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Effect of cardiovascular fitness on performance metrics in Bangladeshi women cricket: a role-specific analysis employing the harvard step test

Efecto de la aptitud cardiovascular en las métricas de rendimiento en el críquet femenino de Bangladesh: un análisis específico del rol que emplea la prueba de pasos de Harvard

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Abstract. Background: Cardiovascular fitness is essential for sports performance, enabling players to endure intense training, delay fatigue, and reduce injury risk—all critical factors for achieving optimal results in competitive sports like cricket. Emphasizing inclusive health ensures that all athletes enhance their cardiovascular fitness and overall performance. Purpose: This study aimed to investigate the impact of cardiovascular fitness, assessed using the Harvard Step Test, on the performance indicators of Bangladeshi women cricketers across their respective playing roles. Method: 104 players, including 34 batters, 38 bowlers, and 32 all-rounders, were voluntarily selected from the "Bangladesh National Women's Cricket League 2021-22". Cardiovascular fitness was evaluated through the Harvard Step Test, and role-specific performance metrics such as strike rate, bowling economy, and dismissal rates were analyzed. Statistical analyses included descriptive statistics and one-way ANOVA to assess differences in aerobic fitness across player roles and correlation analyses to examine the relationships between performance metrics and Harvard Step Test scores. Results: The multi-group comparison did not reveal a statistically significant difference in aerobic fitness across the playing roles, $F(2, 101) = 0.668$, $p = 0.515$. Additionally, the Harvard Step Test scores showed a weak and statistically non-significant relationship with role-specific performance metrics: strike rate ($r = 0.20$, $p = 0.06$) for batters, bowling economy ($r = -0.09$, $p = 0.51$) for bowlers, and dismissals ($r = 0.10$, $p = 0.38$) for fielders. Conclusion: Cardiovascular efficiency is similar across batters, bowlers, and all-rounders among Bangladeshi women cricketers. The Harvard Step Test score is not directly associated with role-specific performance in women's cricket. These findings suggest that training programs should adopt a holistic physical fitness approach, incorporating role-specific training to enhance the overall abilities of female cricketers and contribute to the development of women's cricket in Bangladesh.
Keywords: Endurance, Cricket Performance, Strike Rate, Bowling Economy, Wicket Dismissal.

Resumen. Antecedentes: La aptitud cardiovascular es esencial para el rendimiento deportivo, ya que permite a los jugadores soportar un entrenamiento intenso, retrasar la fatiga y reducir el riesgo de lesiones, todos factores críticos para lograr resultados óptimos en deportes competitivos como el cricket. Hacer hincapié en la salud inclusiva garantiza que todos los atletas mejoren su aptitud cardiovascular y su rendimiento general. Propósito: Este estudio tuvo como objetivo investigar el impacto de la aptitud cardiovascular, evaluada mediante el Test de Pasos de Harvard, en los indicadores de rendimiento de las jugadoras de críquet de Bangladesh en sus respectivos roles de juego. Método: Un total de 104 jugadoras, incluidas 34 bateadoras, 38 lanzadoras y 32 polivalentes, fueron seleccionadas voluntariamente de la "Liga Nacional de Cricket Femenino de Bangladesh 2021-22". La aptitud cardiovascular se evaluó a través de la prueba de pasos de Harvard, y se analizaron las métricas de rendimiento específicas del rol, como la tasa de golpes, la economía de los bolos y las tasas de expulsión. Los análisis estadísticos incluyeron estadísticas descriptivas y ANOVA de un factor para evaluar las diferencias en la aptitud aeróbica entre los roles de los jugadores y análisis de correlación para examinar las relaciones entre las métricas de rendimiento y las puntuaciones de la prueba de pasos de Harvard. Resultados: La comparación multigrupo no reveló una diferencia estadísticamente significativa en la aptitud aeróbica entre los roles de juego, $F(2, 101) = 0{,}668$, $p = 0{,}515$. Además, los puntajes de la prueba de pasos de Harvard mostraron una relación débil y estadísticamente no significativa con las métricas de rendimiento específicas del rol: tasa de strikes ($r = 0.20$, $p = 0.06$) para los bateadores, economía de bolos ($r = -0.09$, $p = 0.51$) para los lanzadores y despidos ($r = 0.10$, $p = 0.38$) para los fildeadores. Conclusión: La eficiencia cardiovascular es similar entre las bateadoras, las lanzadoras y las jugadoras de críquet de Bangladesh. La puntuación de la Harvard Step Test no está directamente asociada con el rendimiento específico del rol en el críquet femenino. Estos hallazgos sugieren que los programas de entrenamiento deben adoptar un enfoque holístico de aptitud física, incorporando un entrenamiento específico para mejorar las habilidades generales de las jugadoras de críquet y contribuir al desarrollo del críquet femenino en Bangladesh.
Palabras clave: resistencia, rendimiento en el críquet, tasa de strikes, economía de bolos, despido de wicket.

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Introduction

Cardiovascular fitness is the ability to endure prolonged physical activity, a fundamental factor for sports performance (Atan et al., 2012; Franklin et al., 2022). It denotes how efficiently the heart, lungs, and circulatory system work together to distribute oxygen and nutrients to the muscles during exercise (Hinman & Bennell, 2023; Raghuveer et al., 2020). A well-defined level of cardiovascular fitness, often measured by VO_2 max, allows athletes to

sustain intense exercise for longer periods, reduces fatigue, and lowers the risk of injury—factors critical for achieving optimal performance (Bassett, 2000; Powers & Howley, 1995). VO_2 max, expressed in milliliters of oxygen consumed per kilogram of body weight per minute (ml/kg/min), is a crucial indicator of cardiovascular health and athletic capability (Saltin & Astrand, 1967). Elite male athletes typically score between 60-85 ml/kg/min, elite female athletes between 50-70 ml/kg/min, and untrained active individuals range from 35-50 ml/kg/min (Buttar et al., 2019; Santisteban et al., 2022; Bangsbo et al., 2000; Joyner & Coyle, 2008).

Cricket matches can last hours to days, and they require both anaerobic and aerobic fitness as they demand persistent, intense physical movement (Gharbi et al., 2015; Kathayat & Kumar, 2019; Noakes & Durandt, 2000; Patel et al., 2017; Wagh et al., 2022). Notably, each positional cricket play requires physical and physiological abilities and unique skills (Boby et al., 2024; Vickery et al., 2018). Moreover, the skill-specific biomechanical and technical demands of individual cricket positions, including batting movements, bowling actions and fielding movement coordination, demonstrate the features of the physical and physiological requirements and enable comparison to similar roles in other sports (Biswas et al., 2023; Portus & Farrow, 2011). For instance, Batters run between 22 yards like a shuttle run; while bowlers need to run straight, and after every ball delivery they get a very short pause for the next delivery, after completion of an over consisting of 6 deliveries one receives an average pause of at least 60-90 seconds, as the rules do not permit successive bowling; on the other hand, all-rounders handle both batting and bowling, along with fielding requires running fast against the stricken ball, which batters and bowlers also do. The connection between endurance and performance difference is rooted in players' playing role in the field as the demand for each playing position varies in cricket (Weldon et al., 2020). Bowlers need endurance for extended spells and power for faster bowling (Vickery et al., 2018), whereas batters require agility, quicker reflexes, and faster acceleration capability between 22 yards (Bartlett, 2003; Lockie et al., 2013; Noakes & Durandt, 2000; Pote & Christie, 2014; Vickery et al., 2014).

To estimate VO_2 max means aerobic endurance, experts rely on tests like Cooper 12-minute Run Test, Yo-Yo Intermittent Recovery Test, Beep Test, and Harvard Step Test (HST), and notably HST is one among the most popular, while test like Incremental Treadmill or Cycle Ergometer tests remain popular in the laboratory test list (Bandyopadhyay, 2015; Bangsbo et al., 2008; Basset & Boulay, 2000; Beltz et al., 2016; Cooper, 1968; Gumusdag et al., 2013; Huntsman et al., 2010; Mayorga-Vega et al., 2016; Taddonio & Karpovich, 1951; Zemková & Pacholek, 2023). The HST is a simple yet effective test used widely in clinical and athletic settings (Kim et al., 2022; Krishnan & Revathy, 2022), and it measures fitness by monitoring heart rate recovery after stepping exercise on a bench of specific height (Brouha, 1943; Vangrunderbeek & Delheye, 2013). HST score indicates cardiovascular fitness level and positively correlates with cricket performance (Kathayat & Kumar, 2019). A clear understanding of each cricket positional play based on specific physical needs might benefit from tailoring training and choosing policies to improve performance (Noakes & Durandt, 2000; Rosimus, 2019).

While the literature indicates that studies in this field have been conducted primarily on male cricketers, with very little focus on female cricketers (Biswas et al., 2023; Kathayat & Kumar, 2019; Vickery et al., 2014), our study focuses exclusively on female players. This underscores the importance of exploring the possibility of future comparative studies to examine potential differences between male and female cricketers. Recent studies focusing on female athletes have highlighted the unique physiological demands placed on women in sports, suggesting that tailored training regimens could significantly impact performance outcomes (Biswas & Bhattacharya, 2022; Wang et al., 2023). It is important to consider gender-specific needs in training programs, particularly in sports like cricket, where endurance and agility are critical (Biswas & Bhattacharya, 2022; Wang et al., 2023). No study to date has focused on the endurance ability and role-specific performance of Bangladeshi women cricketers (Boby, 2023). As women's cricket continues to grow in popularity in Bangladesh and globally, it becomes increasingly important to understand how cardiovascular fitness influences performance in female athletes. This study addresses this research gap by examining the relationship between cardiovascular fitness, measured using HST, and role-specific performance metrics in Bangladeshi women cricketers. The findings from this study could provide valuable insights into the development of more effective, tailored training programs that enhance the overall performance of women cricketers.

Method

Participants

104 female cricketers were randomly selected as subjects in the study, categorized into 34 batters, 38 bowlers, and 32 all-rounders. Female cricketers were selected from 'Bangladesh National Women's Cricket League 2021-22', the country's highest-level competition for women cricketers. Cricketers' collective mean age was 23 years, height 1.58 m, weight 53 Kg, BMI 21.15, playing age 8 years, resting heart rate of 73 bpm, and age range from a minimum of 15 years to a maximum of 35 years. Up on further exploration of these parameters across the subgroups of Batters, Bowlers, and all-rounders reveals Batters' mean age 21 years, height 1.59 m, weight 53 Kg, BMI 20.91, playing age 6 years, and resting heart rate 73 bpm; Bowlers mean age 23 years, height 1.57 m, weight

53 Kg, BMI 20.91, playing age 9 years, and resting heart rate 73 bpm; and all-rounders mean age 24 years, height 1.57 m, weight 51 Kg, BMI 20.74, playing age 9 years, and resting heart rate 77 bpm. Women cricketers participated voluntarily in the study.

Inclusion and Exclusion Criteria

At the time of data collection, none participants were menstruating or ill or had sustained any major injury in the six months preceding data collection. Moreover, they were neither taking any medicine that may alter endurance tests nor were they regular smokers or drinkers.

Study Design

A cross-sectional study was designed using a random sampling method to investigate playing role-specific performance relationships with the endurance ability of Bangladeshi women cricketers. Cardiovascular fitness was assessed by the Harvard Stem Test (HST). Players' resting heart rate was measured once for a minute in the pre-test, and heart rate was measured 3 times for 30 seconds with an interval of one minute following the HST in the post-test. Just before the HST and following the resting pulse rate count, players were given time to take a short individual warm-up. To check playing role-based performance in cricket, 'strike rate' for the batter, 'bowling economy' for bowlers, and 'dismissal' for the fielders were considered. All the participants were given detailed instructions about the HST before signing the consent informed form.

Instrument Setting and Recording

To conduct the Harvard Step Test, a wooden bench of 16 inches in height, 24 inches in width, and 30 inches in length was used. During the test, players need to accomplish a complete cycle of stepping up and down in two seconds, which means 30 steps per minute, and the same they kept on doing for a maximum of up to five minutes. 'Metronome beats', an Android-based app, was used for the test, as its preset beats help in correct stepping. The metronome was typically set at 120 beats per minute to maintain the pace of the stepping on the bench. A digital wristwatch (Casio 100 memory digital stopwatch, model: Q & Q HS47-001) was used to count the pulse rate, and a stopwatch was used to count the post-test time. Players started and stopped their test along the metronome, and upon completion of every minute of the test, volunteers were given a time update. Completing the stepping test, players were instantly asked to sit comfortably to rest in a chair. Meanwhile, their pulse was taken from the carotid artery located on the anterior side of the neck for 30 seconds at one-minute intervals following the stepping exercise at 1:00-1:30, 2:00-2:30, and 3:00-3:30 minutes.

Data Collection and Extraction

All primary information like height, weight, training age, and individual playing role-based cricket performance metrics were collected. Performance metrics were collected from an official tournament, 'Bangladesh National Women Cricket League 2021-22', records and match statistics. Players' performance metrics were calculated as follows: 'strike rate' for batters was calculated as (total run scored / number faced balls) x 100, 'bowling economy' for bowlers was measured by dividing the total number of runs conceded by numbers of over bowled, and 'total number of dismissal' for fielders.

Regarding the Harvard Step Test (HST), the volunteers were briefed with full details about the test, given a clear demonstration, and clarified any doubts. Before HST, players were called to rest in a cool and calm room while they felt good to go for the test. Only then were they allowed to take the test. Before starting the stepping test, their pulse was collected skillfully by an investigator sitting in a chair for 15 seconds and multiplied by four to get a minute pulse.

Upon completing the HST, players were immediately seated in a chair, and from this sitting position, pulse was counted for 90 seconds in three separate intervals, counted at one-minute intervals. If a player accomplished five minutes of full duration of the HST while keeping pace with the metronome rhythm set at 120 beats per minute, then five minutes was counted as her total test time. In addition, if the player failed to keep the rhythm and was stopped by an investigator or stopped by herself, the elapsed time up to that point was taken as her final time.

Finally, the recovery time score for Harvard Step Test recovery was calculated as HST Recovery Index = [(Duration of stepping exercise in minute x 100) / Sum of heart rates calculated in 3 intervals during the recovery period)].

Statistical Analysis

Minimum, Maximum, Mean, Standard Deviation, and Correlation were used in the descriptive statistics to explore the data distribution and the preliminary relationships between the variables. Correlation was employed to find the relationship between playing role-based performance and Harvard Step Test score. Spearman's rho was a non-parametric measure to establish association by correlation test as the data failed normality assumptions. On the other hand, in the inferential statistics, the ANOVA test was applied to identify any differences in the players due to their playing role in cricket in terms of cardiovascular fitness score extracted by the HST. The inverse transformation was applied to achieve data normality and homogeneity for the ANOVA treatment. Normality was checked post-transformation using a normality test, along with assessments of skewness and kurtosis, and through visual inspections of histograms and QQ plots. The power of the ANOVA test for 104 players of three groups was calculated (1- β) = 0.96 with a large effect size of 0.40. A power

value of <0.80 suggests that there is a lower likelihood of failing to detect a true effect (type II error) in a statistical test.

Results

Table 1.
Descriptive Statistics of Harvard Step Test Score of Women Cricketers

Groups		Minimum	Maximum	Mean	Std. Deviation
Batter	HST Score	66.37	100.00	84.51	± 8.14
Bowler	HST Score	72.82	112.78	86.54	± 8.84
All-Rounder	HST Score	67.72	104.17	84.64	± 8.98

Table 2.
Analysis of Variance for Harvard Step Test Scores across Different Playing Role

	df	*F*	Sig.
Between Groups	2	.668	.515
Within Groups	101		
Total	103		

N.B.: Data transformed into inverse before administration of ANOVA test

The study reveals from Tables 1 & 2 that the differences in cardiovascular efficiency level by Harvard Step Test score for three groups of Batter ($M = 84.51$, $SD = \pm 8.14$), Bowler ($M = 86.54$, $SD = \pm 8.84$), and All-rounder ($M = 84.64$, $SD = \pm 8.98$); the multi-group comparison did not reveal a statistically significant difference in aerobic endurance across three playing role based players groups in women's cricket of Bangladesh as $F_{.05}$ (2, 101) = .668 and $p = .515$. This suggests that, based on the sample, there is no strong evidence to support the idea that players of any playing position acquire better cardiovascular fitness levels than the others, and any detected differences in the sample means could be due to random variation rather than a true difference in the population.

Table 3.
Descriptive Statistics of Playing Role-based Performance Metrics

Groups		Minimum	Maximum	Mean	Std. Deviation
Batter	Strike Rate	10.00	117.50	64.86	± 21.60
Bowler	Economy	2.50	9.00	4.83	± 1.11
Fielder	Dismissal	1.00	11.00	2.65	± 1.87

Table 4.
Correlation Metrics of Harvard Step Test Score across Playing Role-Specific Performance

			Harvard Step Test Score
Spearman's rho	Strike Rate of Batter	Correlation Coefficient	.20
		Sig. (2-tailed)	.06
	Bowling Economy of Bowler	Correlation Coefficient	-.09
		Sig. (2-tailed)	.51
	Wicket Dismissal by Fielder	Correlation Coefficient	.10
		Sig. (2-tailed)	.38

In the highest cricket league for women in Bangladesh, performance metrics according to playing role mean and standard deviation show for Batters' strike rate $M = 64.86$ & $SD = \pm 21.60$, Bowlers' bowling economy $M = 4.83$ & $SD = \pm 1.11$, and Fielders' wicket dismissal $M = 2.65$ & $SD = \pm 1.87$ as observed in Table 3. The mean denotes the average performance, while the standard deviation (SD) indicates the variation. Here in the study, Batters' strike rate averages 64.86 (SD ±21.60), bowlers' economy is 4.83 (SD ±1.11), displaying more consistency, and fielders' wicket dismissals average 2.65 (SD ±1.87), showing greater variation. Further, the association between Harvard Step Test scores and the role-specific performance in women cricketers depicts that none of the relationships is statistically significant and weak as the relationships between HST and strike rate of Batters observed $r = .20$ & $p = .06$, HST and bowling economy of Bowler $r = -.09$ & $p = .51$, and HST and wicket dismissal by fielder $r = .10$ & $p = .38$ as evident from Table 4.

Discussion

This research looks at the aerobic fitness of cricketers in Bangladesh's apex women's league using Harvard Step Test (HST) results to customize playing role-specific training programs. The mean and Standard Deviation of HST score for Batters 84.51 ± 8.14, Bowlers 86.54 ± 8.84, and All-rounders 84.64 ± 8.98 found in Table 1 of descriptive statistics. Here, it has been evidenced that Bowlers demonstrated the upper hand over Batters and All-rounders in HST scores. Further, the study results show no significant differences in cardiovascular efficiency among Batters, Bowlers, and All-rounders in Bangladeshi women's cricket, as the analysis $F_{.05}$ (2, 101) = .668, $p = .515$ proposing that any differences in aerobic endurance are likely due to random variation rather than real differences in aerobic fitness. These underscore the significance of acquiring an elevated level of aerobic fitness irrespective of one's role in women's cricket (Kathayat & Kumar, 2019b; Okilanda et al., 2024; Petersen et al., 2011).

On the contrary, it has been observed that endurance training in cricket differs by playing roles. At the same time, batsmen need to inhale more oxygen for running speed, and bowlers require strength to manage the recurrent eccentric actions of fast bowling (Jo-Anne, 2012). In addition, aerobic training in cricket should align with the player's role because fast bowlers require high-intensity training, and spin bowlers take advantage of low-intensity training (Vickery et al., 2018). In particular, tailored endurance training is essential for specific playing roles in cricket (Scanlan et al., 2016). Preceding studies conducted mainly on male cricketers emphasize the importance of role-specific aerobic training. However, study results suggest no difference in endurance ability in female cricketers due to different playing roles. Female cricketers are deprived of role-specific endurance training as weightage for female cricket is given less than males, so there is no significant difference in endurance among the role-specific groups.

Moreover, the correlation metrics detailed in Table 4 reveal that women cricketers' performance metrics of Batters' strike rate have a non-significant weak positive correlation, Bowlers' bowling economy has a very weak negative correla-

tion, Fielders' wicket dismissals has a weak positive non-significant correlation with HST scores in top women's cricket league of Bangladesh. It confirms that cardiovascular endurance has no direct association with playing role-based performance metrics in women's cricket. As reported correlation is strong $r = .70\text{-}1.00$, moderate $r = .40\text{-}.69$, weak $r = .10\text{-}.39$, very weak $r = .01\text{-}.09$, and no correlation $r = 0$ (Cohen, 1988). The results indicate that HST scores for cardiovascular fitness do not directly influence players' performance in particular roles in elite-level women's cricket in Bangladesh. Conversely, research shows that cricket performance depends on combining physiological and technical elements. In contrast, cardiovascular fitness contributes to holistic performance, though it does not directly affect effectiveness in particular game scenarios, mostly in high-intensity cricket matches (Petersen et al., 2011; Pote & Christie, 2014b; Vickery et al., 2014b). Therefore, training programs for female cricketers should cover all areas of motor fitness components, such as strength, endurance, speed, flexibility, coordination, and playing role-specific cricket skills.

Conclusion

This study provides valuable insights into the cardiovascular fitness levels of Bangladeshi women cricketers and their impact on role-specific performance metrics. The findings indicate that cardiovascular fitness, as measured by the Harvard Step Test, does not significantly differ across playing roles—Batters, Bowlers, and all-rounder—nor does it strongly correlate with performance metrics such as strike rate, bowling economy, or dismissals.

Given these results, it is recommended that future research explores other components of fitness, such as muscular strength, agility, and flexibility, which may play a more significant role in enhancing performance across different playing roles in cricket. Additionally, employing a longitudinal study design could provide deeper insights into how cardiovascular fitness and other fitness components develop over time and influence performance in the long term. This approach would allow for the assessment of changes in fitness levels and their impact on performance, offering a more comprehensive understanding of the fitness-performance relationship in women's cricket.

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Limitation

The inability of a large number of samples was one of the major limitations, and players' psychology, which was not under the researchers' control, was another limitation of the study.

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Conflict of Interest

There is no conflict of interest among the investigators.

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