

Tracking Changes in Physical Performance and Match Outputs in Elite Female Field Hockey Players Over an Olympic Cycle: A Follow-Up Study

Wayne Patrick Lombard^{1,2,3,*} and Michael Ian Lambert^{1,4}

ABSTRACT

This research aimed to analyse the physical performance and game-related statistics of 17 international female hockey players across an Olympic cycle, exploring whether these metrics changed synchronously. Data from 24 physical performance tests and 102 matches, monitored with 10 Hz GPS units, were evaluated. Minimal variability was observed in the 30 m sprint performance (Coefficient of Variation, $CV = 2.3 \pm 0.8\%$), while the greatest variability was found in pull-up tests ($CV = 35.8 \pm 12.1\%$). Significant temporal improvements were noted in the YoYo test ($p < 0.001$), and sprint times for 10m and 30m distances ($p < 0.001$ for both). Strength, muscular endurance, and neuromuscular metrics also enhanced significantly over time ($p < 0.008$). Reactive Strength Index (RSI), improved over time ($p < 0.008$), but none of the values differed significantly from the first test. On average, players covered 5469 ± 1159 m per match, with no significant change in high-speed running distance (637 ± 246 m) across the five years. However, the average running speed did increase ($114 \pm 13 \text{ m}\cdot\text{min}^{-1}$; $p < 0.001$). The findings elucidate the performance benchmarks for elite female hockey players and suggest that advancements in individual performance tests do not necessarily correlate with match statistics, underscoring the complexity of athletic progression and its implications for player management.

Keywords: Global positioning system, hockey, match demands, physical testing.

1. INTRODUCTION

Field Hockey (hereafter referred to as “Hockey” throughout the paper) is an intermittent high-intensity team sport where the demands of the game fluctuate as play transitions between offensive and defensive phases. Modifications in playing conditions and rules have significantly impacted the sports’ demands. For example, synthetic water-based turf pitches have reduced ball-to-surface friction, increasing ball movement across the playing surface. Additionally, rule changes such as removing the offside rule, allowance for unlimited rolling substitutions, the introduction of the self-pass rule, and the adoption of four 15-minute quarters have contributed to a more dynamic and intense game enhancing its excitement and global appeal (Linke & Lames, 2017; McMahon & Kennedy, 2019; Tromp & Holmes, 2017).

Given these evolving demands, high-level hockey players must undergo rigorous training to develop strength, power, speed, cardiovascular fitness, and resistance to fatigue (Lombard *et al.*, 2021; McGuinness *et al.*, 2019). Fitness testing conducted by strength and conditioning specialists has become a standard practice at the higher levels to assess training responses. The test results provide sports scientists and strength and conditioning specialists with valuable insights into players’ current physical profiles. This information is critical for designing training programmes that cater to the specific needs of each player, including the demands of their playing position (Turner, 2011).

Submitted: September 24, 2024

Published: November 26, 2024

 10.24018/ejsport.2024.3.5.192

¹Health through Physical Activity, Lifestyle and Sport Research Centre (HPALS), Department of Human Biology, Faculty of Health Sciences, University of Cape Town, South Africa.

²APA Training Systems Pty Ltd, South Africa.

³Lakshyan Academy of Sport, India.

⁴Human Kinetics and Ergonomics, Rhodes University, South Africa.

*Corresponding Author:
e-mail: wayne@apatrainingsystems.com



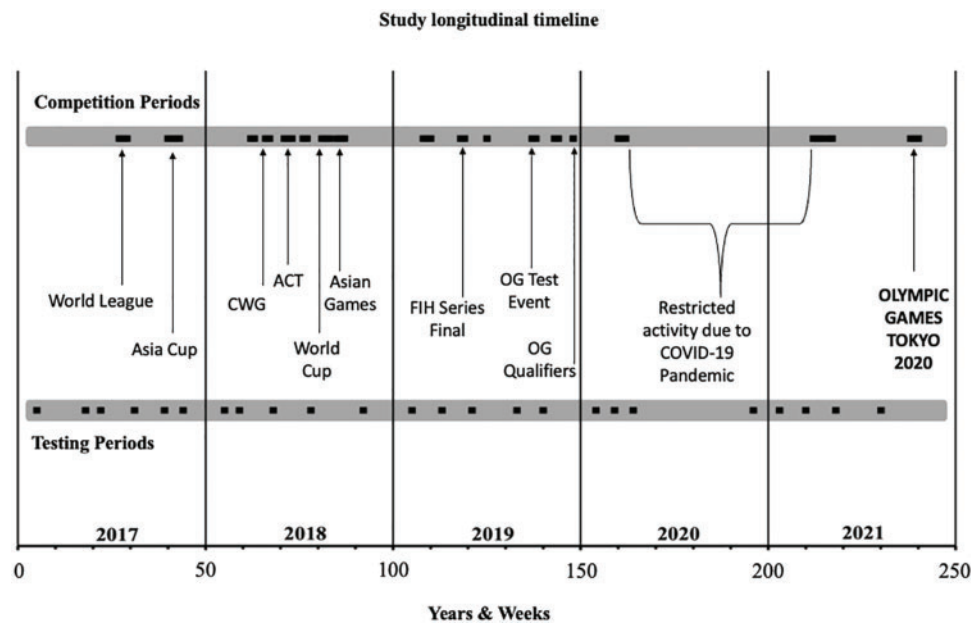


Fig. 1. The study timeline depicted. All major FIH-approved tournaments are shown within the competition periods. All other friendly series that fall between each major tournament are also shown. Each block represents testing occasions in the testing periods timeline. Not all fitness tests were conducted during each testing session (see text for detail).

In our previously published study (Lombard & Lambert, 2024), we analysed the physical fitness testing metrics and their relationship to locomotor activity profiles among female international field hockey players across an Olympic cycle. This study provided foundational insights into the standards required by elite female hockey players and the variations in performance metrics over time. However, it did not fully explore the relationship between these performance characteristics measured during routine testing and the players' match outputs.

To build on this foundation, the current study aims to address this gap by tracking the physical performance and match outputs of 17 international female field hockey players over an Olympic cycle to investigate whether these changes occur synchronously. While our previous research highlighted the standards and variations in fitness metrics, this study seeks to understand how these metrics align with match performance, offering a more comprehensive view of athlete development in elite field hockey.

2. METHOD

2.1. Subjects

All data were collected from international-level Indian female hockey players ($n = 17$) excluding goalkeepers.

2.2. Study Design

The descriptive observational study aimed to analyse all physical performance and match physical output data collected over an Olympic cycle (Fig. 1). Data were retrospectively tracked for the final 17 field players participating in the Tokyo Olympic Games. The testing protocol evaluated the player's anthropometric profiles, Yo-Yo intermittent recovery test level 1 (YoYo IR 1), 10 m and 30 m sprint times, 6 × 30 m repeat sprint ability (RSA), local muscular endurance, upper and lower body strength, and lower body neuromuscular performance. Match demands were assessed using GPS data during match play. Ethical clearance was obtained through the Human Research and Ethics Committee (R623/2020), in accordance with the code of ethics of the World Medical Association's Declaration of Helsinki, 1964.

2.3. Physical Performance Profiling Procedures

Testing data were collected on multiple ($n = 24$) occasions between 2017–2021. Due to the constraints of this study design, not all tests were completed on each occasion. The number of tests varied, between 7 (Repeat Sprint Ability) and 19 (Yo-Yo intermittent recovery 1 test) occasions. Congested match schedules, limited time during training periods and the COVID-19 pandemic restricted testing opportunities. Global Positioning System (GPS) data were also collected for 102 matches over the same

period. Our previous paper detailed the tests (Lombard & Lambert, 2024). They are briefly outlined below.

1. Field-based Testing

All field-based tests were conducted on a water-based International Hockey Federation (FIH) standard synthetic hockey AstroTurf by the same personnel. Before any testing, players performed a supervised dynamic warm-up. Photoelectric sensors (Swift Speedlight System, Australia) were used to determine the times for each sprint, and the 6 × 30 m repeat sprint ability (RSA) test.

2. Yo-Yo Intermittent Recovery Test Level 1 (YoYo IR1)

The Yo-Yo intermittent recovery test level 1 (YoYo IR1) assessed the players' aerobic capacities. The final level achieved in the test was a marker of their aerobic capacity (Bangsbo *et al.*, 2008).

3. 10 m and 30 m Sprint Times

The sprint tests aimed to determine the players' 10 m and 30 m sprint times (s). Each player performed three maximal effort sprints from a 3-point start, covering 30 m each sprint with the fastest time for each distance recorded (Australian Institute of Sport, 2014).

4. Repeat Sprint Ability (RSA)

Repeated sprint ability was assessed using the 6 × 30 m repeat sprint ability test. Players ran 30 m as fast as possible on a rolling 30-second clock, completing six total reps. The total time for all six sprints was calculated and used as their final score (Australian Institute of Sport, 2014).

5. Muscular Strength Testing

The 3RM bench press and squat tests followed the guidelines of the National Strength and Conditioning Associations (NSCA) 3RM testing guidelines (Haff & Triplett, 2015).

6. Muscular Strength Endurance

Upper body local muscular endurance was measured through pull-ups. They were instructed to hold onto the bar with a neutral grip, keeping their arms straight at the bottom and aligning their chins with the bar at the top. The final test score was based on the maximum number of consecutive repetitions they could complete (Dickie *et al.*, 2017).

2.4. Neuromuscular Performance Testing

Lower body neuromuscular performance was assessed with a counter movement jump (CMJ) and the 10/5 pogo hop reactive strength index (RSI) test. Jump height (JH) (cm) and RSI (Jump height (JH)/Ground Contact Times (CGT)) (m.s^{-1}) were measured using a Push Band 2.0 (Train with Push, Toronto, Canada). The CMJ jumps were performed with the players starting upright, arms at their sides. Players were instructed to jump as high and fast as possible, with countermovement depth being self-determined and arm swing being permitted (Lake *et al.*, 2018).

The 10/5 pogo hop test involved players beginning in a standing position with their hands placed on their hips. Players were then instructed to “hop” as fast and as high as possible with as little knee bend as possible 10 times in a row (Stratford *et al.*, 2020). The average of the five best jumps was recorded as their final test score.

2.5. Match Demands

All on-field match demands were captured using Global Positioning System (GPS) technology. GPSports HPU units (GPSports, Canberra, Australia) were used between 2017 and the end of 2019, and Catapult Vector X7 (Catapult Sports, Melbourne, Australia) units were used between 2020 and 2021. Data were then processed using the GPSports SPI IQ software (2017–2019) and Catapult Openfield software (2020–2021). To minimize inter-unit error, players used the same device throughout the study periods (2017–2019 GPSports HPU & 2020–2021 Catapult Vector X7) to improve intra-player data accuracy (Jennings *et al.*, 2012). Each unit has a true GPS sampling rate of 10 Hz and an accelerometer sampling rate of 100Hz. Previous research has shown that 10 Hz devices were both valid ($p < 0.05$) and reliable (% TEM = 1.3%) for total distance (Johnston *et al.*, 2014). Speed thresholds for high-speed running ($>4.5 \text{ ms}^{-1}$) were set in according to previous research (McGuinness *et al.*, 2018). Data were processed for individual active playing time, excluding all major breaks in play, such as penalty corners, video referrals, player substitutions, green or yellow card time-outs, goals scored, and injury time. HDOP and GNSS satellite numbers for the period studied ranged between 0.5–1.5 and 10–18, respectively.

TABLE I: TEAM'S AVERAGE VALUES FOR THE TESTING AND MATCHES

	Mean $\pm$ SD	n
Field-based tests		
YoYo IR1 (level)	19.0 $\pm$ 1.4	265
10 m sprint (s)	1.89 $\pm$ 0.09	135
30 m sprint (s)	4.6 $\pm$ 0.2	137
RSA (s)	37.4 $\pm$ 1.9	80
Upper body		
3RM bench press (kg)	44.6 $\pm$ 5.1	230
Relative bench press (kg.bw.kg ⁻¹)	0.9 $\pm$ 0.1	230
Pull-ups	7.3 $\pm$ 3.8	193
Lower body		
3RM squat (kg)	83.3 $\pm$ 14.0	113
Relative squat (kg.bw.kg ⁻¹)	1.69 $\pm$ 0.28	113
CMJ height (cm)	38.0 $\pm$ 4.7	231
RSI	1.38 $\pm$ 0.28	213
Match data		
Total distance (m)	5469 $\pm$ 1159	1265
HSR (m)	637 $\pm$ 246	1265
Average speed (m.min ⁻¹)	114 $\pm$ 13	1265

Note: RSA = repeat sprint ability, RM = repetition maximum, bw = body weight, CMJ = countermovement jump, RSI = reactive strength index, and HSR = high-speed running.

TABLE II: EACH PLAYER'S COEFFICIENT OF VARIATION FOR THEIR OLYMPIC CYCLE TESTING AND MATCH OUTPUT DATA (N = 17)

	Field-based tests				Upper body			Lower body				Total distance (m)	HSR (m)	Average speed (m.min ⁻¹)
Player	Yo-Yo	10 m	30 m	RSA	3RM BP	Rel BP	Pull-ups	3RM squat	Rel squat	CMJ	RSI			
1	5.0	5.3	2.7	3.6	8.3	8.3	35.0	8.4	8.4	10.7	7.9	18.4	38.0	7.9
2	4.6	5.2	1.8	3.1	9.0	9.0	49.1	4.5	4.7	7.3	9.0	19.6	33.5	6.2
3	3.3	3.5	3.0	3.2	11.1	11.1	56.0	10.1	10.0	8.1	14.9	13.2	28.1	10.5
4	7.1	5.2	3.1	1.8	8.6	8.6	27.9	15.3	15.3	13.3	11.9	23.7	32.0	9.5
5	4.0	3.4	2.2	2.6	11.6	11.6	26.3	11.4	11.4	7.1	14.9	16.3	25.4	8.4
6	5.7	2.7	2.5	2.3	8.0	8.0	60.8	14.4	14.3	9.9	13.6	16.1	30.0	8.2
7	4.4	3.4	1.4	2.6	10.4	10.4	45.4	12.2	12.3	12.0	11.1	18.7	24.9	8.5
8	5.0	3.8	2.3	2.6	7.7	7.7	27.6	10.6	10.5	11.7	10.1	23.6	31.0	8.3
9	4.3	1.3	2.9	–	17.4	17.4	44.1	7.9	7.8	12.1	9.7	10.6	19.2	8.0
10	5.0	3.9	2.7	3.7	3.1	3.1	22.2	8.7	8.9	8.9	19.4	15.8	29.7	8.9
11	6.4	4.9	2.9	7.0	8.6	8.6	39.7	11.5	11.6	8.5	10.3	24.0	31.2	8.9
12	3.0	2.1	1.5	–	8.1	8.1	23.3	7.9	7.8	9.8	17.2	14.8	31.9	9.1
13	4.3	0.3	0.6	–	12.3	12.3	19.2	–	–	8.4	11.4	21.2	26.3	6.9
14	3.4	2.4	1.5	2.7	11.8	11.8	26.0	17.2	17.3	8.9	9.7	19.1	33.9	12.6
15	3.8	6.3	3.1	5.6	4.4	4.4	25.7	9.2	11.4	9.5	9.9	16.3	28.4	9.0
16	5.1	3.6	2.3	4.0	10.9	10.9	64.1	8.2	11.6	7.8	19.8	27.0	27.4	7.8
17	3.6	5.2	3.4	3.0	3.3	3.3	15.4	12.0	14.2	6.5	11.3	14.9	24.1	8.6
Total	4.6 $\pm$ 1.1	3.7 $\pm$ 1.6	2.3 $\pm$ 0.8	3.4 $\pm$ 1.4	9.1 $\pm$ 3.5	9.1 $\pm$ 3.5	35.8 $\pm$ 15.1	10.6 $\pm$ 3.2	11.1 $\pm$ 3.2	9.4 $\pm$ 2.0	12.5 $\pm$ 3.6	18.4 $\pm$ 4.4	29.1 $\pm$ 4.4	8.7 $\pm$ 1.4

Note: RSA = repeat sprint ability, RM = repetition maximum, rel = relative, CMJ = countermovement jump, RSI = reactive strength index, HSR = high-speed running (>4.5 m.s⁻¹).

2.6. Statistical Analysis

This study utilized a longitudinal unbalanced design with heterogeneous variability and incomplete data with an uneven spacing of repeated data. Data are reported as mean $\pm$ standard deviation and intra-participant coefficient of variation. Linear mixed modelling was conducted using IBM SPSS Statistics for Mac, version 28.0.0.0 (IBM Corp., Armonk, N.Y., USA) to evaluate the fixed effects of time for the field testing or match variables while the individual players were considered as random effects for all the analyses (Newans *et al.*, 2022). Post-hoc Bonferroni comparisons were adjusted for multiple comparisons to determine differences between the testing periods when fixed factors were significant ($p < 0.05$). All the comparisons using the Bonferroni tests are reported as $p < 0.05$. A lowess

spline method was used to smooth the curves of the data plotted over time (Prism GraphPad Prism version 9.4.0 for Mac, GraphPad Software, San Diego, California USA, www.graphpad.com).

3. RESULTS

The average age of the players in the squad at the beginning of the longitudinal study was 23 ± 3 years. They weighed 54.4 ± 6.1 kg, with an average height of 160.7 ± 3.0 cm. Physical tests were conducted 24 times during the study, but not all tests were done every time. Table I summarises the mean scores for the team over the study period. The coefficient of variation (CV) for each measurement is shown in Table II. The least variation over the 5 years occurred in the 30 m sprint ($CV = 2.3 \pm 0.8\%$), and the most variation occurred in the pull-up tests ($CV = 35.8 \pm 12.1\%$).

3.1. Field-Based Testing

The changes in the field-based testing are shown in Fig. 2. Performance in the YoYo test (Fig. 2a) was significantly different over time ($p < 0.001$) with weeks 55, 59, 68, 78, 140, 154, 164, 196, 203, 210 and 218 being significantly higher compared to the first test. The highest value (20.0 ± 1.3 level) occurred at week 154. The values remained fairly similar for the remainder of the cycle. The repeated sprint test (Fig. 2b) showed improvements from round 5 of testing (week 55) onwards, with weeks 55, 78 and 113 being significantly better than the first test. The best performance (36.1 ± 1.1 s) occurred in week 78 of the cycle. Repeated sprint data were not measured from week 113 onwards. Sprint times over 10 m (Fig. 2c) and 30 m (Fig. 2d) were significantly different over the season (both $p < 0.001$). The fastest times were recorded in week 78 with scores of 1.82 ± 0.06 s and 4.53 ± 0.15 s, respectively. Sprint tests were not recorded after week 140.

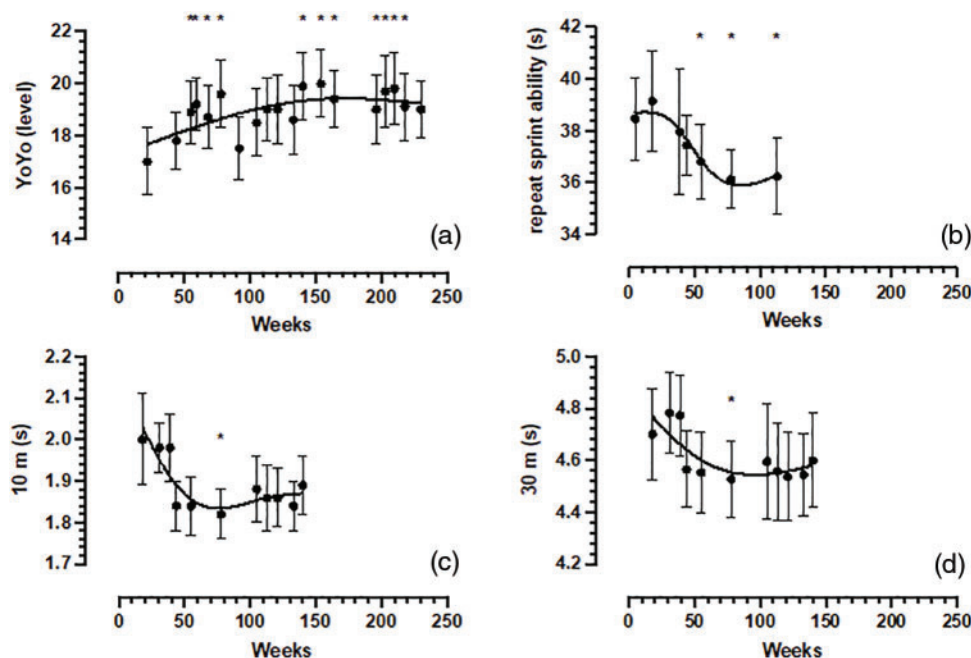


Fig. 2. Changes in the field-based tests over the 5-year cycle (a) YoYo, (b) repeat sprint ability, (c) 10 s sprint and (d) 30 s sprint. The * represents $p < 0.05$ for the comparison with the first test in all the graphs.

3.2. Upper Body Muscular Strength

Significant increases in 3RM bench press scores were observed throughout the study period ($p < 0.001$) (Fig. 3a), with scores being significantly higher from week 121 onwards compared to the first testing session. The bench press scores peaked in week 203 (49.9 ± 4.2 kg). The pattern for the relative bench press (Fig. 3b) was similar to 3RM bench press, except the measurement at 133 weeks was not different from the initial value. Pull-ups also changed over time ($p < 0.001$), with scores different from the first testing session from week 121 onwards. The results from week 196 were not different compared to the first test (week 22). The peak score occurred at week 164 (10.7 ± 3.3 reps).

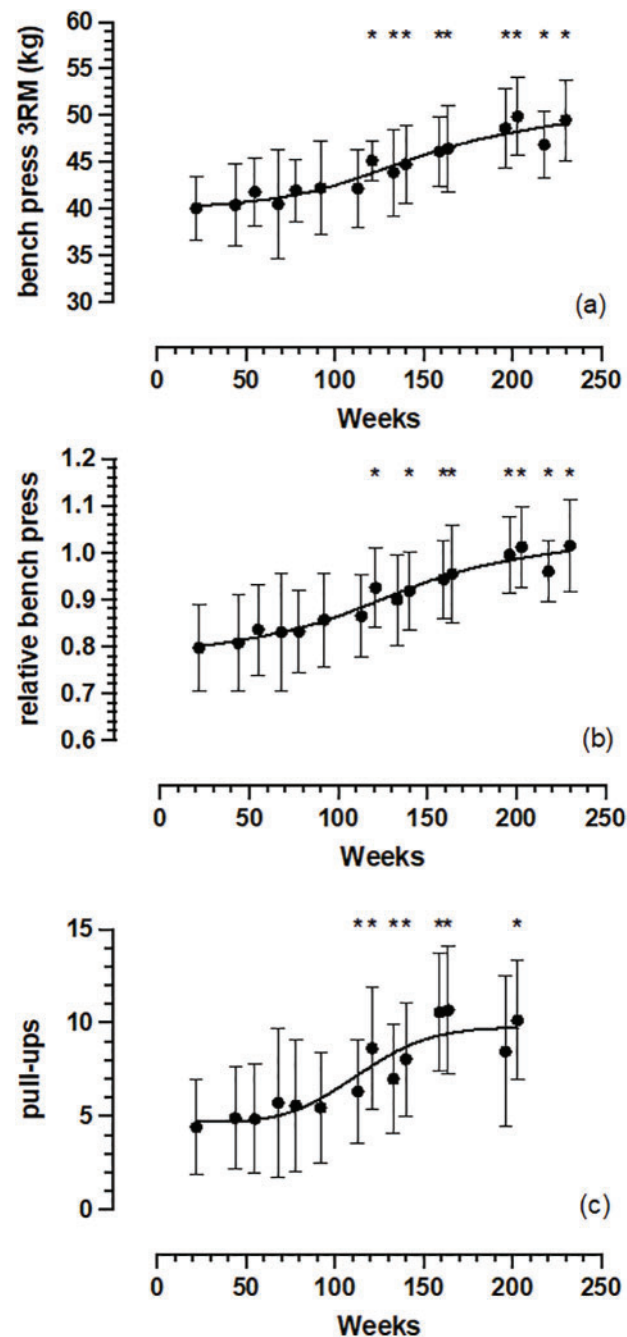


Fig. 3. Changes in the upper body measurements over the Olympic cycle (a) bench press (3M) (b) bench press (relative) and (c) number of pull-ups.

3.3. Lower Body Muscular Strength

Fig. 4 summarises the lower body values over the study period. Both 3RM squat (Fig. 4a) and relative squat (Fig. 4b), showed significant changes over time (both $p < 0.001$), with values increasing significantly from the first test (week 55) onwards. The countermovement jump measurements (Fig. 4c) averaged 38.0 ± 4.7 cm over the study. The value changed significantly over time ($p < 0.001$). Early improvements were noted at week 59, 68 and 78 compared to the first test (week 55). Towards the end of the cycle, the CMJ measurements were similar to the early improvements that occurred near the cycle's beginning.

Reactive strength index (Fig. 4d) also showed significant changes over time ($p < 0.008$), but none of the values differed significantly from the first test. The average reactive strength over the study was 1.38 ± 0.3 .

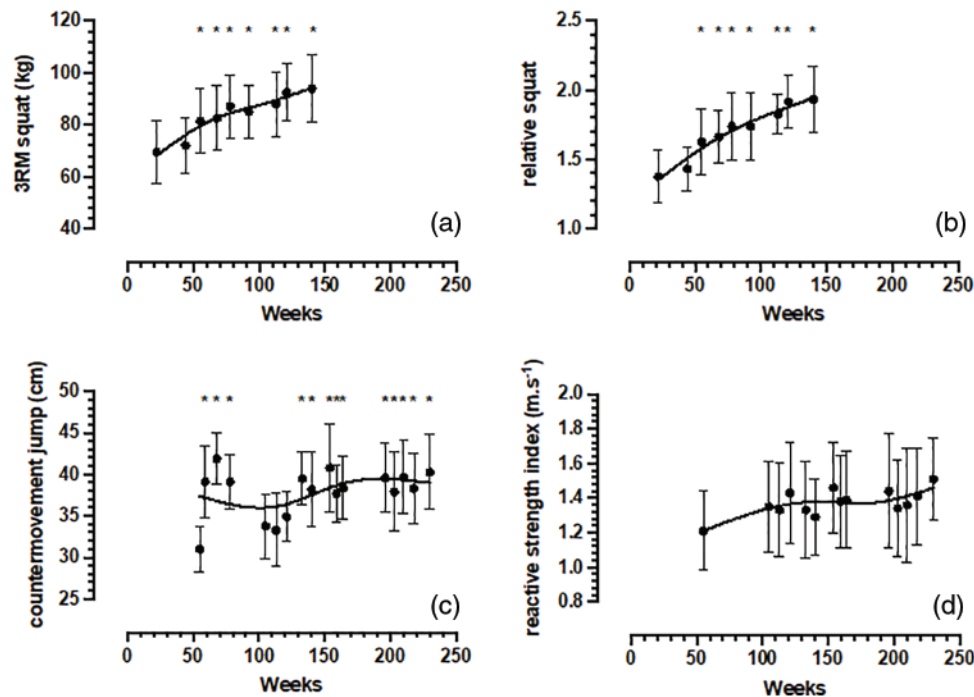


Fig. 4. Changes in the lower body measurements over the Olympic cycle (a) Squat (3RM) (b) squat (relative), (c) countermovement jump height, and (d) reactive strength index (RSI) ($\text{m}\cdot\text{s}^{-1}$).

3.4. Match Performance

Fig. 5 displays the physical outputs achieved during matches over the season. There was a significant difference in the total distance covered during matches ($p < 0.001$), with the lowest significant values observed in match 2 of week 62 (3794 ± 669 m) and match 2 of week 82 (3834 ± 983 m). The total distance covered in the other matches did not differ significantly from that of the first match. The CV for total distance was $18.4 \pm 4.4\%$ (Table II). Although there was considerable variation in high-speed total distance throughout the season ($\text{CV} = 29.1 \pm 4.4\%$), no significant changes were observed. Average running speed (Fig. 5c) increased significantly over the season ($p < 0.001$). The highest values occurred in the first match of week 73 (129 ± 12 $\text{m}\cdot\text{min}^{-1}$), and the second match of week 162 (128 ± 12 $\text{m}\cdot\text{min}^{-1}$). The CV for running speed was $8.7 \pm 1.4\%$ (Table II).

4. DISCUSSION

This is the first study to track the physical performance and match outputs of 17 international female field hockey players over a 5-year Olympic cycle to investigate whether these changes occurred synchronously. Our findings show significant improvements in physical fitness for most tests over the study period. However, physical match outputs did not show similar trends, with limited to no significant changes over time. Asynchronous changes suggest that physical fitness and match performance do not evolve uniformly.

Our previously published study provided foundational insights into the physical fitness testing metrics and their relationship to locomotor activity profiles among female international field hockey players across an Olympic cycle (Lombard & Lambert, 2024). While that study established the standards required by elite female hockey players and highlighted variations in performance metrics, it did not fully explore how these performance characteristics measured during routine testing changed over time. The current study builds on that foundation by addressing this gap. Despite the significant fitness improvements observed, match physical outputs did not show the same trend.

There are three possible explanations for this finding. Firstly, the players had better access to training facilities as they prepared for the Olympic Games, resulting in improved physical performance in controlled physical performance tests (Bishop *et al.*, 2015) but not in match physical characteristics, which are influenced by tactics, opposition and match conditions (Cunniffe *et al.*, 2024). Secondly, the physical performance tests may have limited specificity and not fully capture the demands of the game. Therefore, improvements in physical performance may not necessarily translate to improved match physical characteristics (Lombard *et al.*, 2021). Thirdly, tactical and strategic factors may influence the match demands. For example, a team may adopt a more defensive style of play against a

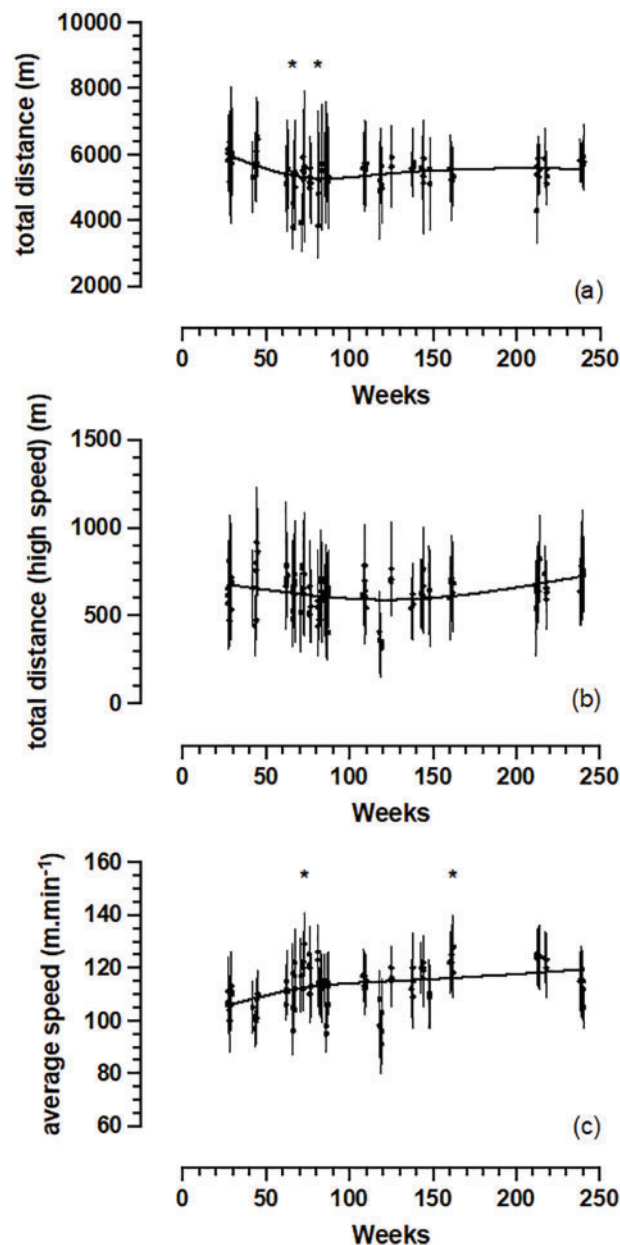


Fig. 5. Changes in the match performance over the Olympic cycle (a) total distance (b) total distance at high speed, and (c) average running speed.

stronger opposition which may result in lower match physical outputs regardless of individual physical performance improvements.

Field-based testing has become integral to team sports programs. By establishing baseline fitness levels, strength and conditioning coaches can gather valuable information on their players' training status, identify areas of weakness or strength, can design training plans that target specific areas to maximize performance during competition. The discrepancies between fitness improvements and match performance could highlight the need for personalised training programs. Different players may require distinct training regimens to optimize their strengths and address specific weaknesses, allowing for more tailored development strategies.

Previous research has shown a positive correlation between aerobic fitness and on-field physical outputs, especially distance covered during high-speed running (Lombard *et al.*, 2021). In our study, the players' average level of 19.0 ± 1.4 for the YoYo IR 1 was between 8%–14% higher (levels 17.5–18.5) than previously reported for international level hockey players (McGuinness *et al.*, 2018). Moreover, there was an average improvement of 12% from the first round to the last round of testing in the YoYo IR1. When considering the players' RSA, the overall average achieved in this study was 37.4 ± 1.9 s, slightly improving by 3% over time. This was considerably slower than what had been previously reported in Australian female players, who averaged 28.6 ± 0.9 s (Australian Institute of Sport, 2014). The 10 m and 30 m sprint times showed a 5% improvement over the study period, with an overall

average of 4.61 ± 0.19 s and 1.89 ± 0.09 s, respectively. The 10 m times achieved in the present study were significantly faster than what has previously been reported in Australian female players, who averaged 1.98 ± 0.04 s (Australian Institute of Sport, 2014). Additionally, Kapteijns *et al.* (2021) report times of 4.57 ± 0.16 s for 30 m. The disparities between our findings and those of other studies underscore the dynamic nature of player development, training strategies, and the potential for optimising various aspects of performance. These insights highlight the relevance of our research within the broader context of player development and training optimisation in elite female hockey.

Despite the common perception that hockey is a non-contact sport, the contrary is actually true, especially on the ball-type contact. A player's "strength on the ball", enhances their ability to win or maintain possession in tight or tackle situations. Additionally, it is reasonable to suggest that upper body strength can impact a player's hitting or flicking power and velocity, although no research has been conducted.

Upper body strength and endurance showed notable improvements, with a 20% increase in absolute strength and a 60% increase in endurance. The players average 3RM bench press of was 44.6 ± 5.1 kg, with a relative bench press falling within the same reported for elite female athletes in previous studies (Laursen & Buchheit, 2019; Australian Institute of Sport, 2014). These improvements in physical fitness did not, however, correspond to similar improvements in match outputs, suggesting that factors beyond physical fitness influence match performance.

It is widely accepted that stronger athletes are generally less likely to get injured and that a higher degree of muscular strength can lead to better performance on the field (Laursen *et al.*, 2018; Suchomel *et al.*, 2016). Moreover, when considering lower body strength, power and reactive strength values, previous research has shown a positive correlation between these physical markers and sprint performance (Seitz *et al.*, 2014). In the current study, players had an average weight of 54.4 ± 6.1 kg. Their relative squat scores of 1.69 ± 0.28 kg.bw.kg⁻¹ fall within the ranges reported in previous research (Laursen & Buchheit, 2019; Australian Institute of Sport, 2014).

Total distance is often used as a proxy measure of match load, while high-speed running during a match corresponds with the decisive short and intense actions that characterise the effort made by players. In the present study, average total distance (5469 ± 1159 m) and high-speed running (637 ± 246 m) were consistent with previous research (McGuinness *et al.*, 2019). However, it is noteworthy that the match physical outputs did not follow the same trends the physical performance testing data in this study. Although neither total distance nor high-speed running distance increased over time, there was a tendency for the average running speed (m.min⁻¹) to increase. Another study on junior female international hockey players (Curran *et al.*, 2022) showed that match-to-match CV for total distance was 4.9% compared to 18.4% in our study. The high-speed running CV in the study of Curran *et al.* was 22.0% compared to 29.1% in our study. The authors suggest that analysing variations in game performance can determine how well a player's locomotor activity has improved over time. If the player's variability decreases without a corresponding increase in mean game locomotor output, it indicates more consistent activity, which is considered better performance. On the other hand, if the mean game locomotor output increases with a narrower range of variability, it also indicates improvement (Curran *et al.*, 2022). Unfortunately, our study was not designed to address this interesting observation.

In conclusion, while most physical performance tests showed improvements through the 5-year cycle, the match physical characteristics did not track these changes. This indicates a complex interplay of various factors, such as training adaptations, player-specific attributes, and tactical adjustments. The time lag between fitness progress and changes in match outputs could point towards a delayed translation of physical improvements into on-field results. This emphasizes the importance of maintaining a long-term perspective when evaluating the effectiveness of training interventions. Focusing solely on fitness gains might not accurately reflect overall performance development. Coaches and performance analysts should consider broader factors, including tactical understanding, decision-making, and mental resilience, to evaluate player progression comprehensively. Asynchronous changes could also indicate that certain aspects of physical fitness might reach a plateau while match outputs continue to evolve. Identifying such plateaus is crucial to avoid stagnation and to explore innovative training methodologies.

5. PRACTICAL APPLICATIONS

Keeping a close eye on team performance has become an integral aspect of high-functioning teams. This involves gathering subjective data and scrutinizing objective measures that encompass both neuromuscular and cardiopulmonary elements. However, delving into the intricacies of monitoring systems reveals their inherently complex nature. Practitioners must navigate a web of factors, from tailoring monitoring strategies to individuals to considering the effects of technical and tactical

adjustments during matches, and everything in between. Despite this complexity, a notable shift in average speed (m.min) suggests an enhancement in match-specific fitness. Previous studies have drawn connections between higher aerobic fitness (measured through a 2.4 km time trial), improved lower body power (measured through the CMJ), and increased high-speed running and average match speed in male hockey players (Lombard *et al.*, 2021). Hence, it's reasonable to propose that tracking YoYo and CMJ values could serve as proxy measures for match physical readiness. In conclusion, this dataset sheds light on the specific criteria elite female hockey players may need to fulfil to participate in the playoff rounds of major tournaments, such as the Olympic Games.

6. CONCLUSION

Asynchronous changes in physical fitness and match outputs underscore the intricate nature of athletic development. This phenomenon calls for a nuanced approach to training, monitoring, and evaluating elite female field hockey players, ultimately enhancing their performance trajectories and the effectiveness of training programs. Tracking the physical performance and match outputs of elite players over an Olympic cycle is invaluable for understanding their adaptation.

ACKNOWLEDGMENT

The authors would like to thank the players and staff of Hockey India for making this study possible.

CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

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