Impact of high and low seasonal temperatures on selected motor components of cricketers: an assessment through repeated measure design

Impacto de las temperaturas estacionales altas y bajas en componentes motores seleccionados de jugadores de críquet: una evaluación mediante un diseño de medidas repetidas

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Abstract

Introduction: Players' motor performance relies on different internal and external factors. Seasonal temperature is one of the major external factors influence motor performance of the cricketers.
Objective: Study aimed to assess the role of high and low seasonal temperatures on selected motor components of cricketers.
Methodology: A repeated measure design was adopted. 100 cricketers were randomly selected. Data were collected on selected motor components in two seasonal temperature ranges: 39.7℃ - 42.3℃ and 6.9℃ - 9.5℃. Cooper's 12-minute run test, Illinois agility test, sit-ups, medicine ball throw test, and reaction ball exercise tests were used as data collection tools for measuring predicted maximal oxygen consumption (predicted VO_2), agility, abdominal strength, upper body strength, and hand-eye coordination respectively. Post normality check suggested to use Wilcoxon Signed-Rank test.
Results: Findings showed significant difference on predicted VO_2, agility, upper body strength, and hand-eye coordination $p<0.01$, while insignificant difference was observed on abdominal strength $p>0.05$.
Discussion: Findings of the study contrasted with Gamage et al., (2016) for VO_2, Gatterer et al. (2021) for upper body strength, Ünal (2002) and Racinais & Oksa (2010) for hand-eye coordination.
Conclusions: High temperature positively affects the predicted VO_2 and agility of cricketers whereas upper body strength and hand-eye coordination were found enhanced during low temperature. Recorded difference on abdominal strength may be due to some random chance rather than a true underlying effect.

Keywords

Cricketers; high temperature; low temperature; motor performance; temperature effect

Resumen

Introducción: El rendimiento motor de los jugadores depende de diferentes factores internos y externos. La temperatura estacional es uno de los principales factores externos que influyen en el rendimiento motor de los jugadores de críquet.
Objetivo: El estudio tuvo como objetivo evaluar el papel de las temperaturas estacionales altas y bajas en componentes motores seleccionados de los jugadores de críquet.
Metodología: Se adoptó un diseño de medidas repetidas. Se seleccionaron aleatoriamente 100 jugadores de críquet. Se recopilaron datos sobre componentes motores seleccionados en dos rangos de temperatura estacionales: 39,7 °C - 42,3 °C y 6,9 °C - 9,5 °C. Se utilizaron la prueba de carrera de 12 minutos de Cooper, la prueba de agilidad de Illinois, abdominales, la prueba de lanzamiento de balón medicinal y las pruebas de ejercicio con balón de reacción como herramientas de recopilación de datos para medir el consumo máximo de oxígeno previsto (VO2 previsto), la agilidad, la fuerza abdominal, la fuerza del tren superior y la coordinación ojo-mano, respectivamente. Tras la comprobación de normalidad, se sugirió utilizar la prueba de rangos con signo de Wilcoxon.
Resultados: Los resultados mostraron una diferencia significativa en el VO2 previsto, la agilidad, la fuerza de la parte superior del cuerpo y la coordinación mano-ojo $p<0,01$, mientras que se observó una diferencia insignificante en la fuerza abdominal $p>0,05$.
Discusión: Los hallazgos del estudio contrastaron con los de Gamage et al. (2016) para el VO2, Gatterer et al. (2021) para la fuerza del tren superior, y Ünal (2002) y Racinais y Oksa (2010) para la coordinación mano-ojo.
Conclusiones: Las altas temperaturas afectan positivamente el VO2 predicho y la agilidad de los jugadores de críquet, mientras que la fuerza del tren superior y la coordinación mano-ojo mejoraron con bajas temperaturas. La diferencia registrada en la fuerza abdominal podría deberse a la casualidad, más que a un efecto subyacente real.

Palabras clave

Jugadores de críquet; temperatura alta; temperatura baja; rendimiento motor; efecto de la temperatura.

Introduction

Cricketers are known for their exceptional athleticism and skills, essential for success in the highly competitive world of cricket (Seymour et al., 2019).While various factors contribute to a cricketer's performance, one often overlooked aspect is the impact of hot and cold temperatures on motor performance (Gamage et al., 2016; Çakir et al., 2016). A 'Game Changer report' published in 2018 mentioned that among all pitch sports, cricket will face the hardest impact of climate change (The Climate Coalition, 2018). External factors, including temperature, air, humidity, etc., influence performance more than internal factors (Gamage et al., 2016). Cricket is played in diverse geographical locations worldwide, subjecting cricketers to various seasonal temperatures (Seymour et al., 2019). High and low temperatures can significantly affect a player's physical and mental capabilities, potentially influencing the outcome of matches and tournaments (Galloway et al., 1997; Gatterer et al., 2021; Çakir, 2016; Nugroho et al., 2024). Temperatures above 22°C raise the risk of hyperthermia, while temperatures below 22°C do not present a heat stress concern (Grantham et al., 2010; Marek et al., 2014; Alcântara et al., 2024). With bare hands exposure to 50C temperature, people felt reduction in their hand skills (Muller et al., 2014). High and low temperatures impact psychological and physiological reactions to exercise, lead to limit athletes' physical performance (Murrey and Kenney, 2020; Seymour et al., 2019; Ramadan et al., 2024). These different temperatures alter the body's capacity to safeguard strength, maximal oxygen consumption (VO2 max), agility, power, etc. Simply put, performance in hot conditions frequently outperforms than in cold temperatures (Çakir, 2019; Erdoğan, 2015).

Cricket is a sport that demands a combination of physical attributes such as speed, agility, strength, endurance, and hand-eye coordination, all of which are essential for batting, bowling, and fielding (Seymour et al., 2019). Leg strength and speed plays a vital role in cricketer's performance and also influence the agility and coordination responsible for wicket keeping, fielding, and between the wickets running (Bangsbo, 2008). These essential elements also help the bowlers to practice and monitor their absorption ability of leg-generated forces during delivery (Bangsbo, 2008). However, these attributes can be compromised when cricketers are exposed to extreme temperatures. In hot climates, high temperatures and humidity levels can lead to dehydration, heat stress, and decreased VO2 max, affecting a cricketer's ability to perform at their peak (Gamage et al., 2016). On the other hand, low temperature can reduce muscle flexibility and increase the risk of injuries while also challenging a player's mental concentration due to discomfort (Racinais and Oksa, 2010; Ünal, 2002). Although empirical research is increasing on the physiological impacts of environmental stressors in sport activities, little empirical evidence has been available on how seasonal changes in temperature conditions (i.e., high summer temperature and low winter temperature conditions) influence the elements of motor system performance variables, e.g., VO2 max., upper body strength, agility, and coordination among cricket players. Not a single research has been found specifically targeting this área, specially in North India where cricket is the most played sport and extreme seasonal temperature variations are recorded every year. The global studies (Garcia, 1991; Gatterer et al., 2021; Racinais and Oksa, 2010; Anibal et al., 2024 etc.) targeted the área with either the different methodology or targetted different or single motor components with different subjects. Thus, in Varanasi (a North-Indian city of Uttar Pradesh State), understanding how hot and cold temperatures influence the motor performance of cricketers is essential for optimizing their training and preparation and devising strategies to excel in various playing conditions.

In light of the importance of different temperatures on motor performance in cricket, this research investigates the effects of hot and cold temperatures on cricketers. By conducting a comprehensive analysis of physiological responses, we seek to provide a holistic understanding of how hot and cold temperatures impact motor performance in cricket. This research has implications for cricketers and coaches in order to form their understanding about how different temperatures can influence the athletic performance of the cricketers.

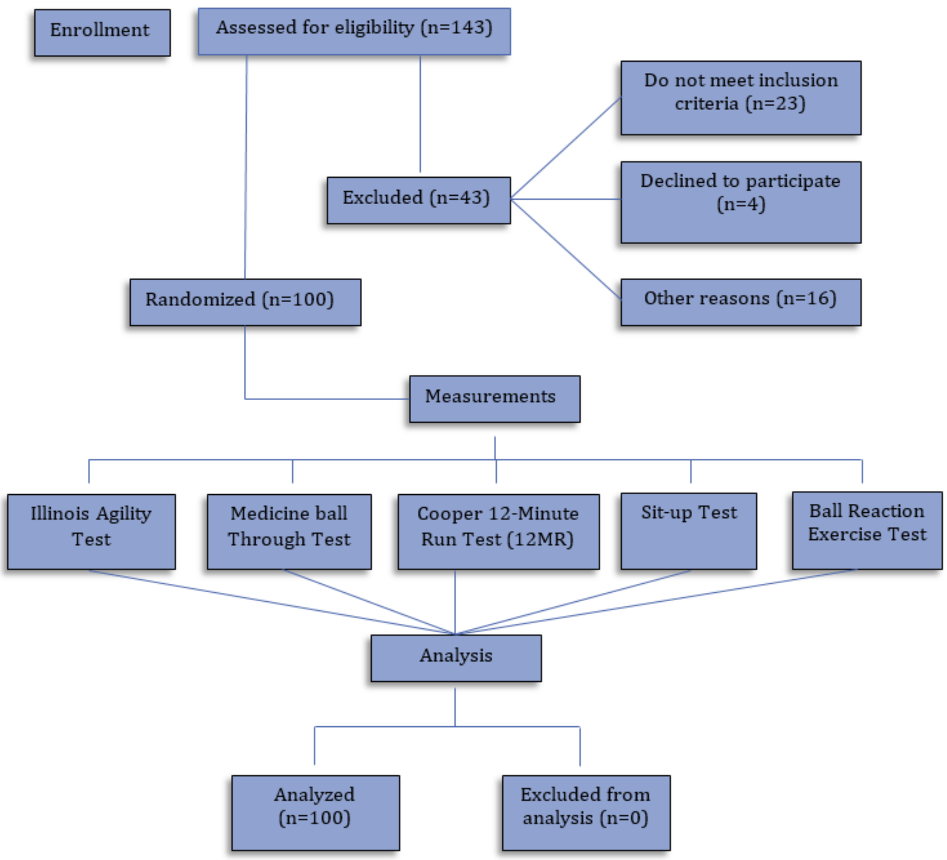
Method

The study aimed to investigate the impact of high and low seasonal temperatures on selected motor fitness components of male cricket players. These components included the Predicted VO_2, agility, abdominal strength, upper body strength, and hand-eye coordination. A repeated measures (within-subjects) design was adopted to conduct the study. This approach allows controlling individual differences as the same subjects were studied under different seasonal temperatures (Burin et al., 2019). Tests to assess these motor fitness components were administered for two consecutive days i.e. 15th and 16th day of June (summer) and December (winter) of 2023, in between 2 pm to 4 pm following a proper warm-up session of 15 minutes. On the 15th day of both June and December, Illinois Agility Test (IAT), and medicine ball throw tests were administered, while Cooper 12-Minute Run test (12MR), Sit-up test and Reaction ball exercise tests were administered on the 16th day of June and December. RAMP protocol was used for the warming-up session. RAMP is a systematic and scientific approach used to elevate body temperature gradually, switch over to activate the key muscles, mobilize the joints, and perform some sport-specific activities (Jeffreys, 2018). The temperature recorded was 39.7°C - 42.3°C in June and 6.9°C - 9.5°C in December.

Participants

The research included 100 healthy male cricket players of age group 16-19 year from Varanasi region (refer to table 1 for anthropometric information). Subjects were the regular participants of the training sessions from past one year. All the participants were selected through a random sampling method. A proper informed consent was obtained from all the participants before administering the study tests.

Figure 1. Shows the flowchart of participants assessed for eligibility, randomized, and analyzed during the study



Procedure

Below given is the procedure of various tests administered to assess the selected motor fitness components under high and low seasonal temperatures. A prior demonstration was shown to the participants for all the tests administered to assess their selected motor components. The ethical clearance was obtained after presenting the study to the review board of Aligarh Muslim University, Aligarh, India.

Illinois Agility Test (IAT)

Illinois Agility Test (IAT), a valid and reliable change of direction test for team sport athletes (Hachana et al., 2013) was conducted to measure the agility of the cricketers. The course had a 10mt length and a 5mt width. The start, finish line, and the two turning points were all marked with four cones. Four additional cones were placed in the center with equal space between them. The distance between each cone in the center was 3.3 meters. Participants were instructed to lie down in pronation position with their palms touching the ground by the side of their shoulders and heads towards the starting line. A start command was given through whistle, subjects stand up as quickly as they can and sprinted forward, took U-turn after crossing the cone placed 10mt away. As soon as they returned they continued to complete the zigzag run (forming horizontal eight '∞') marked by four cones placed in a single line at equal distance of 3.3 meters. After crossing the last cone (technically first) of the mid-line they turned back and ran to cross the cone placed 10 meters away and took final U-turn to cover 10 meters of uphill running to complete the course. Stopwatch was used to measure the time they took from start till the course completion. Time recorded up to 2 decimal points was considered as the score of the participants.

Medicine Ball Throw Test

In order to measure the strength and power of the cricketer's upper body, a medicine ball throw test was conducted. Medicine ball throw test is an excellently reliable test for measuring arm strength and power (Stockbrugger & Haennel, 2001). A medicine ball of 2 pounds and a measuring tape were the equipment used to collect the data from the participants in high and low temperatures. Subjects were asked to stand with their feet shoulder-width apart and hold the medicine ball with both hands close to their chests. Subjects were asked to throw the ball as far away as possible by bringing their arms back facing the same direction and engaging their core muscles by hyper-extension of lower back, and throw explosively by flexing their hip joint creating pressure at knees and ankles. The measurements were taken in meters and up to two rounded-off decimal points from the standing point of the subjects to the point where the ball first landed. This measurement was done with the help of a measuring tape.

Cooper 12-Minute Run Test (12MR)

VO_2 max refers to the maximum amount of O_2 consumed by someone during a maximal-intensity workout and is expressed in milliliters of oxygen per kilogram of body weight per minute (Bassett et al. 2000). A Cooper 12-Minute Run (12MR) test was administered to check the impact of hot and cold temperatures on the effectiveness of the cardio-respiratory system of cricketers. 12MR test is adequate to predict the aerobic fitness of individuals of 18-35 year age group with excellent reliability (Penry et al. 2011). Participants were asked to run as far as they can in 12 minutes. The distance covered by the participants was recorded in meters, and then the value was placed in Cooper's VO_2 max equation, i.e.

VO_2 Max (ml/kg/min) = (Distance covered in meters – 504.9) / 44.73.

After this calculation, the value we got was again divided by the individual's body weight to obtain the final VO_2 max reading.

Sit-up Test

The impact of high and low temperatures on the strength and endurance of the abdominal muscles was tested through bent knee sit-ups. Bent knee sit-up test is an effective test to measure abdominal strength and endurance (Garcia, 1992). The exercise mat and stopwatch were the equipment used along with the partner who grabbed the legs of the performer for stability. Subjects were asked to lie down on their back with their knees bent to a 90-degree angle and feet flat in touch with the floor. Hands were placed at the back of their head without interlocking fingers, and elbows were pointed outward. A partner was instructed to hold the performer's legs to avoid lifting his feet during sit-ups. Performers were asked to lift their upper body off the mat by flexing their abdominal muscles and keeping their lower body in touch with it. The performer was asked to lift his body until his elbows reached past the knees, and similarly, the scapula must touch the mat every time while going down. Measurement was done based on the number of times a subject completed sit-ups in a minute. This correct execution was counted as a one complete sit-up. The correctly executed sit-ups were summed up as the final score. No score was given for incomplete sit-ups.

Reaction ball exercise

Reaction balls are small sized balls made up of either rubber or a silicon material. Its unique shape and design allows unpredictable bouncing which ultimately assist players to improve hand-eye coordination, reaction time, and reflexes (Hadassah, 2023). A reaction ball exercise test may include a combination of exercises. These exercises typically require participants to react quickly and accurately to the path or location of a ball. We included ball catching drills to measure hand-eye coordination of cricketers. For this 'wall throws' technique was used. Participants were asked to stand facing a wall 3 meters away in ready-to-catch position and reaction balls were thrown against the wall followed which they were required to catch the unpredictably bounced balls. Consistency in different speeds, trajectories, and angles were ensured by the same trained thrower to assess hand-eye coordination based on number of successful catches. A 80 beat/min. Metronorm set was used to maintain unifrom speed for each particpant. The degree of difficulty of the catches was set based on hard, moderate, and easy bounce catches depicted by 30°, 45°, and 60° angles (marked at the wall and floor) to provide the deflected trajectories. Twelve, Eighteen, and twenty-four points were allotted to them accordingly. Only ten throws; 3 easy, 4 moderate and 3 difficult with 30°, 45°, and 60° angles were allowed to be completed per subject. A final score is prepared by adding up the points of successful catches.

Data analysis

The Shapiro-Wilk test was applied to assess the normality of the data distribution. It is particularly effective for small sample sizes. Using the Shapiro-Wilk test ensures that the assumptions of subsequent analyses are valid, maintaining the integrity of the statistical conclusions (Shapiro & Wilk, 1965). Shapiro-Wilk test showed the data distribution was not normal following which Wilcoxon Signed-Rank test was used, as it is an appropriate test to perform in case of repeated measure design and non-normal distribution (Wilcoxon, 1992; Pallant, 2010; Field, 2013). Additionally, its rank-based approach enhances robustness to outliers and skewed distributions, ensuring reliable results (Sheskin, 2003). This choice supports the integrity and validity of the findings given the non-normal distribution of the data. Researchers approached with a 0.05 level of significance.

Results

The present study revealed the following results

Table 1 depicts the age, height, weight, and BMI distributions of subjects; the mean age was 18.7 years with a standard deviation (sd.) of 1.630. The noted minimum age was 16 years, while 18.11 years was the maximum age. Similarly, mean height of participants was recorded as 169.2 cm, with a sd. of 4.056. The recorded minimum and maximum heights were 157 cm, and 189 cm respectively. In terms of weight, the mean weight of the participants was recorded as 64.08 kg, with a sd. of 4.524. The minimum recorded weight was 55 kg, while 73.3 kg was the recorded maximum weight. Lastly, the table provides information on BMI; the recorded mean BMI was 21.06 kg/m^2, with standard deviation 1.174. The minimum and maximum BMI recorded were 16.12 kg/m^2, and 24.15 kg/m^2 respectively. As per the average age (18.7 years), the calculated average weight, height, and BMI of the subjects were, 64.08 kg, 169.2 cm, and 21.06 kg/ m2 respectively.

Table 1. Anthropometric information of subjects participated in the study.

Physical parameter	Mean ($\bar{x}$)	Standard deviation (SD)	Minimum	Maximum
Age (years)	18.7	1.630	16.0	18.11
Height (cm)	169.2	4.056	157.0	189.0

Weight (kg)	64.08	4.524	55.0	73.3
BMI (kg/m²)	21.06	1.174	16.12	24.15

BMI = Body Mass Index.

The results from the Shapiro-Wilk test for normality in table 2 indicates that all the selected motor components under high and low seasonal temperature settings follow non-normal distributions. Specifically for each variable, such as predicted VO_2, agility, upper body strength, hand-eye coordination, and abdominal strength, the p-values recorded less than 0.05 in both seasons. This suggests that, variables do not follow a normal distribution and thus reinforces the need to use non-parametric tests.

Table 2. Shapiro-Wilk normality test

	Shapiro-Wilk		
	Statistic	df	Sig.
Predicted VO_2 (Summer)	.937	100	.000
Predicted VO_2 (Winter)	.941	100	.000
Agility (Summer)	.887	100	.000
Agility (Winter)	.899	100	.000
Upper body Strength (Summer)	.917	100	.000
Upper body Strength (Winter)	.932	100	.000
Hand-eye coordination (Summer)	.937	100	.000
Hand-eye coordination (Winter)	.955	100	.002
Abdominal strength (Summer)	.917	100	.000
Abdominal strength (Winter)	.928	100	.000

The results of the Wilcoxon signed-ranks test, as summarized in Table 3, provide insights into the differences in selected motor components between high (mean temp. = 41.01⁰C) and low (mean temp. = 8.2⁰C) temperatures. For Predicted VO_2, the test revealed that cricketrs score higher in Summer with mean value 56.59ml/kg/min., and more positive ranks (N = 64, Mean Rank = 54.85, Sum of Ranks = 3510.50) compared to Winter with mean value 53.20ml/kg/min., and negative ranks (N = 31, Mean Rank = 33.85, Sum of Ranks = 1049.50), indicating an increase in Predicted VO_2 from winter to summer. Similarly, for Agility, Summer with higher mean (14.04 sec.) and positive ranks (N = 62, Mean Rank = 41.30, Sum of Ranks = 2560.50) surpass the Winter (12.74 sec.) and negative ranks (N = 14, Mean Rank = 26.11, Sum of Ranks = 365.50), suggesting improved agility in Summer than in Winter. Conversely, in Winter, the Upper Body Strength (UBS) demonstrated higher mean (15.50 mt) and more negative ranks (N = 59, Mean Rank = 47.87, Sum of Ranks = 2824.50) than in Summer (mean = 14.47 mt) with positive ranks (N = 33, Mean Rank = 44.05, Sum of Ranks = 1453.50), indicating a decrease in UBS from winter to summer. Hand-Eye Coordination (HEC) similarly exhibited higher mean (161.09) and more negative ranks (N = 60, Mean Rank = 55.88, Sum of Ranks = 3352.50) in Winter compared to Summer with mean value 151.42 and positive ranks (N = 39, Mean Rank = 40.96, Sum of Ranks = 1597.50), suggesting a decrease in HEC during summer. In Summer, Abdominal Strength (AS) showed a marginal higher mean (47.67) and number of positive ranks (N = 53, Mean Rank = 43.74, Sum of Ranks = 2318.00) compared to Winter mean (46.83) and negative ranks (N = 34, Mean Rank = 44.41, Sum of Ranks = 1510.00), indicating an increase in AS from winter to summer.

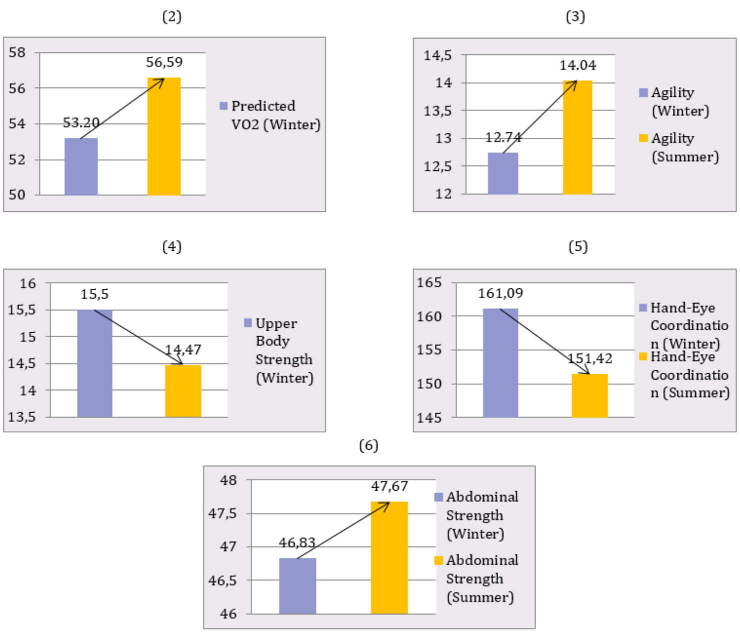
Table 3. Wilcoxon Signed-ranks test shows the differences in selected motor components in High and Low temperature

		N	Mean	Mean Temperature	Mean Rank	Sum of Ranks
Predicted VO_2 (Winter) Predicted VO_2 (Summer)	Negative Ranks	31	53.20 ml/kg/min	8.2⁰C	33.85	1049.50
	Positive Ranks	64	56.59 ml/kg/min	41.01⁰C	54.85	3510.50
	Ties	5				
	Total	100				
Agility (Winter) Agility (Summer)	Negative Ranks	14	12.74 sec	8.2⁰C	26.11	365.50
	Positive Ranks	62	14.04 sec	41.01⁰C	41.30	2560.50
	Ties	24				
	Total	100				
UBS (Winter) UBS (Summer)	Negative Ranks	59	15.50 meters	8.2⁰C	47.87	2824.50

	Positive Ranks	33	14.47 meters	41.01⁰C	44.05	1453.50
	Ties	8				
	Total	100				
HEC (Winter) HEC (Summer)	Negative Ranks	60	161.09	8.2⁰C	55.88	3352.50
	Positive Ranks	39	151.42	41.01⁰C	40.96	1597.50
	Ties	1				
	Total	100				
AS (Winter) AS (Summer)	Negative Ranks	34	46.83	8.2⁰C	44.41	1510.00
	Positive Ranks	53	47.67	41.01⁰C	43.74	2318.00
	Ties	13				
	Total	100				

UBS = Upper body strength
HEC = Hand-eye coordination
AS = Abdominal Strength

Figures 2 to 6: Indicating the bar graph comparison of mean values at a 95% confidence interval of selected motor variables viz. predicted VO_2, Agility, Upper Body Strngth, and Hand-Eye Coordination and Abdominal Strength in winter (December) and summer (June) respectively.



The results of the Wilcoxon signed-ranks test, as depicted in Table 4, demonstrate significant seasonal variations in selected motor components. Specifically, the predicted VO2 component (Z = -4.573b, p = .000) and Agility (Z = -5.734b, p = .000) show highly significant differences between high and low temperature conditions. Upper Body Strength (Z = -2.678c, p = .007) and Hand-Eye Coordination (Z = -3.063c, p = .002) also reveal significant seasonal differences, although at a slightly higher p-value. Conversely, Abdominal Strength (Z = -1.713b, p = .087) does not exhibit a statistically significant seasonal variation, as indicated by the p-value exceeding the conventional threshold of .05. The asymptotic significance values underscore the meaningful impact of seasonal conditions on most of the analyzed motor components, excluding Abdominal Strength, which remains statistically unaffected.

Table 4. Shows test statistics for Wilcoxon signed-ranks test on selected motor components

	Pred. VO_2 (Winter) Pred. VO_2 (Summer)	Agility (Winter) Agility (Summer)	UBS (Winter) UBS (Summer)	HEC (Winter) HEC (Summer)	AS (Winter) AS (Summer)
Z	-4.573	-5.734	-2.678	-3.063	-1.713
Asymp. Sig. (2-tailed)	.000	.000	.007	.002	.087

UBS = Upper body strength
HEC = Hand-eye coordination
AS = Abdominal Strength

Discussion

Our study examined the changes in motor performance of cricketers at different seasonal temperatures (high and low). The findings of our study provide valuable insights into the results of predicted VO_2, agility, upper body strength and hand-eye coordination with significant differences ($p < 0.01$). Higher performance was recorded in high temperature on predicted VO_2, and agility variables, while on upper body strength and hand-eye coordination variable enhanced performance was noted in low temperature compared to high. Though, slightly higher performance was recorded in abdominal strength in high temperature, p-value (0.087) suggests that the observed difference between the two groups could very likely be due to random chance rather than a true underlying effect.

Study results revealed an increased performance of the cricketers on predicted VO_2 in high temperatures, similar to the prior studies (Jeffreys, 2018; Lindberg et al., 2012; Lorenzo et al., 2010). Predicted VO_2 values in high temperatures indicated potentially better aerobic capacity in comparison to low temperatures. This finding aligns with prior studies (Günay et al., 2006; Liang et al., 2013; Erdoğan, 2015) that have suggested improved cardiovascular endurance in high temperatures; consumption of oxygen is higher while exercising in a high temperature hot environment compared to a low temperature cold environment. Lindberg et al., (2012) also determined a significantly higher VO_2 at 20°C than in -12°C. In their study, ten males were tested through maximal exercise period on a bicycle in above given different temperatures. The observed results on VO_2 max in this study might be due to the elevated ambient temperature which is a cause of enhancing muscle temperature, enzymatic reactions and muscle elasticity ultimately resulting into the efficient use of oxygen and better movements (Nybo, 2008; Bishop, 2003). Though, contradictory results were found by Gamage et al., (2016), as they found reduced between-wicket running performance due to dehydration, high temperature and heat stress. The improvement in VO_2 max during high-temperature conditions suggests enhanced aerobic efficiency which is crucial for running between wickets, and chasing balls in the outfield.

According to the results we obtained, high temperature positively affects agility. This finding of our research regarding agility aligns with study findings of Ball et al. (1999), which stated that the 30 meter sprinting speed run is better with the increase rather than decrease in the environment temperature. In their study, strength of sprint produced at 30°C was noted greater than the same produced at 19°C in different environmental temperatures after applying a thirty second sprint to 8 healthy males (Ball et al., 1999). The agility, speed, and coordinative ability increase with the increase in temperature value from -5.5^0 C to 30^0 C (Çakir, 2019). Improved nueromuscular transmission and reduced joint stiffness due to the warmer condition might be the possible causes of improved agility in summer season as also reported by (Racinais & Oksa, 2010). The improvement in agility during high temperature conditions suggests the efficiency in quick directional changes, which is crucial for reacting swiftly during fielding specially for wicket keepers whose performance is dominantly influenced by agility component. Enhanced agility may also benefit bowlers in their approach and follow-through phases and is equally important for the batsmen while taking doublé-tripple runs.

The results of the medicine ball throw indicate enhanced upper body strength for the cricketers during low temperature. This finding appears counterintuitive and also contradictory to previous review of Gatterer et al. (2021), observed a decreased contraction force for maximal wrist flexion during low skin temperature due to cold exposure at 5^0 C. Based on the increase in muscle heat an enhanced performance in jump and speed was observed by a previous study (Bergh and Ekblom 1979). While shifting from low temperature to high temperature, it was also observed that the vertical jump variable is affected positively (Çakir, 2016). However, the study of Cheung et al. (2000) favoured the obtained results on upper body strenth by stating that the low temperature minimizes the onset of central and peripheral fatigue which ultimately assists in strength and fine motor based activities. Thus the noted results on upper body strength might be due to the delayed peripheral fatigue in low temperature. The improved upper body strength may contribute to the batsmens' performance in low temperture in terms of taking more powerful and controlled batting strokes. Bowlers specially medium pacers may also get the benefit in terms of enhanced velocity and accuracy while delivering the ball.

Study results of variable 'reaction ball exercise' recorded higher performance in low temperature rather than high temperature. Reaction ball exercise outcomes are coinciding with the findings of Daanen et al., (2016), which stated, exercising in cold after acclimatization can benefit cognitive focus. This finding counteracts a previous study (Ünal, 2002) which indicated that exercising in cold temperatures increases reaction time and deteriorates coordination and nerve conduction velocity. Racinais and Oksa (2010) also showed an increase in muscular tonus, blood viscosity, the time of muscle contraction, and the relaxation time of antagonist muscles ultimately resulting in delayed reflex action during cold temperatures, thus contradicting our results on hand-eye coordination. Enhanced hand-eye coordination in low temperature might be due to the improved agility which assisted the partcipants react better against the bounce of the reaction ball. Other posible reasons might be the lower sweat rate in low temperature specifically in the hands which might assist in higher hand grip and control over the reaction ball and also the varied temperature of the wall used might be influenced the bouncing back ability of the reaction ball. This enhanced hand-eye coordination may develop sharper reflexes for catching particularly in wicket-keeper, slip and silly point fielders.

The study's results also showed no significant difference between abdominal strength in high and low seasonal temperatures ($P>0.05$). This finding matches with a previous study of Kumar (2020) which recorded insignificant difference in abdominal strength in high and low temperatures. Thus, the observed difference between the two groups could very likely be due to random chance rather than a true underlying effect.

In conclusion, the results showed a different performance landscape in terms of motor fitness measured in high and low seasonal temperatures. Predicted VO_2, and agility, were recorded higher at a high temperature as compared to a low temperature, while upper body strength and reaction ball exercise was recorded higher at a low temperature compared to a high temperature. Changes measured in abdominal strength may be recorded due to random occurrence as noted significance value of Wilcoxon signed-ranked test recorded 0.087 i. e., more than the threshold (0.05). These results highlight the impact of temperature variations on particular motor fitness components and the necessity of customized training plans to maximize performance in high and low seasonal temperature settings.

Our study had some limitations. We emphasized measuring participants' motor performance on selected motor components in high and low temperatures without having any control over the training pattern and training load given to them for a whole year, thus becomes a major limitation. Second, we did not had any control over their lives beyond training sessions in terms of diet, sleep, lifestyle, and other miscellaneous workloads they went through. Third, only male participants were included in our study; thus, the outcomes of the study cannot be generalized on the female athletes as their thermoregulatory system works more efficiently than male counterparts due to the presence of more fat, thus exercising in cold may provide them a proportional edge over males. Moreover, presence of athletic triad especially amenorrhea may limit the aerobic efficiency of females. Last, we investigated only adolescents aged 16 to 19 years, different results may observe in males of different age groups. Despite these limitations, our study provided insightful results backed by empirical evidences. Additionally suggested future studies ought to work toward a greater control or observation of factors such as training load, nutrition, and sleep so that they can isolate any genuine effects of temperature on motor performance. The sample should include women athletes and a wider age group to allow making more generalized conclusions as to the demographic groups.

Conclusions

In conclusion, the study showed increased motor performance on two motor components namely predicted VO_2, and agility in high temperature compared to low temperature, and an increased performance in upper body strength and hand-eye coordination was observed in low temperature rather than high temperature. Furthermore, no significant difference was recorded in abdominal strength. These strong evidences provide an insight that coaches should design their training programs by keeping in mind the varied seasonal temperatures. To explore the area effectively, further studies are required to be done with different age groups, gender, and temperature settings and in a more controlled environment.

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