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Comparison of Cardiorespiratory Endurance between Kathak Dancers and Non-Dancers

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Abstract

Background: Physical inactivity among young adult collegiate women contributes to early cardiorespiratory deconditioning, and there is interest in culturally familiar movement practices that may sustain aerobic fitness. Kathak, a North Indian classical dance form built on sustained rhythmic footwork and rapid spins, has received little quantitative physiological study. This investigation compared estimated maximal oxygen uptake and resting hemodynamic indices between trained female Kathak dancers and sedentary non-dancers.

Methods: A comparative, observational, cross-sectional study was conducted on 30 female participants aged 19 to 26 years, allocated to a Kathak dancer group (n = 15, minimum 3 years of continuous training) and an age-matched sedentary control group (n = 15). Maximal oxygen uptake (VO_2 max) was estimated from the 3-minute Queen's College Step Test using the McArdle regression equation for women. Resting heart rate, systolic blood pressure and diastolic blood pressure were recorded under standardised laboratory conditions. Between-group differences were examined using independent samples t-tests, with Mann-Whitney U tests and Cohen's d reported alongside.

Results: The two groups were statistically comparable in age, height, body mass and body mass index (all $p > 0.05$). Kathak dancers recorded a higher mean estimated VO_2 max than non-dancers (41.33 ± 0.83 versus 35.03 ± 0.82 ml/kg/min; mean difference 6.30 ml/kg/min, 95% confidence interval 5.69 to 6.92; $t(28) = 20.849$, $p < 0.0001$), an advantage of 18.0%. Dancers also showed a lower resting heart rate (71.00 ± 2.07 versus 82.13 ± 2.03 bpm, $p < 0.0001$) and a lower post-exercise recovery heart rate (132.53 ± 4.50 versus 166.67 ± 4.45 bpm, $p < 0.0001$). Systolic blood pressure did not differ significantly ($p = 0.460$). All 15 non-dancers fell in the Below Average normative band, whereas all 15 dancers reached Average (73.3%) or Above Average (26.7%). Within the dancer group, years of training did not correlate significantly with VO_2 max ($r = -0.418$, $p = 0.121$).

Conclusion: Regular Kathak practice was associated with substantially higher estimated aerobic capacity and a more favourable resting and post-exercise heart rate profile than a sedentary lifestyle in young adult women. Kathak appears to be a culturally acceptable movement modality worth considering within community and collegiate fitness programmes, although the cross-sectional design does not permit causal inference and the step test provides an indirect estimate only.

Keywords: Cardiorespiratory Endurance, Kathak Dance, Maximal Oxygen Uptake, Queen's College Step Test, Resting Heart Rate, Recovery Heart Rate, Physical Inactivity

1. Introduction

Cardiorespiratory endurance is the combined capacity of the pulmonary, cardiovascular and muscular systems to take up, transport and use oxygen during prolonged physical work. It is quantified most directly by maximal oxygen uptake (VO_2 max), expressed in millilitres of oxygen consumed per kilogram of body mass per minute, and it depends on pulmonary gas exchange, cardiac output, the oxygen-carrying capacity of blood, capillary density in working muscle and mitochondrial oxidative capacity [1, 11]. Because it integrates so many systems, VO_2 max is widely treated as a functional marker of general health and is used by physiotherapists to guide exercise prescription and to monitor progress during rehabilitation.

Reduced physical activity has become common among collegiate populations. Extended sitting, heavy academic schedules and reduced recreational movement are associated with lower stroke volume, higher resting heart rate, reduced aerobic capacity and disuse changes in skeletal muscle. Young women appear to be particularly affected, and conventional gymnasium-based programmes often show poor long-term adherence in this group. There is therefore a practical need to evaluate structured physical activities that are already familiar and culturally embedded, since these may be sustained over years rather than weeks [11, 17].

Kathak is a North Indian classical dance form characterised by fast rhythmic foot stamping (Tatkar), rapid pirouettes (Chakkars), narrative gesture work (Abhinaya) and alternation between slow and fast rhythmic cycles. The repeated plantar flexion and dorsiflexion of Tatkar loads the triceps surae and quadriceps and engages the peripheral skeletal muscle pump, which assists venous return; and the alternation of tempo across rhythmic cycles produces a pattern of work and relative recovery that resembles interval conditioning [11, 15]. These features suggest that habitual Kathak practice may generate a meaningful aerobic training stimulus, but the proposition has not been examined widely in quantitative terms.

Existing physiological work on Indian classical dance has concentrated on Bharatanatyam. Higher cardiovascular endurance has been reported in Bharatanatyam dancers relative to non-dancers [4], and comparable aerobic capacity has been found between Bharatanatyam and Kuchipudi practitioners [8]. Studies that include Kathak are far fewer. Aerobic capacity has been compared between Bharatanatyam and Kathak dancers using the Queen's College Step Test [5], and pulmonary function, peak oxygen uptake and respiratory muscle strength have been compared between Bharatanatyam dancers, Kathak dancers and age-matched controls [6]. Other Kathak-specific work has addressed body composition [13], health-related fitness components and adiposity [14], and musculoskeletal injury risk [15], rather than maximal aerobic power and resting autonomic indices together. Direct comparison of Kathak practitioners against a genuinely sedentary control group, with both aerobic capacity and resting hemodynamics reported, therefore remains sparse.

The present study was undertaken to compare estimated VO_2 max and resting hemodynamic indices between trained female Kathak dancers and healthy sedentary non-dancers of the same age range. It was hypothesised that Kathak dancers would demonstrate higher estimated VO_2 max, lower resting heart rate and lower post-exercise recovery heart rate than sedentary peers.

2. Materials and Methods

2.1 Study Design and Setting

A comparative, observational, cross-sectional study was carried out in the exercise physiology and fitness testing laboratory of TMV's Indutai Tilak College of Physiotherapy, Pune, Maharashtra, India. Testing conditions were standardised throughout data collection, with ambient temperature maintained between

22 °C and 25 °C and relative humidity between 45% and 55%, in order to limit thermoregulatory drift in heart rate.

2.2 Participants and Sampling

Thirty female participants were recruited by purposive sampling and allocated to two groups of equal size.

- Group A (Kathak dancers, n = 15): healthy women with a verified history of at least 3 years of continuous classical Kathak training, practising a minimum of 2 structured sessions per week amounting to at least 120 minutes of weekly practice.
- Group B (sedentary non-dancers, n = 15): healthy women of the same age range reporting no participation in structured sport, recreational athletics, gymnasium conditioning or dance training, and reporting more than 6 hours of sitting per day.

2.3 Eligibility Criteria

Women aged 18 to 30 years who met the group-specific activity definitions, whose body mass index fell within the normal range of 18.5 to 24.9 kg/m^2, and who were medically cleared for submaximal exercise testing were eligible for inclusion. Participants were excluded for any of the following:

- Documented congenital or acquired cardiovascular disease, bronchial asthma or other chronic respiratory disorder.
- Musculoskeletal injury, joint pathology or lower limb injury within the preceding 6 months.
- Any major surgical procedure within the preceding 6 months.
- Current use of medication affecting autonomic tone, vascular resistance or heart rate response, such as beta blockers, sympathomimetic bronchodilators or sedatives.
- Current smoking, or acute illness reported on the day of testing.
- Unwillingness to provide written informed consent.

2.4 Ethical Considerations

Ethical clearance was granted by the Institutional Ethics Committee of TMV's Indutai Tilak College of Physiotherapy, Pune. The aims, procedures, expected sensations of exertion and confidentiality arrangements were explained to every participant in written and verbal form, and written informed consent was obtained before testing. Participants were identified by numeric codes only. The study was conducted in accordance with the principles of the Declaration of Helsinki.

2.5 Instrumentation

- A rigid wooden stepping platform of 16.25 inches (41.3 cm) in height, as specified for the Queen's College Step Test.
- An acoustic metronome set to 88 beats per minute, producing 22 complete stepping cycles per minute for female testing.
- A digital stopwatch reading to 0.01 second, used to time the 3-minute stepping bout and the recovery counting window.
- A calibrated aneroid sphygmomanometer and stethoscope for auscultatory blood pressure measurement.
- A wall-mounted stadiometer accurate to 0.1 cm and a digital beam balance accurate to 0.1 kg.

2.6 Experimental Protocol

Participants were asked to avoid vigorous exercise, caffeine and alcohol for at least 24 hours before testing. All testing was carried out during morning hours, at least 2 hours after a light meal.

On arrival, each participant rested quietly in a seated position for 15 minutes. Resting heart rate was then obtained by palpation of the radial pulse over a full 60 seconds. Resting systolic and diastolic blood pressure were recorded in the left upper limb, using Korotkoff phase I for systolic and phase V for diastolic pressure. Height and body mass were measured and body mass index was calculated.

Aerobic capacity was assessed with the Queen's College Step Test [1]. Each participant received a demonstration and a short familiarisation period with the four-count stepping pattern of up, up, down, down. Cadence was fixed at 22 complete cycles per minute using the metronome set to 88 beats per minute, and stepping continued without interruption for exactly 3 minutes. Testing was supervised throughout, and predefined criteria for stopping the test early were marked breathlessness, light-headedness, loss of cadence or participant request.

At the end of the 3-minute bout the participant stopped immediately and remained standing. After a 5-second pause, the radial pulse was counted for 15 seconds, that is, from the fifth to the twentieth second of recovery. This 15-second count was multiplied by 4 to obtain the 1-minute equivalent recovery heart rate in beats per minute.

2.7 Estimation of Maximal Oxygen Uptake

Maximal oxygen uptake was estimated from the recovery heart rate using the regression equation established by McArdle and colleagues for women [1]:

VO_2 max (ml/kg/min) = 65.81 − (0.1847 × recovery heart rate in bpm)(1)

2.8 Normative Classification

Individual estimated VO_2 max values were classified against published normative bands for women aged 18 to 25 years: Very Poor below 28.0 ml/kg/min, Poor 28.0 to 32.9, Below Average 33.0 to 37.9, Average 38.0 to 41.9, Above Average 42.0 to 46.9, Good 47.0 to 56.0 and Excellent above 56.0 ml/kg/min.

2.9 Statistical Analysis

Data were compiled in an electronic database and analysed using standard statistical software. Continuous variables were summarised as mean, standard deviation, median, interquartile range and range. Normality was assessed with the Shapiro-Wilk test and homogeneity of variance with Levene's test. Between-group comparisons used the two-tailed independent samples t-test with 28 degrees of freedom, with Welch's correction applied where variances were unequal. The Mann-Whitney U test was run in parallel as a non-parametric check. Effect size was expressed as Cohen's d. Categorical fitness classifications were cross-tabulated and expressed as proportions. Pearson correlation coefficients were computed within the dancer group to examine the association between training exposure and cardiorespiratory measures. Statistical significance was set a priori at $p < 0.05$, with two-sided 95% confidence intervals. No correction for multiple comparisons was applied to the secondary outcomes, and the secondary p-values should therefore be read as exploratory.

3. Results

3.1 Baseline Demographic and Anthropometric Characteristics

All 30 recruited participants completed the protocol, and no test was terminated early. Baseline characteristics are presented in Table 1.

Table 1: Baseline Demographic and Anthropometric Characteristics of Participants (N = 30)

Parameter	Kathak dancers (n = 15) Mean ± SD (range)	Non-dancers (n = 15) Mean ± SD (range)	Mean difference (95% CI)	t (df = 28)	p	Interpretation
Age (years)	23.80 ± 2.24 (19 to 26)	22.93 ± 0.80 (22 to 24)	0.87 (-0.39 to 2.13)	1.410	0.170	Comparable
Height (cm)	161.07 ± 4.25 (150 to 166)	158.47 ± 4.02 (152 to 166)	2.60 (-0.49 to 5.69)	1.722	0.096	Comparable
Weight (kg)	57.00 ± 6.56 (45 to 65)	57.60 ± 3.20 (52 to 65)	-0.60 (-4.46 to 3.26)	-0.318	0.753	Comparable
Body mass index (kg/m^2)	21.93 ± 2.04 (18.03 to 26.37)	22.94 ± 1.16 (20.58 to 25.10)	-1.01 (-2.25 to 0.23)	-1.666	0.107	Comparable

Values are mean ± standard deviation with range in parentheses; two-tailed independent samples t-test; $p < 0.05$ indicates statistical significance.

Mean age was 23.80 ± 2.24 years in dancers and 22.93 ± 0.80 years in non-dancers (t = 1.410, p = 0.170). Height, body mass and body mass index likewise did not differ significantly between the groups. Group mean body mass index values, 21.93 ± 2.04 kg/m^2 and 22.94 ± 1.16 kg/m^2, both fell within the normal range for Asian women. Body size and stature can therefore be regarded as reasonably controlled between groups, which matters here because the stepping workload of the Queen's College Step Test is imposed against body mass.

3.2 Primary Outcome: Estimated Maximal Oxygen Uptake

Table 2: Comparison of Estimated Maximal Oxygen Uptake between Groups (N = 30)

Group	n	Mean VO_2 max (ml/kg/min)	SD	Median (IQR)	Range (min to max)	t (df = 28)	p	Cohen's d
Kathak dancers	15	41.33	0.83	41.43 (1.11)	39.95 to 42.91	20.849	< 0.0001	7.613
Non-dancers	15	35.03	0.82	34.78 (0.74)	33.30 to 36.26			

Shapiro-Wilk test for normality: dancers p = 0.276, non-dancers p = 0.235. Levene's test for equality of variances: F = 0.058, p = 0.812. Non-parametric confirmation by Mann-Whitney U test: U = 225.0, $p < 0.0001$.

Kathak dancers achieved a mean estimated VO_2 max of 41.33 ± 0.83 ml/kg/min and non-dancers 35.03 ± 0.82 ml/kg/min. The absolute difference was 6.30 ml/kg/min (95% confidence interval 5.69 to 6.92 ml/kg/min), corresponding to a relative advantage of 18.0% in the dancer group. The difference was statistically significant (t(28) = 20.849, $p < 0.0001$), and the non-parametric Mann-Whitney U test gave the same conclusion (U = 225.0, $p < 0.0001$). A U value of 225.0 is the maximum obtainable for two groups of 15, and therefore indicates that every dancer scored above every non-dancer. This is visible in the raw values: the lowest dancer score, 39.95 ml/kg/min, exceeded the highest non-dancer score, 36.26 ml/kg/min. The mean difference is illustrated in Figure 1 and the individual distributions in Figure 2.

Figure 1: Comparison of Estimated Maximal Oxygen Uptake between Kathak Dancers and Non-Dancers

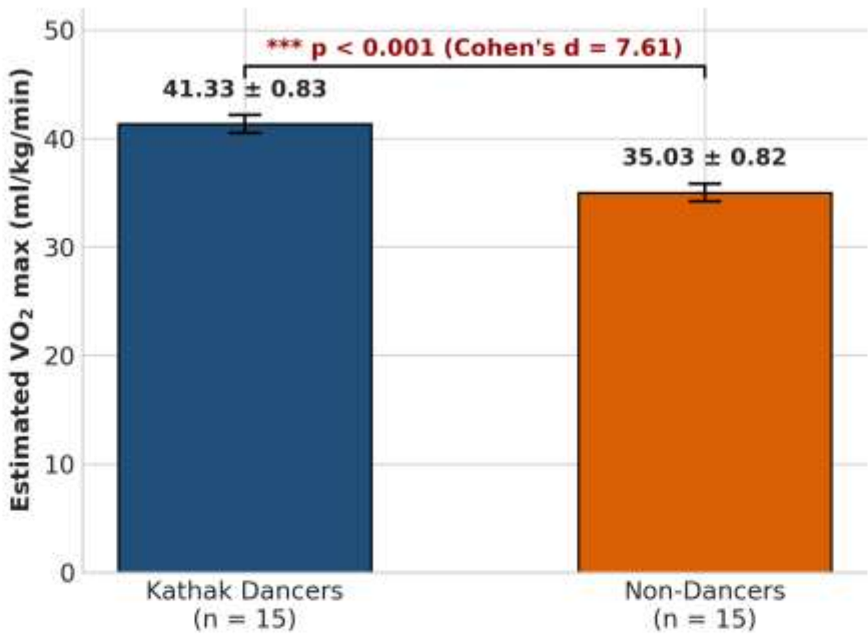


Figure 2: Individual Distribution of Estimated Maximal Oxygen Uptake in Both Groups

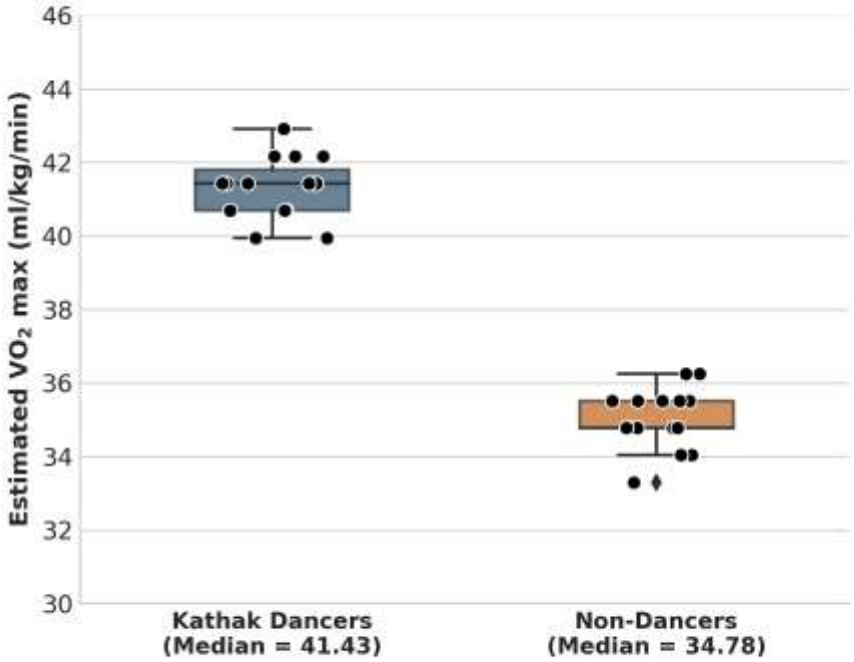


Figure 2 shows that the two distributions do not overlap and that within-group scatter was narrow in both groups. Median values were 41.43 ml/kg/min for dancers and 34.78 ml/kg/min for non-dancers.

3.3 Secondary Outcomes: Resting Hemodynamics and Recovery Heart Rate

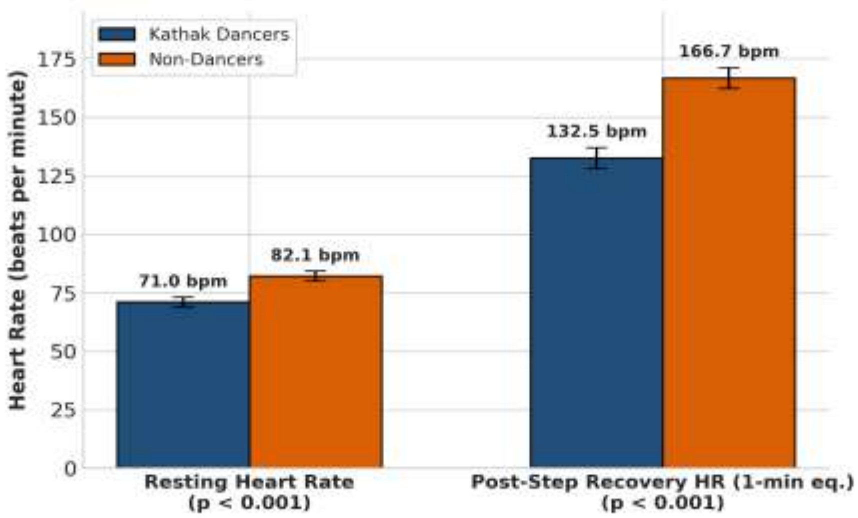
Table 3: Comparison of Resting Hemodynamics and Post-Exercise Recovery Metrics (N = 30)

Parameter	Kathak dancers (n = 15) Mean ± SD	Non-dancers (n = 15) Mean ± SD	Difference	t (df = 28)	p	Cohen's d
Resting heart rate (bpm)	71.00 ± 2.07	82.13 ± 2.03	-11.13	-14.869	< 0.0001	-5.429
15-second post-step pulse (beats)	33.13 ± 1.13	41.67 ± 1.11	-8.53	-20.882	< 0.0001	-7.625
Post-step recovery heart rate (bpm)	132.53 ± 4.50	166.67 ± 4.45	-34.13	-20.882	< 0.0001	-7.625
Systolic blood pressure (mmHg)	124.00 ± 6.63	128.67 ± 23.21	-4.67	-0.749	0.460	-0.273
Diastolic blood pressure (mmHg)	83.47 ± 5.97	79.33 ± 4.51	+4.13	2.138	0.041	0.781

Values are mean ± standard deviation; independent samples t-test; p < 0.05 indicates statistical significance. The 15-second post-step pulse and the post-step recovery heart rate are the same measurement expressed on two scales, and their test statistics are therefore identical.

Resting heart rate was lower in dancers than in non-dancers, 71.00 ± 2.07 bpm against 82.13 ± 2.03 bpm, a mean difference of 11.13 bpm (t = -14.869, p < 0.0001). After the 3-minute stepping bout, dancers recorded 33.13 ± 1.13 beats over the 15-second counting window, equivalent to 132.53 ± 4.50 bpm, whereas non-dancers recorded 41.67 ± 1.11 beats, equivalent to 166.67 ± 4.45 bpm. The difference of 34.13 bpm was statistically significant (t = -20.882, p < 0.0001). These findings are summarised in Figure 3.

Figure 3: Resting Heart Rate and Post-Exercise Recovery Heart Rate in Both Groups



Resting systolic blood pressure did not differ significantly between the groups (124.00 ± 6.63 mmHg against 128.67 ± 23.21 mmHg; $t = -0.749$, $p = 0.460$). Variability was much greater in the non-dancer group, and this dispersion was traced to two participants who presented with markedly raised pre-test systolic readings. Resting diastolic blood pressure was slightly higher in dancers than in non-dancers (83.47 ± 5.97 mmHg against 79.33 ± 4.51 mmHg; $t = 2.138$, $p = 0.041$), with both group means remaining inside conventional normotensive limits.

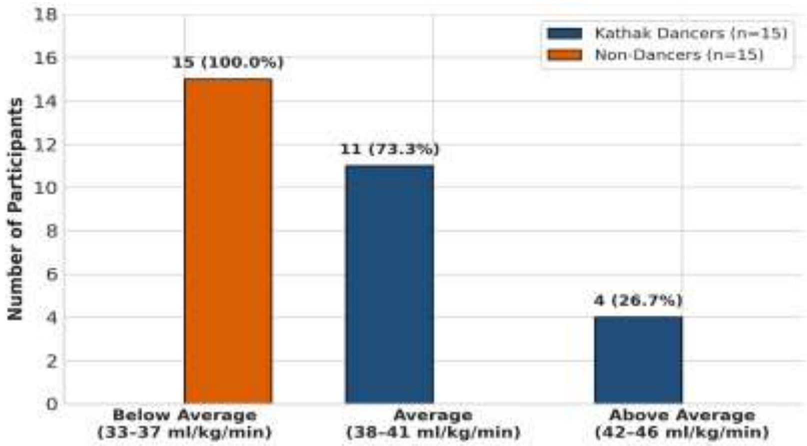
3.4 Normative Fitness Stratification

Table 4: Distribution of Participants across Normative Fitness Bands (N = 30)

Normative rating	VO_2 max range (ml/kg/min)	Kathak dancers (n = 15)	Non-dancers (n = 15)	Whole sample (N = 30)	Percentage of sample
Very Poor	Below 28.0	0 (0.0%)	0 (0.0%)	0	0.0%
Poor	28.0 to 32.9	0 (0.0%)	0 (0.0%)	0	0.0%
Below Average	33.0 to 37.9	0 (0.0%)	15 (100.0%)	15	50.0%
Average	38.0 to 41.9	11 (73.3%)	0 (0.0%)	11	36.7%
Above Average	42.0 to 46.9	4 (26.7%)	0 (0.0%)	4	13.3%
Good	47.0 to 56.0	0 (0.0%)	0 (0.0%)	0	0.0%
Excellent	Above 56.0	0 (0.0%)	0 (0.0%)	0	0.0%
Total		15 (100.0%)	15 (100.0%)	30	100.0%

Categorical classification separated the two groups completely. Every non-dancer, 15 of 15, fell in the Below Average band of 33.0 to 37.9 ml/kg/min. Every dancer reached or exceeded the Average band: 11 of 15 (73.3%) were classified as Average and 4 of 15 (26.7%) as Above Average. No participant in either group reached the Good or Excellent bands, and no participant fell into the Poor or Very Poor bands. The distribution is shown in Figure 4.

Figure 4: Stratification of Participants by Normative Maximal Oxygen Uptake Band



3.5 Training Exposure and Correlation Analysis

Table 5: Kathak Training Characteristics within the Dancer Group (n = 15)

Training variable	Mean ± SD	Range
Duration of training (years)	7.20 ± 2.37	4 to 11
Practice frequency (days per week)	2.07 ± 0.26	2 to 3
Session duration (minutes)	98.67 ± 25.60	60 to 160
Weekly training volume (minutes per week)	204.00 ± 56.67	120 to 320

Within the dancer group, the number of years of training showed no statistically significant correlation with estimated VO_2 max ($r = -0.418$, $p = 0.121$) or with resting heart rate ($r = 0.175$, $p = 0.533$). The point estimate for the association with VO_2 max was negative rather than positive, but the confidence interval around a correlation coefficient computed on 15 observations is wide, and no directional conclusion can be drawn from it. The practical reading is that, within this narrow and relatively homogeneous band of training exposure, additional years of practice were not accompanied by measurably higher aerobic capacity.

3.6 Hypothesis Testing

The null hypothesis stated that there is no significant difference in cardiorespiratory endurance between Kathak dancers and non-dancers. The independent samples t-test on estimated VO_2 max returned $t(28) = 20.849$ with $p = 1.36 \times 10^{-18}$. Since p is below the pre-specified alpha of 0.05, the null hypothesis was rejected and the alternate hypothesis, that dancers show higher cardiorespiratory endurance, was accepted for this sample.

4. Discussion

4.1 Principal Findings

Trained female Kathak dancers in this sample recorded a mean estimated VO_2 max of 41.33 ± 0.83 ml/kg/min against 35.03 ± 0.82 ml/kg/min in age-matched sedentary women, a difference of 6.30 ml/kg/min or 18.0%. Dancers also showed a resting heart rate approximately 11 bpm lower and a post-exercise recovery heart rate approximately 34 bpm lower than non-dancers. Since the two groups were closely matched for age, height, body mass and body mass index, differences in body size are unlikely to account for the performance gap on a weight-bearing stepping task.

4.2 Possible Physiological Mechanisms

The pattern observed is consistent with the adaptations normally produced by repeated moderate to vigorous aerobic work. Rhythmic foot stamping in Kathak involves repeated concentric and eccentric contraction of the triceps surae, quadriceps and gluteal muscle groups. Repeated forceful contraction of the calf musculature assists venous return against gravity through the peripheral muscle pump, and greater venous return raises end-diastolic filling and, by the Frank-Starling relationship, stroke volume. A higher stroke volume permits the same cardiac output at a lower heart rate, which is the conventional explanation for training-associated resting bradycardia. In parallel, sustained aerobic work increases capillary density and mitochondrial oxidative enzyme activity in trained muscle and widens the arteriovenous oxygen difference [11]. The alternation of slow and fast rhythmic cycles within a Kathak composition also produces intermittent bouts of higher intensity separated by lower-intensity passages, a structure that resembles interval work [11, 17]. It should be stressed that these mechanisms are inferred from the pattern of results and from the general exercise physiology literature; none of them was measured directly in this study.

4.3 Resting and Recovery Heart Rate

The resting heart rate difference of 11.13 bpm is consistent with earlier findings in Indian classical dance. Comparison of professional and amateur Bharatanatyam dancers reported mean resting heart rates of 68.47 bpm and 77.93 bpm respectively, alongside higher estimated VO_2 max in the professional group [9]. The resting heart rate of 71.00 bpm recorded in Kathak dancers here falls between those two figures, which is reasonable given that the present dancers trained for roughly 204 minutes per week rather than daily.

The lower recovery heart rate in dancers deserves a careful reading. The Queen's College Step Test imposes an identical external workload on every participant, since step height and cadence are fixed. The pulse counted from the fifth to the twentieth second of recovery therefore reflects both the cardiovascular strain incurred during the bout and the speed of early heart rate decline once stepping stops. Early post-exercise heart rate decline is mediated largely by parasympathetic reactivation together with withdrawal of sympathetic drive. A recovery heart rate of 166.67 bpm in sedentary participants indicates that a fixed submaximal workload placed them close to their age-predicted maximum, whereas the same workload left dancers considerably further from theirs. The single measurement used here does not allow the relative contributions of lower exercise heart rate and faster recovery to be separated, and the study did not include heart rate variability or serial recovery measurements that would be needed to characterise autonomic function properly.

4.4 Blood Pressure Findings

Systolic blood pressure did not differ significantly between groups, and both group means lay within normotensive limits. The very large standard deviation in the non-dancer group, 23.21 mmHg, is attributable to two participants with markedly raised pre-test readings rather than to a general shift in that group. Readings of this magnitude in young women warrant clinical follow-up independently of the research question, and they also mean that the systolic comparison in Table 3 should be treated as unreliable in its present form.

Diastolic blood pressure was marginally higher in dancers, by 4.13 mmHg, at $p = 0.041$. This finding runs against the direction that would be predicted from training status, and it should not be over-interpreted. The difference is small, both group means are normotensive, blood pressure was measured once by manual auscultation rather than averaged across repeated readings, and five secondary comparisons were made without correction for multiple testing. A p-value of 0.041 in that context is fragile, and the most defensible statement is that resting blood pressure did not differ meaningfully between groups.

4.5 Comparison with Previous Work

The dancer mean recorded here sits comfortably within the range reported elsewhere for Kathak practitioners assessed by the same test. Using the Queen's College Step Test in 120 Kathak dancers aged 18 to 50 years, a mean VO_2 max of 39.53 ± 2.46 ml/kg/min has been reported, against 42.23 ± 3.32 ml/kg/min in 120 Bharatanatyam dancers [5]. The value of 41.33 ± 0.83 ml/kg/min obtained in the present younger and more narrowly defined dancer sample falls between those two figures. Higher peak oxygen uptake has also been reported in both Bharatanatyam and Kathak dancers relative to age-matched controls using an incremental shuttle walk test, with a large effect size [6], which supports the direction of the present result using a different testing method.

Higher cardiovascular endurance and faster post-exercise recovery in Bharatanatyam dancers compared with non-dancers have likewise been reported [4], and comparable aerobic capacity has been found between Bharatanatyam and Kuchipudi practitioners, both groups rating above average [8]. Comparison of Indian classical dancers with regular yoga practitioners found significantly higher VO_2 max in dancers among male participants, although the difference among female participants in that study was not statistically significant [7]. Beyond the classical Indian forms, a 12-week programme of low-impact aerobic dance in college-aged women raised directly measured VO_2 max from 38.3 to 41.3 ml/kg/min [12], and a recent review of dance interventions in adults concluded that dance raises VO_2 max across a range of styles [17]. Work on Kathak using other outcome measures has shown more favourable body composition in regular practitioners [13, 18] and higher muscular strength, endurance and flexibility relative to non-dancers [14]. The present findings extend that picture to maximal aerobic power measured against a sedentary comparison group.

4.6 Interpretation of the Effect Size

The Cohen's d of 7.613 obtained for the primary outcome is far larger than effect sizes normally encountered in exercise physiology, and it should not be read as evidence of an unusually powerful training effect. Three features of the design and the measurement account for it, and each of them inflates d without necessarily reflecting a larger physiological difference.

1. The two groups were deliberately selected from opposite extremes of the activity spectrum, one with 4 to 11 years of continuous training and the other with no structured activity at all. Contrasting extremes maximises the between-group difference while minimising within-group spread.
2. Estimated VO_2 max in this protocol is a linear transformation of a single 15-second pulse count. Because that count is an integer multiplied by four, the estimate can only take discrete values separated by 0.739 ml/kg/min. Within-group standard deviations of 0.83 and 0.82 ml/kg/min therefore correspond to roughly one beat of variation in the 15-second count, which is close to the resolution limit of the measurement itself.
3. Cohen's d is the mean difference divided by the pooled standard deviation. A measurement method that produces very small within-group variance will yield a large d for any given mean difference, independently of the biological importance of that difference.

The absolute difference of 6.30 ml/kg/min is the more informative statistic, and it is the one that should be quoted. A difference of that magnitude is clinically meaningful, since gradients of this order in cardiorespiratory fitness are associated with differences in long-term cardiometabolic risk, but it is a difference of ordinary size and it is comparable to what a structured aerobic programme of a few months achieves [12].

4.7 Clinical and Pedagogical Implications

Three practical implications follow, subject to the limitations set out below.

- For exercise prescription, Kathak may be offered to young adult women as a culturally familiar aerobic option, particularly where adherence to gymnasium-based programmes is poor. The dancers in this sample maintained average to above average aerobic fitness on roughly 60 to 90 minutes of practice on 2 to 3 days per week, which is broadly consistent with general physical activity recommendations for adults.
- For preventive health, the finding that every sedentary participant fell into the Below Average band, while none reached Average, indicates a level of subclinical deconditioning among young college women that is worth addressing at a programme level.

- For dance teaching, submaximal step test values and recovery heart rate offer an inexpensive way for instructors to monitor conditioning across a training year and to plan rest intervals around demanding performance schedules. Attention to lower limb loading is also warranted, since foot and ankle complaints are the most frequently reported musculoskeletal problems in Kathak practitioners [15].

4.8 Strengths

Testing was carried out under controlled ambient conditions with metronome-regulated cadence and a fixed step height, which standardises the external workload across participants. The two groups were well matched on age, height, body mass and body mass index, so the principal anthropometric confounders for a weight-bearing task were controlled. Parametric and non-parametric tests were run in parallel and agreed, and normality and homogeneity of variance were checked before parametric testing.

4.9 Limitations

- Maximal oxygen uptake was estimated indirectly rather than measured by expired gas analysis. This limitation carries particular weight in this population, because validation work in sedentary Indian women found that the original Queen's College Step Test equation showed poor agreement with directly measured VO_2 max and tended to overestimate it [2]. The absolute values reported here should therefore be treated as estimates specific to this protocol, and the between-group comparison, in which both groups were tested identically, is more trustworthy than the absolute numbers.
- Recovery heart rate was obtained by manual palpation over a 15-second window and multiplied by four. A miscount of a single beat shifts the estimated VO_2 max by approximately 0.74 ml/kg/min, and pulse palpation immediately after exercise is prone to error. Electrocardiographic or telemetric heart rate monitoring would remove this source of measurement error.
- The sample comprised 30 women from a single institution in one city, which limits generalisability to other age groups, to men, to other dance traditions and to other regions.
- The cross-sectional design compares two existing groups at one point in time and cannot establish that Kathak training caused the observed differences. Self-selection is a plausible alternative explanation, in that women with higher baseline aerobic capacity or greater general activity may be more likely to take up and continue classical dance.
- Habitual physical activity outside dance was established by self-report rather than by accelerometry or a validated questionnaire, so residual differences in incidental activity between the groups cannot be excluded.
- Menstrual cycle phase, haemoglobin status and dietary intake were not recorded, and each can influence submaximal heart rate response in young women.
- The observed body mass index range extended slightly beyond the stated inclusion window of 18.5 to 24.9 kg/m^2, from 18.03 to 26.37 kg/m^2, and this minor protocol deviation is reported for transparency.
- Assessors were not blinded to group allocation, which is difficult to avoid in a study of this design but leaves scope for observer bias in manual pulse and blood pressure measurement.

Future work should incorporate direct cardiopulmonary exercise testing with gas analysis, use a locally validated prediction equation if a field test is retained, recruit larger multi-centre samples including male dancers, record objective measures of habitual activity, and follow a prospective design in which previously sedentary participants undertake a structured Kathak programme. Dance-specific field protocols validated against laboratory measures, as have been developed for other dance styles [19], would also be a useful direction for Indian classical forms.

5. Conclusion

Trained female Kathak dancers in this sample showed higher estimated cardiorespiratory endurance and a more favourable resting and post-exercise heart rate profile than age-matched sedentary women, with an absolute difference in estimated VO_2 max of 6.30 ml/kg/min. Every dancer met or exceeded normative aerobic fitness expectations for her age and sex, while every sedentary participant fell below them. Within the limits of an indirect field test and a cross-sectional design, the results support Kathak as a culturally acceptable movement practice that is compatible with the maintenance of cardiorespiratory fitness in young adult women, and they justify a prospective interventional study to test whether the association reflects a training effect.

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Data Availability

The de-identified dataset analysed during this study is available from the corresponding author on reasonable academic request.

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