Blood Lactate and Heart Rate Responses between Active and Passive Recovery Modes over a 15-min recovery period in Female Dancers after Kathak Dance

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ABSTRACT

Introduction: Dance is physically demanding and results in blood lactate(BL) accumulation and elevated Heart Rate(HR). Researchers recommend using either Active Recovery(AR; e.g., low-to-moderate intensity-exercise) or Passive Recovery(PR; e.g. complete rest) modes after activity. We compared BL and HR responses between AR or PR over a 15-minute recovery period following a Kathak dance. **Methods**: Twelve female dancers(31.0±6.0years; 161.5±4.9cm; 55.5±5.8kg) performed two dance testing sessions (Day 1=AR, Day 2=PR) 48 hours apart. Each session started with a 10-min warm up followed by dancers performing four 2-minute stages of Kathak dance, with three 1-minute periods between stages where we recorded HR and their Rate of Perceived Exertion (RPE:scale=6-20) to match the intensity of both sessions. Post-dance, we recorded dancers' BL and HR at 1, 3, 5, 10, and 15 minutes while they recovered via AR or PR. Separate 2(mode)*5(time) Repeated-Measures-ANOVA followed by simple-main-effects testing and adjusted Bonferroni-pairwise-comparisons examined differences in BL and HR responses across modes and time(α=.05). **Results**: Dancers' HR and RPE were similar across sessions. No mode*time interaction existed in BL($F_{4,8}$=3.6, p=0.06). BL levels were similar across modes($F_{1,2}$=0.5, p=0.5). BL levels reduced over time($F_{4,8}$=6.0, p=0.02), but Bonferroni-comparisons did not reveal any pairwise differences. In HR a significant mode*time interaction ($F_{4,36}$ = 11.0, p = 0.01, $\eta 2$ = 0.55) was observed. Both Active and Passive recovery modes achieved absolute HR levels by 15 minutes, with PR mode stabilizing within 5 minutes. **Conclusions**: Over a 15-minute recovery period after Kathak dance, dancers' BL and HR responses were similar across time in both AR and PR, with HR being higher in AR. Dancers' HR remained similar from 1-3 min post dance recovery and then dropped over time. Thus,

dancers can rest up to 3 minutes and still maintain the same elevated HR. Overall, dancers can choose either AR or PR as their recovery mode based on their individual preferences.

Key Points

1. Over a 15-minute recovery period after Kathak dance, dancers' BL and HR responses were similar across time in both AR and PR, with HR being higher in AR.
2. Dancers can choose either AR or PR as their recovery mode based on their individual preferences.
3. Dancers' HR remained similar from 1-3 min post dance recovery and then dropped over time.

INTRODUCTION

Dancing requires participants to perform complex, diverse, non-steady state, intermittent, of moderate to high intensity physical activity and exercise that can elevate Heart Rate (HR) levels.[1] The intensities of activity differ between training and performance and across durations.[1] An abrupt end to exercise can result in unwanted manifestations such as pooling of blood,[2,12] slower removal of blood lactate (BL),[3] poor circulation, and slow removal of waste products,[4] contributing to muscle soreness and cramping.[3,4,5,6,7,13] Therefore, dancers are commonly recommended to cool down and recover after classes, rehearsals, and during off stage intervals in performance settings.[7]

The impact of blood lactate accumulation, which is often associated with factors contributing to fatigue, and the effectiveness of recovery strategies are critical considerations influencing dance performance. Skeletal muscle fatigue, characterized by a decline in muscle force or power output leading to impaired exercise performance, can be influenced by various factors, including elevated blood lactate levels[8]. These heightened blood lactate levels can serve as a valuable indicator of a fatiguing environment, signaling the potential onset of fatigue and impairment in skill execution.

Elevated blood lactate levels are indicative of the body's reliance on anaerobic energy production during intense dance movements, which can lead to increased lactate production. While lactate itself is not the sole cause of fatigue[8], its presence can be a valuable marker of the metabolic stress dancers experience during demanding routines.

Implementing appropriate recovery techniques, such as active or passive recovery, plays a vital role in mitigating the negative effects of blood lactate accumulation and addressing the multifaceted causes of fatigue. These recovery strategies help restore muscle function, clear

metabolic byproducts like lactate, ensuring optimal performance throughout demanding dance routines.

Considering these factors can help in designing effective training strategies to support dancers' performance and overall well-being. By managing lactate levels and fatigue effectively, dancers can optimize their physical abilities and enhance their dance performance.

HR and BL are both internal indicators of activity intensity that provide information about the speed at which homeostasis is achieved post exercise.[3,9] An elevated HR during recovery will facilitate the redistribution and oxidation of excess BL after activity, therefore an activated cardiovascular system is advantageous for BL clearance. [2]

Cool down recovery post activity can be done via two modes: Active and Passive. Active Recovery (AR) involves low-moderate intensity[2] exercise and Passive Recovery (PR) involves complete seated,[5,10,12,15,16,] or supine[12,14] rest. Since most of the lactate is oxidized by skeletal muscles working at a lower intensity, and since the lactate redistribution occurs via the blood flow, active rather than passive recovery after lactate-accumulating exercise appears to be more effective at clearing accumulated lactate[2]. Researchers report that AR is better than PR for clearing BL for recovery periods of 7-20 minutes in both continuous and intermittent exercises,[2,5,15,16,17] but even more particularly in continuous exercises like running, cycling, and swimming. However, these studies on intermittent activities were focused on high-combat sports which generate high levels of BL.[10,15,] Alternatively, Van Hooren et al. [18] report that while cool down recovery is largely ineffective at improving post-exercise recovery physiological markers such as lactate in muscle, subsequent performance and muscle soreness; it may accelerate respiratory and cardiovascular system recovery and avoid post-exercise syncope. AR for BL

removal is less important for those who do not perform another activity within 90 minutes, as BL is usually cleared within 20-120 minutes regardless of post-exercise activity.[19]

Despite the abundance of studies in sports science literature[2,5,10,12,14,15,22] focusing on blood lactate (BL) clearance during activities involving multiple bouts, and the increasing number of published research [17,21] examining BL and heart rate (HR) responses in dance, there is still a relative lack of research investigating recovery strategies such as active/ passive recovery to facilitate BL clearance and HR responses specifically within the context of dance.

Kathak is a classical Indian dance form that often includes multiple bouts of both fast and explosive activity interspersed with slower movements and can last from a few minutes to several hours. Fast activity in Kathak dance is characterized by pirouettes, concise upper body movements, repetitive and percussive footwork, and is performed with rhythmic precision accompanied by the sound of clapping bare feet and the ringing of brass ankle bells that weigh up to 2.5 kg. In contrast, slower bouts of performance involve lighter footwork, slower body movements, and voice work. (See Figure 1) Thus, Kathak dancers have multiple bouts of activity and recovery across an entire Kathak dance performance.

.<<Figure 1 Approximately here >>

Combining the information that dancers can use AR or PR to recover, and that Kathak dancers have multiple periods of activity and rest, it is important for practitioners and dancers to examine how BL and HR responses differ across recovery modes after a Kathak dance. This information may allow dancers to optimize recovery efficiently between multiple bouts of

activity during a performance or between dance classes. Thus, our purpose was to examine differences in BL and HR responses between AR and PR modes after taking part in a Kathak dance protocol.

METHODS

Study Design

We used a non randomized repeated measures study design.

Participants

Twelve female Kathak dancers (age 31.0 ± 6.0 years; height 161.5 ± 4.9 cm; weight 55.5 ± 5.8 kg) with a minimum of 6 years Kathak dance experience and 4 hours per week participation in Kathak dance volunteered for this study. We recruited participants via social and printed media in the United Kingdom. Recruitment was restricted to only female participants in this study to eliminate any effect of sex.[19]

Ethics Review and Informed Consent

The <<Blinded>> Ethics Committee approved this study with specific reference to standardized ethical procedures. Participants were emailed a detailed information sheet in advance of the testing day specifying the protocol and blood sampling procedures before giving written informed consent to participate in the study.

Testing Protocol and Equipment

A metronome was used to set speed and the tempo throughout the protocol, and an Indian Tabla drum was played to accompany the Kathak dance. The protocol was played upon a 32 inch screen or large projector screen within the dance studio. Testing stations were set up at the back of the studio. The stations consisted of blood testing equipment, water and chairs for the

participants. The ear-capillary blood sampling procedure for BL testing was based on the British Association of Sports and Exercise Sciences laboratory guidelines.[20]

Procedures

When the dancers arrived at the studio, the investigators introduced the study to them. The dancers completed Medical Par-Q forms (adapted from Choisholm et al.) [23] To avoid overcrowding, we limited data collection to 3 people per session. Participants were individually allocated a tester who assessed their consent and Medical Par-Q forms. The same tester then recorded anthropometric data and fitted participants with HR monitors and watches (Polar Accurex Inc., USA). The participants were then familiarized with the testing protocol and the Borg Rating of Perceived Exertion (RPE) 6-20 scale, where dancers rated their perceived feelings of exertion – i.e., how hard they believed they were working. [11] This process also allowed the researchers to compare the intensity at which they danced between sessions. The dancers fitted their ghungroos when seated – as is standard for Kathak dance and their resting HR were recorded at that time.

Warm Up

Then, all participants performed a standardized warm up that was displayed upon the screen. We chose a 10-minute warm up and 15-minute recovery mode based on prior research[10]. The 10-minute warm-up protocol consisted of walking, skipping, jogging in a circle and changing direction whilst incorporating upper-body movements. Participants were introduced to the movement sequence through a video sequence containing both movement and verbal instructions. Participants were given the opportunity to ask researchers questions and to practice movement sequences at a reduced intensity.

Dance Protocol

Then, participants started performing the Kathak dance protocol (Table 1). This protocol consisted of four two-minute stages of Kathak dance drills, interspersed with one-minute recovery periods for HR and RPE data collection between the dance stages, where participants continued with percussive footwork and upper body movements at a lower intensity to the Kathak sequences. This exemplifies the characteristic progression of classical Kathak dance performances, wherein speed and intensity escalate progressively from the beginning to the end, but without the voicework.

The primary investigator who is a professional Kathak dancer developed the 8-minute set dance protocol. The protocol included typical Kathak movements that are often integrated into choreography for performances and consisted of four phases that increased in speed and precision of dance spins and heavy rhythmic footwork. The movements included 'Chakkars' or pirouettes (Figure 1) performed on the heel with arms positioned either horizontally, or above the head. 'Hastaks', a combination of upper movements contrasting with heavy rhythmic footwork, wrist rotations and spinal rotations and bends. Footwork involved stamping combinations that increase from single speed to eight times the speed.

The dance tempo ranged from 120 beats per minute (bpm) in phase one to 350 bpm in phase four representing typical tempo, speed and suitable duration of a Kathak dance performance. The protocol was filmed for consistency of dance protocol administration and subjective movement observation. The included Kathak dance drills were fast and challenging but had simple and low technical demands. We kept the protocol simple to reduce a learning effect and instead maintain focus on the physiological test elements rather than teaching skills.[22] Verbal cues were provided to the participants if necessary, but were kept to a minimum.

<<Table 1 Approximately here >>

RPE and HR between Kathak Dance Protocol Stages

Immediately following each two-minute dance stage, the participants would continue with very light footwork and arm movements whilst the RPE 6-20 (Rate of Perceived Exertion) Scale (6=no exertion at all, and 20=Maximal exertion) would appear on the large screen and the dancer would inform the tester of their RPE score. We also recorded HR and provided participants with water ad libitum. Here the participants were also informed of the forthcoming sequence, enabling them to mentally prepare for the next stage that was at an increased intensity, with faster and more dynamic movement set to 120 bpm.

Active and Passive Recovery Modes

Upon completion of the four stage protocol, dancers used AR or PR mode as pre-decided by the investigators (Day 1=AR, Day 2=PR) for recovery. The recovery mode protocol started immediately after the Kathak dance protocol, with the first BL sample obtained 1-minute after the end of the dance protocol. Each tester had a maximum of 1-minute to obtain the sample after which the participant returned to either the AR or PR protocol. See Table 2 for the details of the recovery mode protocols.

<<Table 2 Approximately here >>

HR and BL measurements were taken at 1, 3, 5, 10, and 15 minutes as per previous studies.[10,16] Participants returned to the studio for testing a second time after a 48-hour washout period to mitigate any cross-over effects. The same warm-up and dance protocols were

performed as during the first session, with the participants then recovering using the other of the two recovery modes.

Statistical Analyses

We conducted paired sample t-tests of participants' RPE and HR to ensure that the reliability of the Kathak protocol, that is – the protocols had similar workload intensity across the two sessions. BL and HR responses across modes and time were examined using two separate 2 (mode: AR, PR) * 5 (time: 1, 3, 5, 10, and 15 min) repeated measures ANOVAs (α=.05), with simple main effects testing and Bonferroni pairwise comparisons that adjusted for p-values as appropriate. All statistical analyses were conducted using Statistical Package for Social Sciences (SPSS) version 22 (SPSS Inc.; Chicago, IL) software.

RESULTS

Reliability of Kathak Protocol

Dancers' HR and perceived workload intensity was similar across the 4 stages of dance protocol and days. (Table 3) Dancers mean HR in AR and PR across the dance protocol was 163 bpm and 172.7 bpm respectively. These mean HR levels indicate that dancers were engaged in 'vigorous' intensity activity based on the maximum Heart Rate of an individual being 220-age.[11]

<<Table 3 Approximately here >>

Heart Rate

A mode * time interaction ($F_{4,36}$ = 11.0, p=0.01, partial η^2=.55 1-β=1.0) existed in HR. A significant mode * time interaction was observed in heart rate (HR) during the recovery period.

By the 15-minute mark, HR in both Active and Passive recovery modes had returned to absolute levels, indicating effective recovery in both groups. However, a notable difference emerged in the pace of HR recovery between the two modes. Within the first 5 minutes, HR in the Passive Recovery (PR) mode had already stabilized, suggesting a faster recovery compared to the Active Recovery (AR) mode.

<<Figure 2 Approximately here >>

Blood Lactate

No mode * time interaction existed in BL ($F_{4,8} = 3.6$, $p = 0.06$, partial $\eta^2 = .31$, $1-\beta = .18$). BL levels were similar across modes ($F_{1,2} = 0.5$, $p = 0.5$, partial $\eta^2 = .37$, $1-\beta = .10$) (See Table 3). Although BL levels differed across time ($F_{4,8} = 6.0$, $p = 0.02$, partial $\eta^2 = .86$, $1-\beta = .99$), Bonferroni adjusted comparisons did not reveal any pairwise differences.

<<Figure 3 Approximately here >>

DISCUSSION

Primary Findings

Our primary findings were that over a 15-minute recovery period after Kathak dance, dancers' BL and HR responses were similar across time in both AR and PR, with HR being higher in AR. Dancers' HR remained similar from 1-3 min post dance recovery, and then dropped over time. In the following sections we compare the current results with prior literature, interpret the results, provide implications for dance practitioners, and suggest directions for future work.

BL and HR Responses

Dancers' BL responses were similar across both active and passive recovery modes. Partial explanations for this finding may lie in the timing of BL measurements, and the intensity of the dance protocol. Specifically, in the current study, we did not measure BL immediately after the dance protocol. Rather, BL was measured at 1 minute into recovery due to logistics of data collection. Still, the timing of BL measurements aligns with previous research suggesting that peak BL levels are typically observed 3-8 minutes post-exercise. [27] Of note, the dance protocol in our study elicited relatively low blood lactate values (AR = 2.8 ± 0.9 mmol.L-1 and PR = 4.0 ± 1.2 mmol.L-1). This observation implies that the experienced Kathak dancers in the present study may not have found the dance demand to be sufficiently challenging. (HR ~ 70-75% of maximum and RPE of ~14-15) for them to reach peak BL accumulation. Therefore, the delivery, uptake, and oxidation of BL were likely facilitated in a similar manner regardless of recovery mode. Taken as a whole, our findings suggest that BL was cleared over the 15-minute recovery period in a similar manner for both active and passive recovery modes. As a result, female dancers can choose their preferred recovery mode after a 15-minute Kathak dance.

We found that HR was higher in AR than PR. HR in both conditions remained similar one to three minutes post dance. Then, dancers' HR reduced gradually by the end of the 15 minute period. The AR mode took the full 15 minutes to return to the same absolute level as the PR mode, whereas the PR mode reached a steady state after only 5 minutes. During dance performance, maintaining an elevated HR during short periods off-stage may ensure that the dancer's cardiovascular system remains ready for the next bout of dance performance. Combined, the current study findings and the prior reports suggest that during an extended Kathak dance

performance, where dancers must perform multiple pieces, after the initial 1 min rest period, they can take up to a 3 minute break while still maintaining an elevated HR. This way dancers can still ensure that their cardiovascular system remains ready for the next bout of activity.

After the 3 minute interval, dancers' HR reduced to baseline 15 minutes after the dancer protocol in both AR and PR. In support, Takahashi and Miyamoto [9] also found that HR recovered similarly after cycling, but 10 min after the exercise (i.e., 3 min after the AR), HR was lower in the AR interventions. In Takahashi's study, the recovery was set at a continuous level at 4-8 times less intensity than the testing protocol itself, and the AR was lower than PR at 7 minutes post-exercise protocol. Therefore, it is possible to speculate that if the intensity of the AR in our study had been set to a continuous or steady state, like the Takahashi study, larger differences could have been observed between AR and PR.

Strengths, Limitations, and Future Recommendations

The current study makes a novel contribution to the field by investigating recovery modes in Kathak dance, thereby providing original insights. With practical applicability in the Dance & Medicine field, the study's analysis of the Kathak dance style offers valuable and unique perspectives.

We opted for a homogeneous group of participants based on time and availability constraints, intentionally assigning them to each trial. However, this deliberate assignment of participants to active recovery (AR) and passive recovery (PR) on different days introduces potential order effects, posing a limitation that may lead to selection and confounding biases. Consequently, these factors restrict the generalizability of the results and the validity of the conclusions drawn from the study. To address this, future research should randomize recovery

protocols. It is also noteworthy that certain data points, including peak heart rate (HR) values immediately after the fourth phase of the testing protocol, were not recorded, potentially impacting the results, therefore it is advised to collect immediate post-activity measurements. Furthermore, interruptions during the AR protocol for blood lactate (BL) sampling and the repeated tests may have influenced intensity levels and subsequent outcomes. To ensure more consistent results, future studies should collect HR and ratings of perceived exertion (RPE) immediately after activity cessation and maintain a continuous intensity level throughout the recovery period.

Despite these limitations, the study findings demonstrate consistent HR and RPE responses across sessions, suggesting a similar workload for the dancers. The average HR of approximately 160 beats per minute corresponds to 70-75% of the maximum HR for individuals in their thirties. Reported RPE scores of around 14-15 indicate a "hard" exertion level, falling short of "very hard" or "maximum effort." Consequently, reaching peak HR and RPE levels may not be necessary during the dance protocols. The consistent HR and RPE responses across days further support the reliability of the Kathak protocol.

Considering the small sample size limitations, the preliminary nature of the current results underscores the need for further research with larger sample sizes. Future studies should aim to better understand the relationship between recovery modes and blood lactate clearance after Kathak dance, and expand investigations to encompass other dance genres. Additionally, exploring alternative measures such as oxygen uptake and incorporating self-reported psychophysical responses can contribute to a more comprehensive understanding of recovery patterns in Kathak dance and other dance forms.

Practical Implications

The findings of this study are not generalizable to other traditional Indian dance forms due to the distinct characteristics inherent in each dance style.

An important finding of the current study is that dancers' HR remained elevated for up to 3 minutes immediately after the dance protocol, irrespective of the recovery protocol. This means that if dancers need to perform repeated bouts, they can take up to a 3-minute break while still maintaining an elevated HR. After this time, HR starts to drop in both AR and PR. The practical implication of this observation is that if dancers are performing multiple pieces during a long performance lasting several hours, they can use either recovery protocol to maintain an elevated HR during intervals. The elevated HR will allow them to stay warmed up and ready for multiple appearances on stage without needing to warm up again.

Conclusions

In summary, in this study, we found that during a 15-minute recovery period after Kathak dance, there were similar responses in both active and passive recovery modes for blood lactate and heart rate, with heart rate being higher in active recovery. Additionally, dancers' heart rate remained elevated for up to 3 minutes post-recovery after which it dropped over time. Thus dancers can take a 3-minute break and still maintain an elevated heart rate, making either active or passive recovery modes viable options for them to choose from based on their personal preferences.

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Figure 1: A Kathak dancer performing fast multiple 'chakkars' (heel-based pirouettes) with weighted Ghungaroos (bells) on the ankles, intensifying the dance activity.

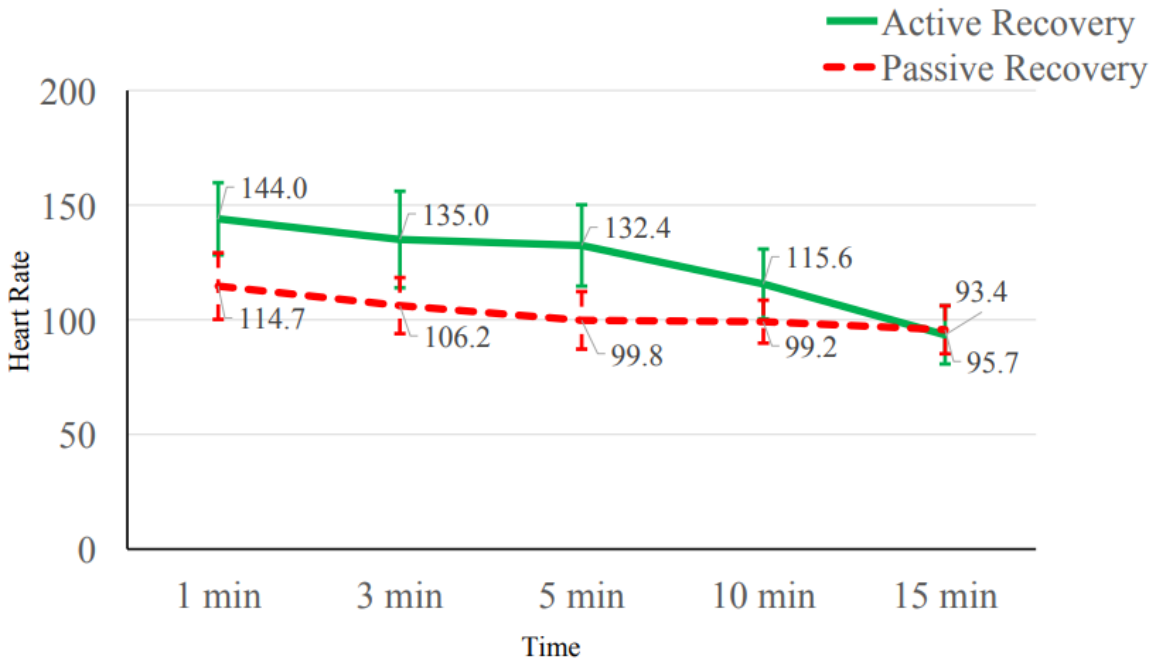

Figure 2: Kathak HR Responses between AR PR across time at 1, 3, 5, 10 and 15 minutes. A significant mode by time interaction was present $p<0.05$. Data displays means and standard deviations (SD) for active and passive conditions. See table 2 for main components of the recovery protocol.

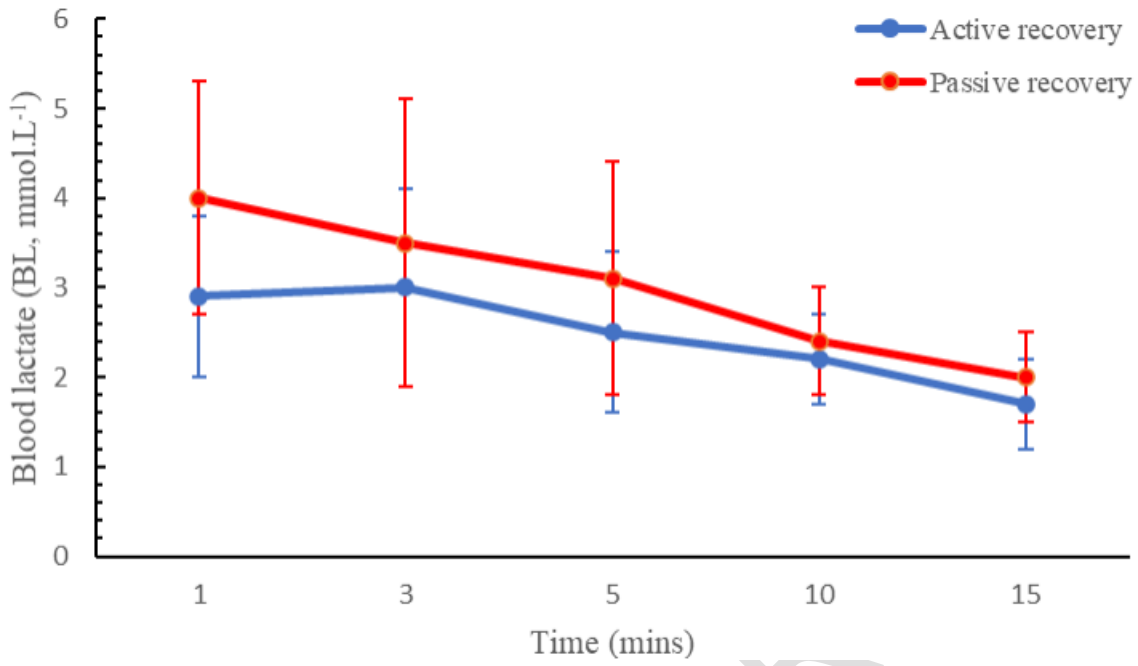

Figure 3: Kathak BL responses between AR and PR across time at 1, 3, 5, 10 and 15 minutes. Data displays means and standard deviations (SD) for both conditions.

Table 1: Phases in the Kathak Dance Protocol

Phase	**Name of movement**	**Movement**	**Metronome Beats per minute (bpm)**	**Repetitions**	**Rest (seconds) Footwork only**
One (1 min)	Pavan feri	Left arm above head Right arm in front of chest Turning anti clockwise on heel, with footwork	130 bpm	9	6
	Avartan	Light footwork			10
One (1 min)	Bhramari	8 single speed anti clockwise spins with arms out at chest height,with footwork	130 bpm	10	6

		2 double speed spins			
Report RPE/ HR (1 min)		Light footwork	120 bpm		
Two (1 min)	Jaipur spins	7 single speed turns with elbows raised to chest height 3 double speed turns, with footwork Anti-clockwise on heel	160 bpm	13	10
Two (1 min)	Fast footwork	Stamping feet creating clapping sound	350 bpm	1	
Report RPE/ HR (1 min)		Light footwork	120 bpm		
Three	10 spins	7 medium anti-	150 bpm	10	10

(2 mins)		clockwise spins, 3 fast with arms out at chest level, with footwork			
Report RPE/ HR (1 min)		Light footwork			
Four (2 mins)	Paltas	1 spin to left 1 spin to right (16 total) With various arm combinations, with footwork	160 pm	16	10
AR or PR begins					

Note: RPE= Rate of Perceived Exertion, HR = Heart Rate

Each round lasted for 2 minutes. Each round was interspersed with a 1 minute interval for data collection.

Table 2: Activities during the Active and Passive Recovery protocol after taking part in a Kathak dance protocol from minutes 1-15 including blood sampling collection points.

Time (minutes)	**Active Recovery**	**Passive Recovery**
0-1	Run around studio/ changing directions	Seated at testing station
1-2	Blood sample collection (Seated at testing station)	Blood sample collection (Seated at testing station)
2-3	Light jog around studio	Seated at testing station
3-4	Blood sample collection (Seated at testing station)	Blood sample collection (Seated at testing station)
4-5	Slow spinal rotations with circular arm movements	Seated at testing station
5-6	Blood sample collection (Seated at testing station)	Blood sample collection (Seated at testing station)
6-10	Dynamic stretching	Seated at testing station
10-11	Blood sample collection (Seated at testing station)	Blood sample collection (Seated at testing station)
11-15	Static stretching (Hamstrings, calves, hips, spine, legs up the wall)	Seated at testing station

15	Blood sample collection (Seated at testing station)	Blood sample collection (Seated at testing station)

Table 3: Heart Rate (HR, beats per minute) and Rate of Perceived Exertion (RPE, scale=6-20) at Stages 1, 2 and 3 of the Kathak dance protocol (M ± SD) . No significant differences were found between recovery trials.

	Heart Rate			**Rate of Perceived Exertion**		
Stage	Active Recovery	Passive Recovery	p-value	Active Recovery	Passive Recovery	p-value
Stage 1	161.6 ± 14.5	173.2 ± 16.2	*0.36*	12.6 ± 0.9	13.3 ± 1.4	*0.71*
Stage 2	163.8 ± 17.2	170.6 ± 10.6	*0.23*	13.3 ± 1.4	13.75 ± 1.4	*0.43*
Stage 3	166.0 ± 23.9	174.5 ± 10.9	*0.59*	14.7 ±0.9	15 ± 1.7	*0.66*

Note: Paired-samples t-test results