

A Comparative Study of Aerobic and Anaerobic Capacity of Raiders and Defenders in Kabaddi Game

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Abstract— As population grows perpetually with an ever-rising rate of urbanization, the rate of vehicles on the road has been rising drastically, a phenomenon that has posed a severe problem of parking within most cities. Finding an empty parking lot has become a frustrating and time-consuming activity particularly during commercial places and urban zones that have a high density. As a result of this, drivers tend to embark on an endless tour of finding car space and this creates undue movement of vehicles, traffic jam, wastage of fuel and higher levels of air and noise pollution. To solve these problems, intelligent parking systems can now be thought of to monitor the parking space in a better way and organize the parking space in a more efficient manner. The proposed system will be an Arduino and sensors smart car parking system, which will be designed to provide a simple yet intelligent and automated way of controlling parking slots. It uses a microcontroller in the form of Arduino Uno, an infrared (IR) sensor, a servo motor, and a 16×4 LCD display. The IR sensors scan the entry and exit of cars and relay it to Arduino. With this information, the servo motor will automatically either close or open the gate. In the meantime, the LCD screen shows the availability of parking slot in real time where the drivers can know immediately whether a parking spot is available or not. Such a system conserves time, man power and unnecessary wastage of fuel expenses occasioned by time trying to find a parking spot. It will also help to reduce pollution, improve efficiency of parking

facilities. This is a feasible parking system which is not expensive, has proven reliability and can be easily utilized to help make cities of to-morrow cleaner and smarter.

Keywords: Arduino Uno, automation, infrared sensors, smart parking system, ultrasonic sensors, vehicle detection.

I. INTRODUCTION

Kabaddi is a physical contact sport from the Indian subcontinent. It has undergone significant transformations in the recent past. The year 2014 witnessed the launch of the Pro Kabaddi League (PKL), which transformed kabaddi into the second most-watched sports league in India. It significantly changed the physical and technical demands placed on athletes. While participating in this sport, the athlete should breathe in, exert ballistic effort, make this decision, and execute precision work.

The game involves short raids of 5–30 seconds, alternating with recovery periods, and a high demand on the aerobic and anaerobic energy systems. Kabaddi is growing towards greater specialization in offensive players called raiders who are supposed to possess high explosive power, speed, and anaerobic endurance; defensive players need to be ready for a number of engagements, requiring explosive tackle ability and aerobic fitness for all-round performance.

Grasping the physiological demands of specific positions is key to developing training programs, talent identification, and performance optimization. Existing literature, however, shows inconsistent

findings on whether raiders and defenders differ systemically in their aerobic and anaerobic capacities. Due to this research gap, the present study undertakes a comparative study on university-level male kabaddi players.

II. REVIEW OF RELATED LITERATURE

Khanna et al. (1996) measured VO_2 max in Indian national kabaddi players at 47.82 ± 3.68 ml/kg/min, and reported mean raid duration of 20.8 ± 6.26 seconds with post-match blood lactate of 6.13 ± 2.53 mmol/L, confirming the predominantly anaerobic nature of raid play.

Iran oust and Taheri (2014) assessed elite national players and found raiders demonstrated significantly higher Wingate peak power (11.8 ± 1.2 vs 10.6 ± 1.3 W/kg; $p < 0.01$) and greater fatigue index (38.4% vs 32.8%; $p < 0.05$), indicating both higher explosive output and lower fatigue resistance compared to defenders.

Singh and Yadav (2019) established normative RAST data for university-level players, reporting that raiders exhibited peak power of 10.4 ± 1.1 vs 9.2 ± 0.9 W/kg for defenders ($p < 0.01$), with no significant fatigue index difference. Gautam and Sharma (2024) synthesized evidence showing raiders achieve higher peak power and post-match lactate levels, while defenders exhibit faster heart rate recovery and higher relative VO_2 max. These position-specific adaptations are consistently supported by the literature.

Sudhakar and Krishnamurthy (2025) reported in a 12-week intervention that combined training produced superior VO_2 max improvements, with positional analysis showing raiders deriving greater benefit from the anaerobic component (+18.4% repeated sprint ability) while defenders benefited more from circuit training (+15.2% sustained work capacity).

III. METHODOLOGY

A. Research Design: The research design adopted for the study comprised comparative to study physiological differences of playing positions in kabaddi of competition level.

B. Participants: Using purposive sampling, thirty male kabaddi players of university level from the state of Rajasthan were chosen as a sample in this study. The kabaddi players were equally divided into two groups raiders ($n = 15$) and defenders ($n = 15$). The inclusion criteria required that participants aged between 18–25 years must have at least 2 years of experience in competitions and have a well-defined primary playing position for the last 6 months. Players regularly performing both roles were excluded. Participants signed an informed consent and underwent health screening before testing.

Table 1: Descriptive Characteristics of Participants

Variable	Group	N	Mean	SD
Age (years)	Raiders	15	21.47	2.13
	Defenders	15	21.73	2.08
Height (cm)	Raiders	15	172.4	5.6
	Defenders	15	170.8	5.2
Weight (kg)	Raiders	15	68.4	7.2
	Defenders	15	67.9	6.8
Playing Experience (years)	Raiders	15	4.8	1.9
	Defenders	15	5.1	2.0

C. Instrumentation and Testing Protocols

•To estimate aerobic capacity, participants run as far as possible in 12 minutes on a standard 400 m track.

VO₂max was estimated with the formula $V\dot{O}_{2max} = (\text{Distance in meters} - 504.9) \div 44.73$.

•The running-based anaerobic sprint test (RAST) measures anaerobic capacity through six 35-meter sprints performed at maximum intensity. The sprinting times and body mass were used to calculate Peak Power, Minimum Power, Average Power, and Fatigue Index.

D. Statistical Analysis: The data was described by standard deviation and mean. Raider and defender physiological variables subjected to independent samples t-test. In each group, Pearson correlation coefficients were examined. All analyses were conducted using $\alpha = 0.05$ to ascertain significance.

IV. RESULTS & DISCUSSION

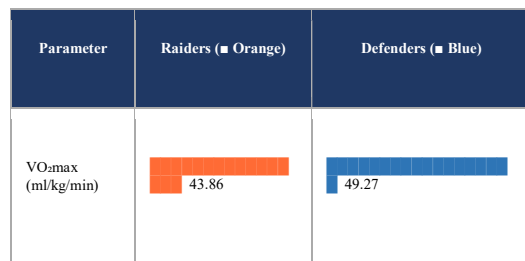
A. Aerobic Capacity (VO₂max):

Table 2: Descriptive Statistics and t-test Results for Aerobic Capacity (VO₂max)

Variable	Group	Mean	SD	SE M	t-value	p-value
VO ₂ max (ml/kg/min)	Raiders	43.86	3.42	0.88	-4.02	0.0004*
	Defenders	49.27	3.88	1.00		

* Significant at $p < 0.05$ | $df = 28$ | Mean difference = 5.41 ml/kg/min in favour of Defenders.

Figure 1: Comparison of Mean VO₂max between Raiders and Defenders



The mean VO₂max of defenders (49.27 ± 3.88 ml/kg/min) was significantly higher than that of raiders (43.86 ± 3.42 ml/kg/min), which showed a

mean difference of 5.41 ml/kg/min ($t = -4.02$; $df = 28$; $p = 0.0004$). We rejected the null hypothesis that there is no difference in aerobic capacity. The values of defenders were close to those reported for national level players (47.82 ml/kg/min; Khanna et al., 1996) and of raiders were comparable to those reported for sub-elite levels (Singh & Sandhu, 2011). Due to the nature of their position, defenders have greater high aerobic capacity to always be in a ready state for further defence actions, to remain in semi-squat positions, and to recover quickly in cases of successive tackles.

B. Anaerobic Capacity Parameters:

Table 3: Descriptive Statistics of Anaerobic Capacity Parameters (RAST)

Parameter	Group	Mean	SD	SEM
Peak Power (W/kg)	Raiders	10.24	1.08	0.28
	Defenders	9.18	0.96	0.25
Minimum Power (W/kg)	Raiders	7.18	0.84	0.22
	Defenders	6.64	0.76	0.20
Average Power (W/kg)	Raiders	8.76	0.92	0.24
	Defenders	7.92	0.85	0.22
Fatigue Index (%)	Raiders	29.84	5.26	1.36
	Defenders	27.66	4.98	1.29

Table 4: Independent t-test Results for Anaerobic Capacity Parameters

Parameter	Mean Diff.	t-value	df	p-value	Significance
Peak Power (W/kg)	1.06	2.87	28	0.008*	Significant
Minimum Power (W/kg)	0.54	1.86	28	0.074	Not Significant
Average Power (W/kg)	0.84	2.64	28	0.014*	Significant
Fatigue Index (%)	2.18	1.17	28	0.251	Not Significant

*Significant at $p < 0.05$ Raiders demonstrated higher values for all anaerobic parameters.

Figure 2: Comparison of Anaerobic Power Parameters (Raiders vs Defenders).

Parameter	Raiders (■ Orange)	Defenders (■ Blue)
Peak Power (W/kg)	10.24	9.18
Avg. Power (W/kg)	8.76	7.92
Min. Power (W/kg)	7.18	6.64
Fatigue Index (%)	29.84	27.66

Raiders have shown much greater peak power (10.24 ± 1.08 W/kg; $p = 0.008$), average power (8.76 ± 0.92 W/kg; $p = 0.014$) than defenders. These results agree with other studies (Singh and Yadav, 2019; Irandoust and Taheri, 2014). The raider group's high explosive attacking capacity reflects the ATP-PC system demands explosive capacity for raid initiation, changes of direction, and evasive maneuvers. A greater average power superiority indicates an improved ability to sustain anaerobic power output across successive raids.

The positions did not significantly affect either the minimum power ($p=0.074$) or the fatigue index ($p=0.251$). At university level, the fatigue resistance profiles of athletes in specific positions are not yet

differentiated. Studies at elite levels show a significant finding. Defenders show much lower fatigue indices that attackers (Irandoust & Taheri, 2014). The trend for defenders (27.66%) vs. raiders (29.84%) is as expected.

C. Relationship Between Aerobic and Anaerobic Capacity:

Table 5: Pearson Correlation Coefficients between VO₂max and Anaerobic Parameters

Group	Variable Pair	r	p-value	Interpretation
Raiders (n=15)	VO ₂ max vs Peak Power	0.24	0.396	Non-significant
	VO ₂ max vs Avg Power	0.31	0.267	Non-significant
	VO ₂ max vs Fatigue Index	-0.28	0.316	Non-significant
Defenders (n=15)	VO ₂ max vs Peak Power	0.18	0.522	Non-significant
	VO ₂ max vs Avg Power	0.22	0.438	Non-significant
	VO ₂ max vs Fatigue Index	-0.35	0.201	Non-significant

There were weak to moderate correlations for all aerobic-anaerobic parameters which were non-significant (r range: -0.35 to 0.31; all $p > 0.05$), suggesting that these qualities are fairly independent in university-level kabaddi players.

A plausible explanation for the negative behavior of VO₂ max and fatigue index ($r = -0.35$ in defenders) is the potential impact of better aerobic capacity on a team player's recovery between sprints. The

quicker recovery makes it easier to maintain power throughout the playing period.

D. Hypothesis Testing Summary:

Table 6: Summary of Hypothesis Testing

Results		
H	Statement	Result
H ₁	Significant difference in aerobic capacity between raiders and defenders	Accepted (p = 0.0004)
H ₂	There is significant difference between raiders and defenders in anaerobic capacity	Partially Accepted - Peak Power (p=0.008) and Average Power (p=0.014) were significant, whereas Minimum Power (p=0.074) and Fatigue Index (p=0.251) were not significant.
H ₃	No significant correlations were found for aerobic and anaerobic capacity within groups	Rejected — All correlations non-significant (p > 0.05)

V. CONCLUSION

Physiological profiles of raiders and defenders of university kabaddi players were assessed in the study. The aerobic capacity (VO₂ max: 49.27 vs 43.86 ml/kg/min; p = 0.0004) of defenders is significantly higher to maintain readiness and recover their cardiovascular system to defend several times if needed. Raiders exhibit substantially greater anaerobic peak power (10.24 vs 9.18 W/kg; p = 0.008) and average power (8.76 vs 7.92 W/kg; p = 0.014), demonstrating the explosive nature of repeated offensive raiding.

Fatigue index and minimum power were not different indicating that position specific fatigue resistance profiles are not yet fully developed at university competitive level. There was no inter-correlation between aerobic and anaerobic

capacities, confirming both as independent physiological qualities that require separate and targeted training.

The results support position-specific conditioning, and as such, raiders should primarily develop anaerobic power through plyometric and sprint training while defenders should emphasise aerobic conditioning and sustained work capacity. The physiological standards we established here – raiders: peak power ≥ 10.0 W/kg; defenders: VO₂ max ≥ 48.0 ml/kg/min – may be useful to guide university-level talent identification and position allocation.

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