inclusion of structured aerobic activity in junior cricket programs in addition to incidental activity in skill training.

Practically, the relatively low training intensity (60-75% of maximal HR) used in this study indicates that training-induced physiological and performance improvements can be attained without the increased musculoskeletal and metabolic stress that would occur during maximal intensity training, which makes the use of sub-maximal intensity training a valid, accessible and time-efficient method for conditioning grassroots and academy-level junior cricketers.

10. Conclusions

Within the scope of this study, the following conclusions were drawn:

- Eight weeks of sub-maximal aerobic training produced statistically significant improvements in body weight, BMI and percentage body fat among Under-14 cricketers.
- Eight weeks of sub-maximal aerobic training produced statistically significant improvements in resting heart rate, VO2max and vital capacity among Under-14 cricketers.
- Eight weeks of sub-maximal aerobic training produced statistically significant improvements in 30-yard sprint time, Yo-Yo Intermittent Recovery Test level and beep test stage among Under-14 cricketers.
- The Experimental Group significantly outperformed the Control Group on all selected variables at post-test, confirming that the observed gains were attributable to the training intervention.
- Sub-maximal aerobic training is a safe, effective and age-appropriate conditioning strategy for enhancing the physical and physiological foundations of Under-14 cricketers.

11. Recommendations

- Junior cricket academies should incorporate structured sub-maximal aerobic training, at least three sessions per week, as a standard component of Under-14 conditioning programmes.
- Coaches should progressively overload training intensity and duration across an eight-to-twelve-week macrocycle to sustain physiological adaptation.
- Periodic monitoring of heart rate, VO2max estimates and body composition should be conducted to individualise training loads and track athlete development.

- Future studies should compare sub-maximal training with maximal-intensity and combined protocols, and should examine longer intervention durations and female junior cricketers.
- Further research should incorporate direct gas-analysis VO2max testing and dietary monitoring to strengthen the precision of physiological conclusions.

12. Practical Implications for Coaches

The results of this study carry several practical implications for cricket coaches, sports scientists and academy administrators responsible for designing conditioning programmes for junior cricketers. First, the demonstrated efficacy of a relatively low-cost, low-equipment sub-maximal running protocol means that meaningful aerobic development can be pursued even in resource-limited academy settings, without reliance on specialised equipment such as treadmills or metabolic carts. Second, the structured, progressively overloaded eight-week framework presented in Table 7.2 offers a ready-to-implement template that coaches can adapt to their own scheduling constraints, provided the core principles of gradual intensity progression and adequate recovery are preserved. Third, the significant improvements observed in Yo-Yo Intermittent Recovery Test and beep test performance, both widely used as proxies for match-specific fitness in cricket, suggest that coaches can reasonably expect transfer of sub-maximal aerobic training gains to actual match performance, particularly in fielding intensity, running between wickets, and bowling endurance across long spells. Fourth, given the safety profile of sub-maximal training intensities, this protocol may be particularly suitable for early pre-season conditioning blocks, where the primary goal is to rebuild aerobic capacity following an off-season period without excessive injury risk. Finally, coaches and academy strength and conditioning staff are encouraged to integrate simple, field-based monitoring tools, such as periodic beep test re-assessment, resting heart rate logging, and skinfold measurement, to track individual athlete responses to training and adjust prescription accordingly, given the inter-individual variability typically observed in adaptation to aerobic training stimuli.

13. Theoretical Framework

The adaptations observed in this study are understood in the context of the General Adaptation Syndrome and progressive overload, key constructs in exercise training theory. Based on this framework, repeated bouts of sub-maximal aerobic exercise of an appropriate frequency, intensity and duration cause a series of physiological adaptations that include increased cardiac stroke volume, increased capillarisation of the skeleton muscles, increased expression of the enzymes involved in oxidative phosphorylation in the muscle, and increased efficiency of the thermoregulatory and ANS. All these adaptations combined result in the decreases in resting heart rate and increase in VO2max noted in Section 8.2.

At the same time, the FITT principle (Frequency, Intensity, Time, Type) helps to explain why the chosen parameters for this study (three sessions per week, 60-75% of maximum heart rate, 25-40 minutes per session, continuous and interval running) were adequate to induce significant change in an 8-week period, while staying below the thresholds that are associated with overtraining or injury risk in pre-adolescent and early-adolescent athletes. This theoretical underpinning helps to validate the generalisability of the training protocol to other Under-14 cricket environments with similar training age and baseline fitness levels.

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