International Journal of Sport Studies for Health

Journal Homepage

Comparative Analysis of Female Swimmers and Female Para Swimmers: A Deep Dive into Physiological and Psychological Profiles

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A r t i c l e I n f o

Article type:
Original Research

How to cite this article:
Kumar, K., Sharma, M., Poonia, R., Kumar Grover, V., Singh, J., Nutan, & Choudhary, P. (2026). Comparative Analysis of Female Swimmers and Female Para Swimmers: A Deep Dive into Physiological and Psychological Profiles. *International Journal of Sport Studies for Health*, *9*(3), 1-8.
http://dx.doi.org/10.61838/kman.intjssh.5601

A B S T R A C T

Objective: This study aimed to compare selected physiological and psychological characteristics of Indian female competitive swimmers in able-bodied and para-swimming categories.

Methods and Materials: Fifty-two female competitive swimmers participated in the study, including 26 able-bodied swimmers and 26 para-swimmers. Physiological measures included peak expiratory flow rate, breath-holding capacity, vital capacity, and systolic and diastolic blood pressure. Psychological measures included will to win, mental toughness, aggression, and competitive anxiety. A quantitative cross-sectional design was used. Data were analyzed using descriptive statistics, independent-samples t-tests, and effect-size estimates. Given the number of comparisons, the findings were interpreted as exploratory.

Results: Para-swimmers demonstrated a slightly higher will-to-win score than able-bodied swimmers (8.731 ± 1.564 vs. 8.346 ± 1.413). In contrast, able-bodied swimmers reported higher aggression (80.039 ± 14.717 vs. 72.154 ± 13.815), mental toughness (37.269 ± 4.635 vs. 31.885 ± 5.595), and competitive anxiety (19.346 ± 3.006 vs. 16.808 ± 2.482). Differences in mental toughness and competitive anxiety were statistically significant ($p < 0.01$). Able-bodied swimmers also showed higher peak expiratory flow rate (439.423 ± 52.865 vs. 425.385 ± 38.754 L/min), breath-holding capacity (46.977 ± 6.070 vs. 46.314 ± 6.870 s), and vital capacity (3.327 ± 0.250 vs. 3.208 ± 0.170 L), as well as lower systolic blood pressure (125.039 ± 14.081 vs. 130.000 ± 12.202 mm Hg) and diastolic blood pressure (79.077 ± 11.085 vs. 82.846 ± 6.613 mm Hg). Most physiological differences were not statistically significant ($p > 0.05$), although the difference in vital capacity was borderline significant after adjustment for unequal variances ($p = 0.050$).

Conclusion: Physiological and respiratory characteristics were generally comparable between female able-bodied swimmers and para-swimmers. However, significant differences were observed in mental toughness and competitive anxiety. These findings indicate that impairment-related and competitive factors may influence specific psychological characteristics and support the development of tailored, impairment-informed coaching and psychological support programs for female para-swimmers.

Keywords: *Para-Swimming, Peak Expiratory Flow, Systolic Blood Pressure, Will to Win, Mental Toughness*

Article history:
Received 10 January 2026
Revised 17 June 2026
Accepted 24 June 2026
Published online 01 July 2026

1. Introduction

Swimming is one of the primary sports featured in the Olympic and Paralympic Games (1). It is a globally popular sport featuring the second-highest number of Olympic athletes (2). Competitive swimming is a physically and mentally demanding sport, representing a distinct type of exercise from land-based activities due to its unique muscle engagement and breathing patterns (3). It involves almost all the large muscle groups, demanding endurance, strength, coordination, and technical skills [4]. The most important physiological factors determining competitive swimming performance are maximal oxygen uptake (VO2max), muscular endurance, and swimming technique efficiency (4). Furthermore, the hydrodynamic drag and buoyancy of water increase the performance requirements, making swimming a unique sport compared to land-based activities.

Besides physical demands, competitive swimming imposes significant psychological pressure on athletes. Pre-competition anxiety and performance-related stress among swimmers are common phenomena that may negatively impact performance (5). It has been demonstrated that pre-competitive state anxiety affects performance perception and readiness, making the incorporation of mental preparedness and coping strategies crucial in training and competition (5). Therefore, integrating both physical conditioning and mental training into athletes' regimens is essential for achieving optimal swimming performance.

Physiologically, competitive swimming relies on both aerobic and anaerobic energy systems. It requires high cardiovascular fitness and muscular strength, with the contribution of each physiological demand varying across different race distances (6). Body composition also plays a significant role, as an optimal lean body mass coupled with low fat mass contributes to improved propulsion and reduced water resistance.

Psychological variables such as anxiety, motivation, and attribution style are equally important in determining performance. Swimmers frequently experience high levels of anxiety, which are consistently reported to interfere with confidence and competitive performance. Furthermore, motivation and self-efficacy are dependent on how athletes perceive success or failure (4). Consequently, psychological assessment has become a vital component of a competitive athlete's overall profile.

While the visibility and competitive accomplishments of female swimmers have increased, scientific inquiry into this population remains disproportionately scarce, particularly concerning performance parameters and mental health. This deficit is further pronounced by the paucity of evidence-informed research on female para-swimmers, for whom the complex interaction of physical impairment, functional classification, sport-specific technique, and equipment underscores the critical need for quantitative investigations. Existing literature has insufficiently addressed the physiological and psychological aspects of female swimming and largely neglects the specific performances of para-athletes within this domain. Investigations in these areas are urgently needed to encourage and create equitable, safe, and optimized training environments. Such research provides the empirical evidence necessary to develop gender-specific and impairment-informed coaching strategies.

Para-swimming has evolved into a highly organized and competitive sport that utilizes standard classification systems based on functional ability to ensure fair competition. Because stroke mechanics, physiological responses to training, and performance outcomes are significantly affected by specific physical impairments, personalized training methods are strictly required. Researchers also note that para-swimmers are prone to unique psychological stressors in both daily life and competition, necessitating specialized mental preparation strategies.

However, despite growing research interest over the years, there remains a notable lack of comparative research investigating the integration of physiological and psychological parameters between female able-bodied swimmers and female para-swimmers. Therefore, the present research seeks to compare selected physiological and psychological variables between national-level female able-bodied swimmers and para-swimmers. This will help fill the existing gaps in the literature by offering evidence-based information in terms of educating the training design, athletes' development, and psychological support systems.

2. Methods and Materials

A comparative cross-sectional research design was employed to systematically investigate and compare the physiological and psychological attributes of female competitive swimmers. In this study, senior national-level female swimmers representing both able-bodied and para-swimming categories were recruited based on strictly defined inclusion criteria to ensure sample homogeneity (7).

Data collection was conducted at two premier national-level competitive swimming events in India: the 2nd Odisha National Swimming Championship and the XXIII National Para Swimming Championship, held between April and June 2024. These venues were selected due to the congregation of national-level athletes. To minimize contextual bias between the two events, both competitions were held in 50-meter Olympic-standard indoor pools with comparable environmental conditions, and all measurements were administered by the exact same research team utilizing standardized protocols 24 to 48 hours prior to the athletes' primary events.

2.1 Participants

Participants were selected using a purposive sampling method based on their qualification and participation in the aforementioned national-level events. "National-level" was operationally defined as athletes who had achieved the minimum qualifying standards set by the Swimming Federation of India (SFI) or the Paralympic Committee of India (PCI) and had a minimum of three years of competitive racing experience at the state or national level. A total of 52 competitive female swimmers participated in the study, comprising 26 able-bodied swimmers and 26 para-swimmers. All participants provided written informed consent prior to data collection in accordance with the Declaration of Helsinki. The participants' ages ranged from 18 to 27 years. While basic demographic and competitive eligibility were confirmed, detailed anthropometric measurements and specific impairment classifications were not systematically recorded during the competition period, which is acknowledged as a methodological limitation.

2.2 Data Collection: Psychological Assessment

The assessment protocol examined specific physiological and psychological factors hypothesized to influence competitive swimming performance. All psychological questionnaires were administered in English (the standard language of competition briefing), which was comprehended by all participants, and were completed in a quiet environment at the competition venue. Specifically, four psychological variables were operationalized and measured:

(1) The Will to Win Questionnaire (8) was utilized to evaluate achievement motivation and competitive drive. The scale yields a total score ranging from 0 to 14, where higher scores indicate a stronger desire for competitive victory. The instrument's internal consistency in this study was robust (Cronbach's alpha = 0.82).

(2) The Buss-Perry Aggression Questionnaire (BPAQ; 29 items) (9) was employed to measure aggressive dispositions across four dimensions: physical aggression, verbal aggression, anger, and hostility. Responses are scored on a 5-point Likert scale (total score range: 29–145), with higher scores reflecting greater trait aggression (Cronbach's alpha = 0.85).

(3) The Sports Mental Toughness Questionnaire (SMTQ; 14 items) (10) was used to assess mental resilience, confidence, and the ability to perform under pressure. Scores range from 14 to 56, where higher scores indicate superior mental toughness (Cronbach's alpha = 0.79).

(4) The Sports Competition Anxiety Test (SCAT) (11) was utilized to assess competitive trait anxiety, specifically the tendency to perceive competitive situations as threatening. The 15-item inventory yields scores from 10 to 30; scores below 17 indicate low anxiety, 17–24 indicate average anxiety, and above 24 indicate high anxiety (Cronbach's alpha = 0.88).

Concerning physiological assessments, four variables were measured using calibrated biological instruments and standardized testing procedures, conducted during the morning hours (08:00–10:00) to control for diurnal variations.

(1) Peak expiratory flow rate (PEFR), a measure of respiratory functioning, was measured using a certified digital peak-flow meter. Participants performed three maximal forced expirations from a standing position, with the highest value recorded in liters per minute (L/min).

(2) Breath-holding capacity, indicative of hypoxic tolerance and respiratory control, was measured using a digital stopwatch. Participants performed a maximal inspiration followed by voluntary apnea, and the maximum duration was recorded in seconds.

(3) Vital capacity, the maximum volume of air exhaled following a maximal inhalation, was determined using a calibrated digital spirometer. The best of three trials was recorded in liters (L).

(4) Systolic and diastolic blood pressure were measured using a validated automated digital sphygmomanometer. Participants rested in a seated position for five minutes prior to measurement, and the average of two readings taken two minutes apart was recorded in mm Hg to ensure accuracy.

2.3 Statistical Analysis

Descriptive statistics (mean ± standard deviation) were calculated for all psychological and physiological variables. To compare the parameters between able-bodied swimmers and para-swimmers, independent samples t-tests were conducted using SPSS version 20.0. Levene's test was used to assess the assumption of homogeneity of variances; where this assumption was violated, the Welch t-test (equal variances not assumed) was interpreted. The nominal statistical significance level was set at $p < 0.05$. To control for the increased risk of Type I error associated with multiple comparisons, a Holm-Bonferroni sequential correction was applied to the psychological and physiological variables. Furthermore, to evaluate the practical significance of the differences, Cohen's d effect sizes and 95% confidence intervals (CI) for the mean differences were calculated. Effect sizes were interpreted as small (d = 0.2), medium (d = 0.5), and large (d = 0.8).

3. Results

Independent samples t-tests were conducted to analyze the differences in selected psychological and physiological parameters between female able-bodied swimmers and para-swimmers (Tables 1 and 2). Levene's test was utilized to assess the homogeneity of variances, determining whether to interpret the standard independent t-test or the Welch t-test (equal variances not assumed).

Table 1. Descriptive Statistics of Psychological and Physiological Parameters of Female Able-Bodied Swimmers and Para-Swimmers

Parameter	Swimmer Category	N	Mean	(SD)
Psychological Variables				
Will to Win	Able-Bodied Swimmers	26	8.346	1.413
	Para-Swimmers	26	8.731	1.564
Aggression	Able-Bodied Swimmers	26	80.039	14.717
	Para-Swimmers	26	72.154	13.815
Mental Toughness	Able-Bodied Swimmers	26	37.269	4.635
	Para-Swimmers	26	31.885	5.595
Competitive Anxiety (SCAT)	Able-Bodied Swimmers	26	19.346	3.006
	Para-Swimmers	26	16.808	2.482
Physiological Variables				
Peak Expiratory Flow (L/min)	Able-Bodied Swimmers	26	439.423	52.865
	Para-Swimmers	26	425.385	38.754
Breath Holding Time (s)	Able-Bodied Swimmers	26	46.977	6.07
	Para-Swimmers	26	46.314	6.87
Vital Capacity (L)	Able-Bodied Swimmers	26	3.327	0.25
	Para-Swimmers	26	3.208	0.17
BP Systolic (mm Hg)	Able-Bodied Swimmers	26	125.039	14.081
	Para-Swimmers	26	130	12.202
BP Diastolic (mm Hg)	Able-Bodied Swimmers	26	79.077	11.085
	Para-Swimmers	26	82.846	6.613

For psychological parameters, able-bodied swimmers demonstrated significantly higher scores in Mental Toughness ($p < 0.001$, Cohen's $d = 1.05$) and Competitive Anxiety (SCAT; $p = 0.002$, Cohen's $d = 0.92$) compared to para-swimmers (Table 2). Both findings exhibited large effect sizes and remained statistically significant following a Holm-Bonferroni correction for multiple comparisons. Conversely, para-swimmers exhibited slightly higher mean scores for the Will to Win ($p = 0.357$), and able-bodied swimmers scored higher in Aggression ($p = 0.052$), though neither reached statistical significance (Table 1 and Table 2).

Table 2. Independent Samples t-test Comparing Psychological and Physiological Parameters

Parameter	Mean Difference	95% CI of Difference	t	df	*p-value*	Cohen's d
Psychological						
Will to Win	-0.385	[-1.215, 0.445]	-0.931	50	0.356	-0.26 (Small)
Aggression	7.885	[-0.070, 15.840]	1.992	50	0.052	0.55 (Moderate)
Mental Toughness	5.385	[2.523, 8.247]	3.779	50	< 0.001*	1.05 (Large)
SCAT (Anxiety)	2.539	[1.003, 4.075]	3.32	50	0.002*	0.92 (Large)
Physiological						
Peak Expiratory Flow (L/min)	14.039	[-11.788, 39.866]	1.092	50	0.28	0.30 (Small)
Breath Holding Time (s)	0.664	[-2.951, 4.279]	0.369	50	0.714	0.10 (Small)
Vital Capacity (L)†	0.119	[0.001, 0.237]	2.018	44.07	0.05	0.56 (Moderate)
BP Systolic (mm Hg)	-4.962	[-12.300, 2.376]	-1.358	50	0.181	-0.38 (Small)
BP Diastolic (mm Hg)†	-3.769	[-8.884, 1.346]	-1.489	40.8	0.144	-0.41 (Small)

Abbreviations: *CI, Confidence Interval; df, degrees of freedom; SCAT, Sports Competition Anxiety Test; BP, Blood Pressure. * Indicates statistical significance remaining after Holm-Bonferroni correction ($p < 0.05$). † Welch t-test interpreted (equal variances not assumed) due to significant Levene's test.*

Physiologically, able-bodied swimmers exhibited slightly higher mean values for Peak Expiratory Flow and Breath Holding Time, while Systolic and Diastolic blood pressures were marginally higher in para-swimmers (Table 1); however, none of these baseline cardiovascular or respiratory differences were statistically significant ($p > 0.05$) and effect sizes were generally small (Table 2).

Notably, Levene's test for Vital Capacity was significant ($p = 0.029$), prompting the use of the Welch t-test, which revealed a borderline difference in Vital Capacity between the cohorts (mean difference = 0.119 L, $p = 0.050$, Cohen's $d = 0.56$) (Table 2). While indicating a moderate effect size, this finding must be interpreted cautiously as a borderline difference rather than definitively significant, particularly when accounting for exploratory multiple comparisons.

4. Discussion and Conclusion

This study systematically investigated the physiological and psychological parameters differentiating female able-bodied swimmers from female para-swimmers. Our findings challenge deficit-based models of disability by demonstrating that physiological capacities are largely comparable between the cohorts, whereas significant divergences exist within specific psychological domains. Regarding psychological profiles, able-bodied swimmers exhibited significantly higher mental toughness and competitive trait anxiety compared to para-swimmers. Notably, the 'will to win' was marginally higher in para-swimmers, indicating that achievement motivation transcends physical impairment and functional classification.

The significantly higher competitive anxiety observed in the able-bodied cohort contrasts with some previous literature but may reflect differences in competitive density or environmental pressures specific to able-bodied national championships. Szájer et al. (12) previously identified that able-bodied Olympic swimmers scored higher on self-confidence and freedom from worry compared to Paralympic peers. Our finding of lower mental toughness in para-swimmers aligns with this, suggesting that athletes with impairments navigate unique psychological challenges and stressors that require specialized mental preparation (13). Consequently, targeted psychological interventions focusing on volitional control, anxiety management, and resilience are essential for para-athletes (4, 14).

Physiologically, the two cohorts demonstrated remarkable comparability. Baseline cardiovascular parameters (systolic and diastolic blood pressure) showed no significant differences; importantly, the slightly higher blood pressure averages in para-swimmers should be interpreted as natural physiological variances rather than indicators of superior or inferior performance. Respiratory parameters, including peak expiratory flow and breath-holding time, were also statistically similar. While vital capacity presented a borderline significant difference ($p = 0.050$) favoring able-bodied swimmers, the overall

physiological parity indicates that specialized swim training elicits robust, comparable cardiopulmonary adaptations regardless of physical impairment (15-20). These psychophysiological profiles underscore the critical role of impairment type and functional classification in shaping athletic development. Because stroke mechanics and training responses are directly influenced by anatomical constraints, coaching frameworks must evolve beyond generalized programs. Implementing impairment-informed coaching strategies—integrating individualized biomechanical adjustments with mental visualization and stress reduction—can profoundly enhance both competitive performance and emotional well-being in para-swimmers (21-24).

This study possesses several methodological limitations that warrant consideration. First, the relatively small sample size (n = 52) and reliance on purposive sampling limit the broader generalizability of the findings and reduce the statistical power needed to detect small effect sizes. Second, while para-swimming classifications were documented, the inherent heterogeneity of physical impairments within the para-swimmer cohort complicates direct comparisons, as different disabilities impart distinct physiological constraints. Third, although contextual bias was minimized through environmental matching, data were collected across two distinct national championships, which may subtly influence psychological states like pre-competitive anxiety. Fourth, the cross-sectional design precludes any causal inferences regarding long-term training adaptations. Finally, the absence of actual swimming performance indicators (e.g., race times, personal best records, or rankings) limits the ability to correlate these psychophysiological profiles directly with competitive success. Future research should employ longitudinal designs, larger samples matched for specific impairment classes, and direct performance metrics to further elucidate these relationships.

4.1 Limitations

This study possesses several methodological limitations that warrant consideration. First, the relatively small sample size (n = 52) and reliance on purposive sampling limit the broader generalizability of the findings and reduce the statistical power needed to detect small effect sizes. Second, because the primary scope of this study was focused strictly on psychological and basic cardiopulmonary parameters, detailed anthropometric data (e.g., exact height, body mass, training volume) and specific para-swimming classifications (impairment type and functional class) were not systematically recorded during the competition period. Because physiological and psychological variables can be influenced by the type and severity of impairment, the inherent heterogeneity within the para-swimmer cohort complicates direct comparisons. Third, although contextual bias was minimized through environmental matching, data were collected across two distinct national championships, which may subtly influence psychological states like pre-competitive anxiety. Fourth, the cross-sectional design precludes any causal inferences regarding long-term training adaptations. Finally, the absence of actual swimming performance indicators (e.g., race times, personal best records) limits the ability to correlate these psychophysiological profiles directly with competitive success. Future research should employ longitudinal designs, larger samples matched for specific impairment classes, and direct performance metrics.

5. Conclusion

In conclusion, this comparative analysis reveals that female able-bodied swimmers and para-swimmers possess highly comparable baseline physiological capacities, effectively challenging deficit-based models of disability in sport. However, significant differences emerged within their psychological profiles, specifically regarding mental toughness and competitive trait anxiety, which were higher in the able-bodied cohort. The assertion that able-bodied athletes performed uniformly "better" is entirely unsupported by the data, particularly given the marginally higher achievement motivation observed in para-swimmers and the statistical equivalence across most cardiovascular and respiratory metrics. Ultimately, these findings suggest that while cardiovascular and respiratory adaptations to elite swimming are robust across both groups, psychological demands are uniquely shaped by functional impairments and specific competitive contexts. Future training frameworks should prioritize impairment-informed psychological support and highly individualized coaching strategies to optimize both performance and well-being for female para-swimmers.

Authors' Contributions

All authors equally contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data sharing is available upon request from the corresponding author.

Acknowledgments

We thank everyone for their participation in this study.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethical Considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki for research involving human participants. Ethical approval was obtained from all individuals Prior to participation, the (Ethics Approval No. 04/2024/PES/1098). All Individuals were informed about the purpose and procedures of the study, and written informed consent was obtained from each participant. Participation was voluntary, and participants were assured of their right to withdraw from the study at any stage without any consequences. The confidentiality and anonymity of all participants were strictly maintained throughout the data..

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