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Acute cardiovascular and metabolic responses to a single line dance session

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Abstract

Physical inactivity among middle-aged women remains a major contributor to increased cardiovascular and metabolic health risks worldwide. This study sought to examine the acute cardiovascular and metabolic responses during a 45-minute instructor-led line dance session in physically active middle-aged women. A single-session cross-sectional observational design was employed involving thirty participants aged 30–50 years who completed a standardized routine consisting of warm-up, main session, and cool-down phases. Every participant wore a Polar H10 heart-rate monitor and an accelerometer to collect data throughout the session. Exercise intensity was classified into five heart-rate zones according to the percentage of maximum heart rate (HRmax), while caloric expenditure was estimated using heart-rate data and MET values. Descriptive analysis was employed to delineate cardiovascular and metabolic responses, while multivariate regression assessed predictors of total caloric expenditure, controlling for age and body mass index (BMI). The average intensity of the participants' exercise was 72.8 ± 5.6% HRmax (132.5 ± 10.4 bpm), the mean energy cost was 245.6 ± 35.2 kcal, and the MET value was 4.2 ± 0.6. The majority of the session duration was allocated to Zone 3 (38.2 ± 6.1%) and Zone 4 (18.4 ± 4.7%). The time spent in Zones 3–5 was a significant predictor of caloric expenditure ($\beta = 0.68$, $p < 0.001$, $R^2 = 0.74$). These findings demonstrate that a single 45-minute instructor-led line dance session produces moderate-to-vigorous acute cardiovascular strain and metabolic responses, as reflected by heart rate zone distribution and energy expenditure in physically active middle-aged women.

Keywords: Line dance, heart rate zones, caloric expenditure, MET.

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Authors contribution: a – Preparing concepts; b – Formulating methods; c – Conducting research; d – Processing results; e – Interpretation and conclusions; f - Editing the final version.

INTRODUCTION

Physical inactivity remains a major public health concern in Asia and continues to contribute substantially to the rising burden of non-communicable diseases (NCDs). The World Health Organization reports that approximately 31% of adults globally do not meet recommended physical activity levels, with prevalence in several Asian countries being comparable or higher, particularly among women (WHO, 2024). In Indonesia, national data indicate that 33–35% of adults are insufficiently physically active, with women showing higher prevalence than men (Anindya et al., 2022). This pattern parallels the growing burden of NCDs, which account for more than 70% of total mortality, with cardiovascular disease and metabolic disorders as the leading causes of death (Badr et al., 2019). Insufficient physical activity is a key modifiable risk factor underlying these conditions, primarily through its effects on cardiorespiratory function and metabolic regulation. Being physically inactive and having low cardiorespiratory fitness remain two of the most significant preventable contributors to global morbidity and mortality, accounting for more than five million deaths annually. Although regular engagement in moderate-to-vigorous physical activity (MVPA) enhances aerobic capacity, metabolic regulation, and cardiovascular function (Franklin et al., 2022), middle-aged women frequently encounter structural and contextual barriers that limit sustained participation in structured exercise. These barriers include disproportionate domestic and caregiving responsibilities, occupational–family role conflicts, limited access to safe and culturally appropriate facilities, time constraints, and diminished motivation (Guthold et al., 2018). Importantly, such constraints do not merely reduce opportunities for activity but directly contribute to low adherence and poor long-term sustainability of physical activity participation within this population. These circumstances underscore the need for exercise modalities that are accessible, socially acceptable, and compatible with daily routines. In this regard, the United Nations

Sustainable Development Goal (SDG) 3 emphasizes the promotion of healthy lifestyles and the reduction of premature mortality from non-communicable diseases through increased physical activity engagement (Alarifi et al., 2025).

Sustained engagement in physical activity is influenced not only by physiological demands but also by psychological mechanisms of adherence. Self-Determination Theory (SDT) posits that exercise behaviors are more likely to be maintained when activities support autonomy, competence, and social relatedness, thereby fostering intrinsic motivation (Gillespie et al., 2015). The affect regulation framework further suggests that activities perceived as enjoyable and emotionally positive are associated with greater adherence regardless of intensity (Lee et al., 2016). Dance-based exercise integrates music, rhythm, and structured group interaction, elements that have been linked to favorable affective responses and higher acceptance in community settings, particularly among adult women. Line dance, characterized by synchronized group movement without partner dependency, reduces performance anxiety and social comparison pressures (Schneekloth & Brown, 2018). Its non-competitive and group-based structure may operationalize the autonomy and relatedness components of SDT by facilitating supportive participation without evaluative pressure. Within a broader policy context, SDG 5 (Gender Equality) can be analytically understood as a structural framework that promotes equitable access to health-related opportunities, including participation in physical activity among women. Rather than serving as a normative statement, SDG 5 provides a context for examining how women's autonomy and access intersect with exercise behavior.

Dance-based exercise modalities exhibit distinct intensity profiles (Kasih et al., 2024; Sampieri et al., 2024). High-intermittent formats such as Zumba frequently elicit vigorous intensities exceeding 80% HRmax and are characterized by substantial heart rate variability due to rapid tempo changes and explosive movements (Puspodari et al., 2022; Schneekloth & Brown, 2018). Traditional aerobic dance classes typically produce more uniform moderate-intensity responses around 60–75% HRmax with limited exposure to higher training zones (Griadhi et al., 2021). Line dancing differs from both formats through its structured and synchronized choreography with controlled rhythmic progression, potentially yielding a more stable intensity distribution while intermittently reaching moderate-to-vigorous zones. Empirical evidence indicates that many dance modalities achieve intensities between 65–80% of age-predicted HRmax with energy expenditures ranging from 3–6 METs (Ito, 2019; Liang et al., 2024). Given that global guidelines recommend at least 150 minutes of moderate-intensity activity per week (WHO, 2024), a 45-minute session represents a substantial contribution toward weekly volume when performed regularly. However, most physiological investigations rely on average heart-rate values, which may obscure temporal fluctuations in metabolic load during structured dance sessions. Continuous heart-rate zone profiling offers a more precise approach for capturing the distribution of intensity across physiologically meaningful zones. Time spent in higher-intensity zones (Zones 3–5) reflects exercise performed near or above the aerobic threshold, where oxygen uptake and metabolic demand increase substantially compared to lower intensities. Because energy turnover per unit time is elevated in these zones, accumulated time within them becomes particularly relevant for estimating total caloric expenditure. Despite the growing popularity and accessibility of line dance, objective evidence describing its acute heart-rate zone distribution and metabolic demand in adult women remains limited, and the relationship between time accumulated in higher-intensity zones and total energy expenditure during structured sessions has not been sufficiently clarified.

Accordingly, this study examined the acute cardiovascular and metabolic responses during a 45-minute instructor-led line dance session in physically active women aged 30–50 years. The analysis focused on (1) the distribution of exercise duration across heart-rate training zones, (2) per-session MET estimation and caloric expenditure, and (3) the association between accumulated time in Zones 3–5 and total energy expenditure while controlling for age and body mass index (BMI). The single-session design incorporating continuous heart-rate monitoring was intentionally selected to characterize acute physiological responses and to provide detailed mapping of intensity distribution across the session. Any illustrative exercise prescription scenarios are hypothetical and based solely on accumulated activity duration; they do not constitute evidence of long-term physiological adaptation within the scope of this acute study design.

METHOD

This study employed a single-session exercise response design (also referred to as an acute bout physiological trial) to investigate the immediate cardiovascular and metabolic responses during a standardized 45-minute instructor-led line dance session. This design was selected to enable the direct and intensive measurement of physiological parameters (e.g., continuous heart rate, accelerometry) in response to a controlled exercise stimulus, without the confounding effects of long-term adaptation, intervention, or between-subject comparisons over time. It is the appropriate methodological framework for characterizing the acute physiological demands and energy cost of a specific physical activity bout, aligning precisely with the primary research aim (Wang & Cheng, 2020).

Researchers selected 30 adult women aged 30 to 50 (mean ± SD: 42.3 ± 5.8 years) from the Dharma Wanita community at Universitas Negeri Surabaya for this study. The sample size was calculated using a power analysis with a statistical power of 0.80 and a significance level of $\alpha = 0.05$. A medium effect size could be identified with this measurement alone (Serdar et al., 2020). All participants met the following criteria: they were physically active (engaged in at least 2 workouts per week for the past 3 months), free from musculoskeletal, metabolic, or cardiovascular disorders, non-smokers, and not using any substances that could influence metabolism or heart rate.

Participants were excluded if they were unable to complete the full exercise protocol or if heart rate recordings were of insufficient quality due to signal loss or non-physiological artifacts. Heart rate data were screened for potential artifacts, including abrupt spikes, dropouts, or flat-line segments associated with sensor displacement or poor skin contact. Data segments containing artifacts were removed, and participants with more than 10% invalid heart rate data during the session were excluded from the final analysis. Participants provided written consent prior to data collection, and the Sport & Exercise Research Center at Universitas Negeri Surabaya approved the study protocol.

A demographic questionnaire was distributed to begin the experiment, and the Polar H10 heart rate monitor and accelerometer (Polar Electro Oy, Finland) were calibrated. For at least 12 hours before the test, participants were advised to avoid caffeine and physically demanding activities (Francisco et al., 2025). To ensure their bodies were stable, each participant rested in silence for ten minutes after being instrumented (Notay et al., 2016). There were three sections to the line dancing class: a warm-up lasting five minutes, a main session lasting thirty-five minutes, and a cool-down lasting five minutes. Everything took forty-five minutes. The choreography followed a typical progressive routine, beginning with simple patterns and gradually increasing in complexity. To standardize and control the exercise intensity across all sessions, the accompanying music was selected to maintain a tempo within the range of 120–140 beats per minute (BPM)**,** which is associated with moderate-to-vigorous physical activity in dance-based interventions (Fong Yan et al., 2024; Schneekloth & Brown, 2018). A certified instructor from the Indonesian Line Dance Association (ILDI) Surabaya led each session to ensure safety, proper movement execution, and a progressive increase in intensity (Wahyuniati et al., 2025; Firdaus Kafrawi et al., 2025). Polar Flow software kept track of all heart rate and step data all the time, syncing the data in real time so it could be looked at later (Pramukantoro et al., 2024).

The Polar H10 sensor, with an error margin of ±1 bpm and renowned for its high accuracy compared to electrocardiography (ECG), was used to collect physiological data (Schaffarczyk et al., 2022). The average heart rate (HRavg), maximum heart rate (HRmax), and the proportion of time spent in each heart rate training zone were among the variables measured. HRmax was calculated using the ACSM formula (HRmax=220−age) (Molina et al., 2025). Training intensity was categorized into five zones as presented below:

Table 1. Classification of training intensity zones based on percentage of maximum heart rate

Zone	% HRmax	Intensity
Zone 1	50–60%	Recovery
Zone 2	60–70%	Light
Zone 3	70–80%	Moderate
Zone 4	80–90%	Vigorous
Zone 5	90–100%	Maximal

Metabolic Equivalent of Task (MET) values were initially derived from the Compendium of Physical Activities to estimate energy expenditure during line dancing, with intensity values ranging from 3.5 to 5.0 METs depending on rhythm and movement complexity (Herrmann et al., 2024). To improve individual-level accuracy, MET estimates were adjusted using an indirect heart rate–to–oxygen uptake (HR→VO_2) approach, whereby recorded heart rate responses were used to refine metabolic intensity estimates based on established linear HR–VO_2 relationships during aerobic exercise. The accelerometer recorded cumulative step counts, which were converted into distance using a stride length of 0.5 m per step, a value previously validated for field-based physical activity research (Kafrawi et al., 2025).

Data were analyzed using IBM SPSS Statistics version 28. Descriptive statistics (mean, standard deviation, and range) were calculated for all cardiovascular and metabolic variables. Multiple linear regression analysis was performed using the forced-entry (enter) method, whereby all predictors were entered simultaneously into the model, to examine the association between accumulated time spent in higher-intensity heart rate zones (Zones 3–5) and total caloric expenditure, with age and body mass index (BMI) included as covariates (Luo et al., 2023).

The assumptions of linear regression were verified: normality of residuals was assessed using the Shapiro–Wilk test, homoscedasticity using the Breusch–Pagan test, and multicollinearity was evaluated through variance inflation factors (VIF < 10). Regression results are reported as standardized beta coefficients (β), 95% confidence intervals (CI), and adjusted coefficients of determination (adjusted R^2). Statistical significance was set at $p < 0.05$.

RESULT

This study investigated the immediate cardiovascular and metabolic responses induced by a 45-minute line dance session in physically active adult women. All participants successfully adhered to the protocol without experiencing adverse events, and the data quality from the Polar H10 monitor satisfied the reliability criterion for continuous recording. Tables 2–4 and Figure 1 show both descriptive and inferential results.

Table 2. Descriptive statistics of cardiovascular and metabolic parameters during a 45-minute line dance session (n = 30)

Variable	Mean ± SD	Minimum	Maximum
Age (years)	42.3 ± 5.8	31	50
BMI (kg/m²)	24.1 ± 3.2	19.8	30.4
HR Average (bpm)	132.5 ± 10.4	115	154
HR Max (% predicted)	72.8 ± 5.6	65	85
Total Caloric Expenditure (kcal)	245.6 ± 35.2	190	310
MET Value	4.2 ± 0.6	3.3	5.4
Steps per session	4,850 ± 520	3,920	5,620
Estimated distance (km)	2.43 ± 0.26	1.96	2.81

Table 2 shows the descriptive statistics of the cardiovascular and metabolic parameters that were measured during the session. The participants' average heart rate during exercise was 132.5 ± 10.4 bpm, which is 72.8% of their age-predicted HRmax. The average MET value of 4.2 ± 0.6 is within the range for moderate-intensity exercise (3–6 METs). The average energy expenditure per session was 245.6 ± 35.2 kcal. Participants accrued approximately 4,850 steps, corresponding to an estimated distance of 2.43 km, during the 45-minute line dance session.

Table 3. Distribution of exercise time across heart rate training zones

Heart Rate Zone	% HR Max	Duration (min)	% Total Time	Intensity Category
Zone 1	50–60%	2.7 ± 1.0	5.9 ± 2.1	Recovery
Zone 2	60–70%	12.8 ± 2.4	28.5 ± 5.3	Light
Zone 3	70–80%	17.2 ± 2.8	38.2 ± 6.1	Moderate
Zone 4	80–90%	8.3 ± 2.1	18.4 ± 4.7	Vigorous
Zone 5	90–100%	4.1 ± 1.5	9.0 ± 3.2	Maximal

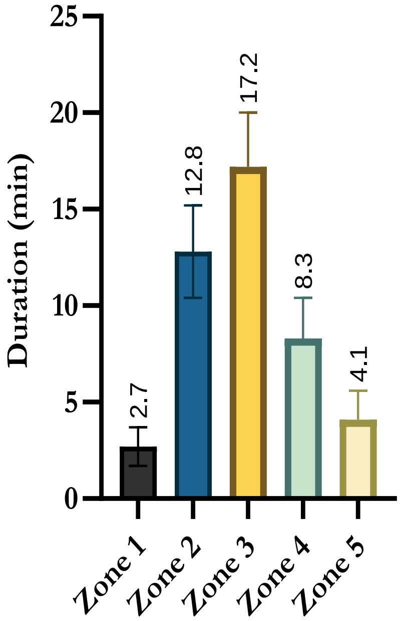

Fig 1. Distribution of Average Exercise Duration Across Heart Rate Zones During Line Dance.

Table 3 presents the distribution of time spent in each heart-rate zone, and Figure 1 illustrates the proportional allocation across zones. The largest proportion of session time was spent in Zone 3 (70–80% HRmax; 38.2 ± 6.1%), followed by Zone 2 (60–70% HRmax; 28.5 ± 5.3%) and Zone 4 (80–90% HRmax; 18.4 ± 4.7%). Participants spent minimal time in Zone 1 (<60% HRmax) and Zone 5 (>90% HRmax). The combined time accumulated in Zones 3–4 accounted for the majority of the session duration.

Table 4. Multivariate linear regression predicting total caloric expenditure

Predictor	β	95% CI	*p*-value
Time in Zone 3–5 (min)	0.68	0.52 – 0.84	<0.001***
Age (years)	-0.12	-0.29 – 0.06	0.21
BMI (kg/m²)	-0.08	-0.25 – 0.09	0.39

Model Fit: $R^2 = 0.74$; F(3,26) = 24.9; $p < 0.001$
Note: $p < 0.05$*, $p < 0.01$*, **$p < 0.001$.

The multivariate linear regression analysis showed that time spent in higher-intensity heart rate zones (Zones 3–5) was significantly associated with total caloric expenditure (β = 0.68, 95% CI [0.52–0.84], p <

0.001). Age (β = -0.12, p = 0.21) and BMI (β = -0.08, p = 0.39) were not statistically significant predictors. The model explained 74% of the variance in total caloric expenditure ($R^2 = 0.74$).

DISCUSSION

The findings of this study reveal the specific intensity profile of a typical 45-minute line dance session. Participants spent the majority of their time in Zone 3 (moderate intensity, 70–80% HRmax), accounting for 38.2% of the session, followed by substantial portions in Zone 2 (light intensity, 28.5%) and Zone 4 (vigorous intensity, 18.4%). This distribution indicates that line dancing is predominantly an aerobic, moderate-intensity activity punctuated by intermittent bursts of higher-intensity effort (Zones 4 and 5). The low time spent in Zone 1 (recovery) suggests minimal passive intervals, resulting in a sustained cardiovascular load throughout the session. The average intensity of 72.8% HRmax and the mean MET value of 4.2 confirm that the session reached moderate-to-vigorous physical activity (MVPA) intensity. The observed pattern, prolonged moderate-intensity effort interspersed with vigorous micro-bursts, resembles interval-based structures known to enhance cardiorespiratory stimulation and caloric expenditure efficiently. Accordingly, the acute energy expenditure of approximately 246 kcal per session can be attributed to this temporal distribution of intensity, in which cumulative time spent above the aerobic threshold (Zone 3 and beyond) drives metabolic demand (Warot & Zukow, 2025).

A key mechanistic finding from the present data is the strong positive association between total caloric expenditure and time accumulated in moderate-to-high intensity zones (Zones 3–5), as reflected by the standardized regression coefficient (β = 0.68) and explained variance ($R^2 = 0.74$). This pattern aligns with established physiological principles, indicating that exercise intensity, as indexed by heart rate or ventilatory threshold indicators, substantially influences individual differences in energy expenditure during aerobic activities (Benítez-Muñoz et al., 2025; Mulya, Rahmawati, and Rahim, 2024). Maintaining effort above the aerobic threshold, typically corresponding to Zone 3, increases oxygen consumption and energy turnover per minute (Sulaeman & Hasyim, 2022). Intermittent exposure to Zones 4–5 further elevates energy demand due to greater anaerobic contribution and post-exercise oxygen consumption (Piko et al., 2019). These findings support the observed association between heart-rate zone distribution and estimated energy expenditure during line dance sessions and reinforce the analytical value of heart-rate monitoring for describing intensity-dependent metabolic cost (Hansen et al., 2022).

From a physiological standpoint, participants spent a substantial proportion of the session at or above 70% HRmax, reflecting sustained moderate-to-vigorous cardiovascular intensity. Heart-rate responses within this range are consistently associated with elevated oxygen uptake and increased metabolic demand during dynamic exercise (Yahat, 2025). The predominance of exposure within Zones 3 and 4, therefore, indicates a meaningful acute aerobic stimulus rather than sporadic peaks of effort. Monitoring time spent in specific heart-rate zones provides a structured framework for quantifying within-session physiological strain and characterizing the internal training load imposed by structured dance-based exercise. The association between accumulated time in higher-intensity zones and caloric expenditure further supports the internal coherence of the observed intensity profile without extending interpretation beyond the acute experimental design.

Several methodological considerations should be acknowledged. Heart-rate zone classification based on age-predicted HRmax (220 − age) may misclassify individual physiological thresholds (Neufeld et al., 2019). Such misclassification could shift zone boundaries, alter estimated time accumulation within Zones 3–5, and consequently influence total energy expenditure calculations. Although threshold-based or HRV-derived methods may provide more individualized calibration, the present approach reflects common field-based practice. Caloric expenditure was estimated using MET conversions combined with heart-rate and accelerometer data rather than direct calorimetry. At the same time, widely applied and reasonably valid for group-level comparisons, this method may introduce individual-level estimation error (Morouço et al., 2025). Finally, the cross-sectional acute design limits interpretation to immediate cardiovascular and metabolic responses. Future investigations incorporating repeated-session designs, individualized threshold calibration, and direct fitness measurements may enhance precision in intensity classification and energy expenditure modeling within dance-based exercise contexts.

CONCLUSION

This study characterized the acute cardiovascular and metabolic responses elicited during a single 45-minute instructor-led line dance session in physically active middle-aged women. The session was marked by an average exercise intensity of 72.8 ± 5.6% of age-predicted HRmax, with the majority of time spent in moderate (Zone 3, 70–80% HRmax) and vigorous (Zone 4, 80–90% HRmax) heart rate zones and minimal exposure to recovery and maximal zones. This intensity distribution resulted in an acute energy expenditure of 245.6 ± 35.2 kcal per session, with a mean MET value of 4.2 ± 0.6.

Multivariate regression analysis demonstrated that time accumulated in higher-intensity zones (Zones 3–5) significantly predicted total caloric expenditure ($\beta = 0.68$, $p < 0.001$), explaining 74% of the variance after controlling for age and BMI. These findings provide an objective description of heart rate zone distribution and energy cost during a structured line dance session, reflecting its immediate cardiorespiratory and metabolic demands. As the investigation used a single-session design, the results reflect acute physiological responses and do not permit inference about long-term training adaptations or health outcomes. Future studies employing longitudinal designs and direct physiological measurements are required to examine adaptations associated with repeated participation.

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