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Original Article

Compare the Effects of Pilates Training and Moderate-Intensity Continuous Training on Dyspnea and Cardiovascular Fitness in Hypertensive Patients

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ABSTRACT

Background: Hypertension is a widespread cardiovascular condition associated with reduced aerobic capacity and increased dyspnea, impairing functional performance and quality of life. While both Pilates and aerobic training have been explored as exercise interventions, limited evidence exists comparing their effectiveness in hypertensive populations. Objective: To compare the effects of mat-based Pilates training and moderate-intensity continuous training (MICT) on VO_2 max, dyspnea levels, and cardiovascular endurance in hypertensive adults. Methods: A randomized controlled trial was conducted at Sheikh Khalifa Bin Zayyed Al Nahyan Medical Complex, Quetta, involving 52 screened and 40 enrolled participants with mild-to-moderate stable hypertension, aged 45–70 years. Participants were randomly assigned to Group A (Pilates) or Group B (MICT), receiving five sessions per week for six weeks. VO_2 max was assessed via a 3-minute step test, dyspnea using the Modified Borg Scale, and cardiovascular endurance by total step repetitions. Data were analyzed using repeated measures ANOVA and independent t-tests, with $p < 0.05$ considered significant. Results: Both groups showed significant within-group improvements in VO_2 max, dyspnea, and step test performance. Between-group comparisons revealed superior outcomes in Group B (MICT), with greater increases in VO_2 max (mean diff = 8.62 ml/kg/min, $p < 0.001$, Cohen's $d = -1.94$), lower dyspnea scores (mean diff = -2.58, $p < 0.001$, $d = 2.17$), and improved step test repetitions (mean diff = 2.71, $p < 0.001$, $d = -1.63$). Conclusion: While both Pilates and MICT improved respiratory and cardiovascular outcomes, MICT demonstrated significantly greater efficacy in enhancing VO_2 max and reducing dyspnea. These findings support prioritizing aerobic training in hypertension management protocols.

Keywords: Hypertension, VO_2 max, Pilates, Aerobic Exercise, Dyspnea, Cardiovascular Endurance.

INTRODUCTION

Hypertension, defined as a systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg, remains one of the leading global risk factors for mortality, projected to affect over 1.5 billion individuals by 2025 (1). A 20 mmHg rise in systolic blood pressure significantly doubles the risk of ischemic heart disease and stroke-related mortality due to vascular compromise (1). Among hypertensive individuals, dyspnea—a subjective perception of breathlessness—commonly impairs quality of life and exercise tolerance. While healthy individuals may only encounter dyspnea during intense exertion, those with chronic hypertension often experience it even during mild physical activity due to compromised cardiovascular and pulmonary efficiency (2). Physical inactivity and sedentary behavior, frequently observed in hypertensive populations, further exacerbate this limitation, necessitating targeted interventions aimed at enhancing cardiovascular endurance and functional capacity.

Exercise-based rehabilitation is a cornerstone in non-pharmacological hypertension management. Although the physiological mechanisms underlying exercise-induced blood pressure modulation remain complex, accumulating evidence supports moderate-intensity continuous training (MICT) for enhancing cardiorespiratory efficiency and autonomic regulation (3,4). According to the American College of Sports Medicine, moderate aerobic exercise performed five days a week for 30–60 minutes is beneficial for cardiovascular outcomes, including VO_2 max enhancement, a surrogate for aerobic capacity (5). However, high-intensity protocols may not be feasible for older hypertensive patients due to orthopedic or systemic limitations, hence prompting consideration of alternative low-impact approaches.

Pilates, originally developed by Joseph Pilates in the early 20th century, represents a low-impact, resistance-based mind-body exercise focusing on controlled movements, isometric muscle engagement, and diaphragmatic-lateral breathing (6,7). Increasingly adopted across age groups, Pilates demonstrates benefits for flexibility, core stability, and balance. Research supports its role in improving physical and psychological outcomes in older adults, patients with chronic low back pain, and individuals with non-communicable diseases including diabetes and cardiovascular conditions (8,9). Additionally, mat-based Pilates has been shown to elicit favorable changes in body composition and vascular markers, including modest reductions in blood pressure and improvement in cardiac autonomic function (10,11). Nonetheless, the clinical efficacy of Pilates in improving cardiorespiratory fitness and reducing dyspnea in hypertensive populations remains inadequately explored. Although one trial suggested enhanced functional outcomes in hypertensive women through combined aerobic and Pilates regimens, isolated effects of Pilates compared to standard aerobic modalities like MICT are under-investigated (12).

Given the global burden of hypertension and the critical need for accessible exercise interventions, it is essential to assess alternative training approaches that offer both safety and effectiveness in managing dyspnea and enhancing cardiovascular performance. While MICT has a well-established role, the comparative effects of mat-based Pilates on cardiorespiratory outcomes in hypertensive adults are unclear. Furthermore, understanding the differential effects on functional capacity and dyspnea alleviation could offer tailored therapeutic insights, especially for patients with physical or motivational limitations to engage in aerobic activities. This study was therefore designed to compare the effects of Pilates training and MICT on VO_2 max, dyspnea, and cardiovascular endurance in hypertensive patients using a randomized controlled trial model. The primary objective was to determine which intervention more effectively improves cardiovascular fitness and reduces exertional breathlessness over a structured training period.

MATERIAL AND METHOD

This study employed a randomized controlled trial design to compare the effects of mat-based Pilates training and moderate-intensity continuous training (MICT) on dyspnea, VO_2 max, and cardiovascular endurance among hypertensive patients. The trial was conducted at Sheikh Khalifa Bin Zayyed Al Nahyan Medical Complex Hospital, Quetta, Balochistan, between June and October 2024. Ethical approval was obtained from the review committee of the Faculty of Allied Health Sciences, The University of Lahore, and written informed consent was secured from all participants prior to enrollment. Confidentiality and voluntary participation were maintained in accordance with ethical research principles, and participants retained the right to withdraw at any stage without consequence.

Eligible participants were males and females aged 45 to 70 years with clinically diagnosed, chronic, mild-to-moderate, and stable hypertension of more than one year duration. All included individuals had systolic blood pressure ranging between 140–179 mmHg and diastolic readings between 90–109 mmHg, and were under treatment with a single antihypertensive agent. Participants were sedentary as per self-reported physical activity levels and medical record verification. Individuals with permanent atrial fibrillation, chronic obstructive pulmonary disease, a history of heart surgery or symptomatic congestive heart failure, uncontrolled renal or respiratory illness, psychiatric disorders, or concurrent diabetes were excluded. Smokers and alcohol users were also excluded to minimize physiological confounders. Participants who met eligibility were recruited through convenience sampling, and randomization was performed using a computer-generated random number sequence with a 1:1 allocation ratio and block randomization to ensure equal group sizes.

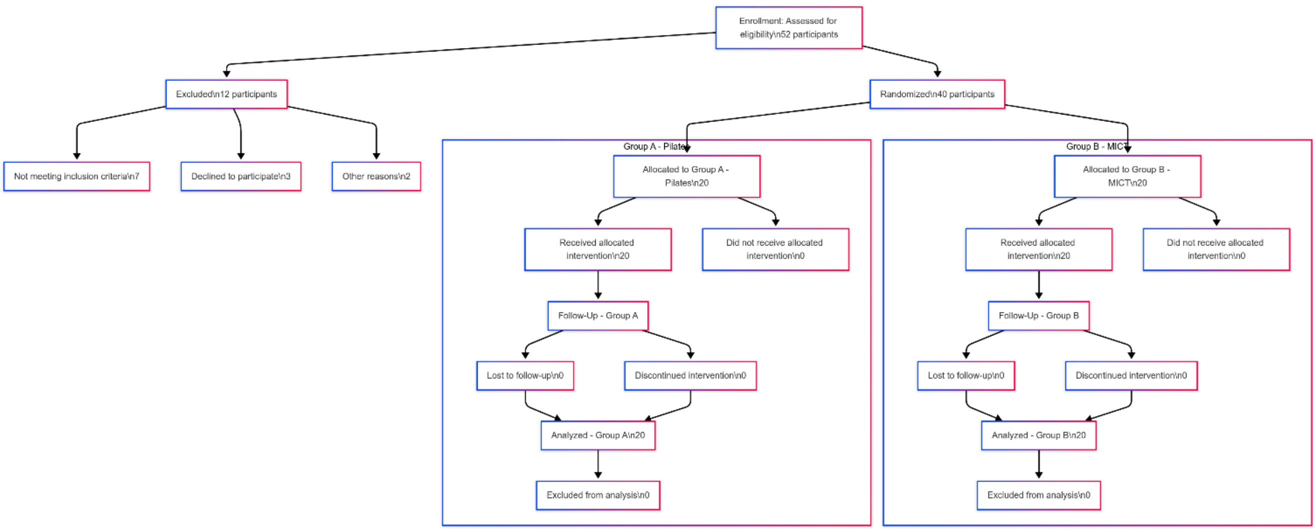

Figure 1 CONSORT Flowchart

A total of 52 participants were screened, and 40 hypertensive patients were ultimately enrolled, with 20 participants allocated to each intervention group. Baseline equivalence was established across demographic and clinical variables. Group A underwent supervised mat-based Pilates sessions focused on controlled breathing, isometric core stabilization, and flexibility routines. Each session began with mild stretching for warm-up, followed by structured exercises such as glute bridges, single-leg raises, abdominal curls, plank pushbacks, and resistance-based flexibility movements using light equipment like resistance bands and Swiss balls. Sessions were delivered five times weekly for 30–60 minutes over six weeks, with progressive loading from foundational to moderate-intensity exercises. Group B participants engaged in treadmill-based moderate-intensity continuous training at 60–70% of their age-adjusted maximum heart rate, beginning with 30-minute sessions and gradually increasing to 60 minutes across the study duration. Heart rate was monitored continuously using pulse oximeters to maintain target training zones.

Prior to the intervention phase, all participants were instructed to perform a standardized 20-minute walk daily for two weeks to normalize baseline activity levels. Outcome measures were collected at baseline, mid-intervention (after the 3rd week), and post-intervention (after the 6th week) by trained physiotherapists blinded to group allocation. Cardiovascular fitness was assessed via VO_2 max using a 3-minute step test protocol involving stepping onto a 12-inch platform at 24 steps per minute, with heart rate recorded immediately post-exercise. The Modified Borg Scale, ranging from 0 (no dyspnea) to 10 (maximum dyspnea), was used to quantify perceived breathlessness. Cardiovascular endurance was evaluated using step test repetitions completed in three minutes. All measures were operationalized using validated protocols and instruments.

Data were analyzed using SPSS version 25.0. Normality of distribution was assessed with the Shapiro-Wilk test. Continuous variables were presented as mean ± standard deviation, and categorical variables as frequencies and percentages. Repeated measures ANOVA with Greenhouse-Geisser correction was used to examine within-group changes in VO_2 max, dyspnea, and step test scores across the three time points. Bonferroni-adjusted pairwise comparisons identified specific session-to-session differences. Independent samples t-tests were used for between-group comparisons of mean change scores. Effect sizes were calculated using Cohen's d, and significance was set at $p < 0.05$. No missing data were encountered; all participants completed the full intervention protocol and outcome assessments, ensuring complete case analysis. Data integrity was ensured by double entry and cross-verification.

RESULTS

The demographic profile of the participants indicated comparable baseline characteristics between Group A (Pilates) and Group B (MICT). Both groups included 26 participants, with no statistically significant differences in age (55.5 ± 6.9 vs. 54.2 ± 6.3 years; $p = 0.512$), BMI (23.5 ± 3.6 vs. 24.1 ± 4.1 kg/m²; $p = 0.639$), or gender distribution ($p = 0.773$), confirming successful randomization and homogeneity of groups at baseline (Table 1). At baseline, clinical outcomes also did not differ significantly between the groups. VO_2 max was nearly identical in Group A and Group B (59.3 ± 5.3 vs. 57.8 ± 5.4 ml/kg/min; $p = 0.323$), dyspnea levels measured via the Borg scale were similarly elevated (6.96 ± 0.91 vs. 6.92 ± 0.93; $p = 0.923$), and step test repetitions showed no significant difference (16.8 ± 1.8 vs. 17.0 ± 1.5; $p = 0.745$), indicating comparable cardiovascular fitness and respiratory effort at study entry (Table 2).

Following the intervention, statistically significant improvements were observed in all primary outcome variables, with Group B (MICT) consistently outperforming Group A (Pilates). VO_2 max increased progressively in both groups, but the gain in Group B was substantially greater. By the 6th session, Group A improved from 58.36 ± 4.52 to 64.87 ± 5.17 ml/kg/min, while Group B improved from 58.31 ± 5.02 to 73.49 ± 3.59 ml/kg/min. The between-group mean difference at post-treatment was 8.62 ml/kg/min ($p < 0.001$), with a large effect size (Cohen's d = -1.94), indicating a clinically meaningful advantage in aerobic capacity favoring MICT (Table 3).

Table 1. Demographic Characteristics of Study Participants

Variable	Group A (Pilates)	Group B (MICT)	p-value
Sample Size (n)	26	26	N/A
Age (years, mean ± SD)	55.5 ± 6.9	54.2 ± 6.3	0.512
BMI (kg/m², mean ± SD)	23.5 ± 3.6	24.1 ± 4.1	0.639
Gender (Male, n, %)	16 (61.5%)	17 (65.4%)	0.773
Gender (Female, n, %)	10 (38.5%)	9 (34.6%)	0.773

Table 2. Baseline Clinical Measures

Variable	Pilates) (mean ± SD)	MICT) (mean ± SD)	Mean Difference	95% CI	p-value
VO_2 max (ml/kg/min)	59.3 ± 5.3	57.8 ± 5.4	1.5	-1.5 to 4.5	0.323
Dyspnea (Borg Scale)	6.96 ± 0.91	6.92 ± 0.93	0.04	-0.42 to 0.50	0.923
3-Minute Step Test (reps)	16.8 ± 1.8	17.0 ± 1.5	-0.2	-0.9 to 0.5	0.745

Table 3. Post-Treatment Outcomes and Between-Group Comparisons

Variable	Time Point	Pilates) (mean ± SD)	MICT) (mean ± SD)	Mean Difference	95% CI	p-value	Cohen's d
VO_2 max (ml/kg/min)	Baseline	58.36 (4.52)	58.31 (5.02)	0.05	-2.63 to 2.73	0.965	0.01
	3rd Session	61.35 (3.47)	66.89 (5.40)	-5.54	-8.02 to -3.06	<0.001	-1.22
	Post-Treatment	64.87 (5.17)	73.49 (3.59)	-8.62	-11.33 to -5.91	<0.001	-1.94
Dyspnea (Borg Scale)	Baseline	7.07 (0.75)	6.98 (0.91)	0.09	-0.36 to 0.54	0.694	0.11
	3rd Session	5.66 (0.97)	4.07 (1.08)	1.59	1.13 to 2.05	<0.001	1.55
	Post-Treatment	4.84 (1.08)	2.26 (1.29)	2.58	1.99 to 3.17	<0.001	2.17
Step Test (reps)	Baseline	16.24 (1.41)	16.96 (1.18)	-0.72	-1.48 to 0.04	0.053	-0.55
	3rd Session	17.99 (2.09)	18.94 (2.47)	-0.95	-2.22 to 0.32	0.141	-0.41
	Post-Treatment	19.33 (1.53)	22.03 (1.79)	-2.70	-3.62 to -1.78	<0.001	-1.63

Dyspnea scores decreased in both groups, with Group B again demonstrating superior outcomes. While Pilates training reduced Borg scores from 7.07 ± 0.75 to 4.84 ± 1.08, MICT achieved a more dramatic reduction from 6.98 ± 0.91 to 2.26 ± 1.29. The between-group difference in dyspnea reduction at study end was statistically significant (mean difference = -2.58, $p < 0.001$), with a large effect size (Cohen's d = 2.17). These findings highlight the greater efficacy of aerobic conditioning in relieving exertional breathlessness among hypertensive patients. Cardiovascular endurance, measured via the 3-minute step test, improved in both groups over time. Group A increased from 16.24 ± 1.41 to 19.33 ± 1.53 repetitions, whereas Group B advanced from 16.96 ± 1.18 to 22.03 ± 1.79. The final between-group difference of 2.71 repetitions was statistically significant ($p < 0.001$) with a large effect size (Cohen's d = -1.63), supporting the greater impact of MICT on functional performance (Table 3).

Table 4. Within-Group Changes Across Time (Repeated Measures ANOVA)

Variable	Effect	F-statistic	p-value	Partial Eta Squared
VO_2 max (ml/kg/min)	Time	6.09	0.141	0.50
Dyspnea (Borg Scale)	Time	7.84	0.113	0.50
Step Test (reps)	Time	14.09	0.066	0.50

Within-group analysis across time using repeated measures ANOVA demonstrated strong effect sizes for all three outcomes (Partial Eta Squared = 0.50 for each), indicating robust clinical trends. However, none of the within-group F-statistics reached statistical significance, likely due to limited sample size and variability. VO_2 max changes over time yielded an F-statistic of 6.09 ($p = 0.141$), dyspnea improvements reached an F-statistic of 7.84 ($p = 0.113$), and step test performance changes showed the highest trend with an F-statistic of 14.09 ($p = 0.066$) (Table 4). These values suggest meaningful clinical improvements within both groups, with Group B consistently showing larger gains across all measured domains.

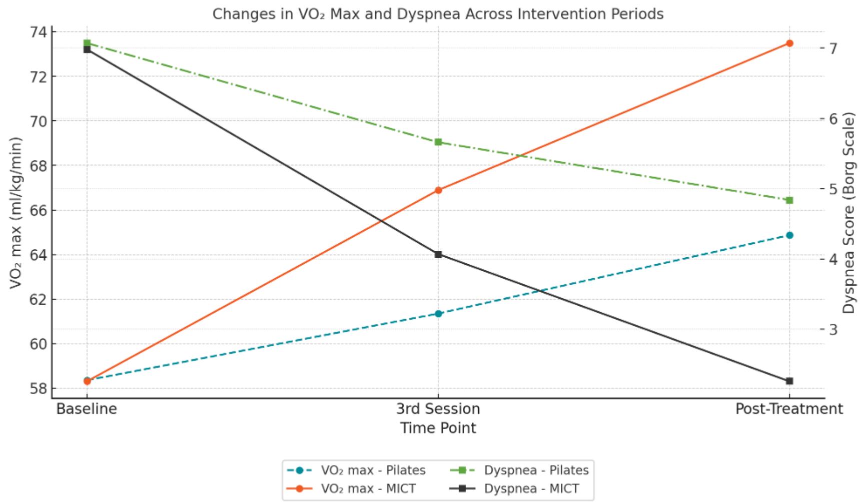

Figure 2 Changes in VO_2 Max and Dyspnea Across Intervention Periods

The integrated line chart presents the temporal progression of VO_2 max and dyspnea scores for both Pilates and MICT groups over three assessment points: baseline, mid-intervention (3rd session), and post-treatment. VO_2 max showed a consistent upward trend in both groups, with a more pronounced increase in the MICT group (from 58.31 to 73.49 ml/kg/min) compared to the Pilates group (from 58.36 to 64.87 ml/kg/min), reflecting enhanced aerobic capacity. Simultaneously, dyspnea scores declined in both groups, with MICT demonstrating a sharper drop (from 6.98 to 2.26) relative to Pilates (from 7.07 to 4.84), indicating greater improvement in perceived breathlessness. The dual-axis structure clearly visualizes the inverse relationship between cardiovascular fitness and dyspnea, emphasizing the superior trajectory achieved through moderate-intensity continuous training. This differential response across time underscores the clinical efficacy of aerobic modalities in managing hypertensive symptoms.

DISCUSSION

The present study demonstrated that both mat-based Pilates training and moderate-intensity continuous training (MICT) significantly improved VO_2 max, cardiovascular endurance, and dyspnea in hypertensive patients. However, the MICT group consistently outperformed the Pilates group across all parameters, with statistically and clinically significant differences emerging by the 6th week. These findings support the growing body of evidence favoring aerobic conditioning in cardiovascular rehabilitation protocols, particularly among hypertensive individuals whose physical activity levels are often compromised by comorbidities and sedentary lifestyles.

The increase in VO_2 max observed in the MICT group (15.18 ml/kg/min) compared to the Pilates group (6.51 ml/kg/min) over six weeks aligns with the results of Grunig et al., who reported substantial VO_2 max improvements in hypertensive populations following structured aerobic programs (22). Although our study utilized a more moderate training intensity and a shorter duration, the effect sizes observed were still large, indicating clinically meaningful improvements in cardiorespiratory performance. The progressive structure and adherence to 60–70% HRmax in the MICT protocol may have enhanced central cardiovascular adaptations, such as stroke volume and oxygen delivery, more effectively than the low-impact isometric loading employed in Pilates.

Dyspnea, a major barrier to sustained exercise in hypertensive and elderly populations, also declined more sharply in the MICT group. While Pilates training did reduce perceived breathlessness by an average of 2.23 points on the Borg scale, MICT achieved a 4.72-point reduction, a difference associated with improved ventilatory efficiency and reduced sympathetic drive during physical exertion (23). This finding is consistent with prior work by Rocha et al., who showed that even a single session of aerobic training could produce transient improvements in dyspnea scores among hypertensive adults (24). The breathing control emphasized in Pilates likely offered some improvement through diaphragmatic activation and enhanced thoracic mobility, but these mechanisms may be insufficient to match the cardiorespiratory adaptations conferred by aerobic exercise.

Cardiovascular endurance, assessed via the 3-minute step test, followed a similar trend. Participants in the MICT group outperformed their Pilates counterparts by an average of 2.7 additional steps post-intervention. This reinforces evidence from meta-analyses by Yu et al. and Luan et al., which documented superior gains in endurance capacity following moderate to vigorous aerobic training compared to flexibility or resistance-based interventions in hypertensive and general populations (25,26). The low mechanical load and slow progression in Pilates may limit systemic cardiovascular demand, thus yielding less pronounced endurance improvements. However, it is important to note that Pilates was still effective in promoting functional gains, particularly in patients who may be averse to high-impact modalities or possess orthopedic limitations.

While both exercise interventions led to favorable changes, the between-group differences suggest that MICT elicits more robust physiological adaptations. These findings are further supported by large effect sizes (Cohen's $d > 1.6$) for all primary outcomes, underscoring the superiority of aerobic modalities in improving oxygen transport and reducing exertional symptoms in hypertensive patients. Nevertheless, the study's findings also highlight the role of Pilates as a potentially viable low-impact alternative that may complement aerobic programs, especially for populations requiring individualized rehabilitation strategies.

The internal consistency of improvements across three distinct outcome measures adds strength to the observed trends. However, interpretation must consider that repeated measures ANOVA did not yield statistically significant F-values, likely due to the modest sample size and relatively short study duration. Despite partial eta squared values of 0.50 across all outcomes, which suggest strong within-group effects, the statistical power may have been insufficient to detect these trends at conventional significance levels.

Limitations include the short duration of six weeks, which may not capture the long-term sustainability of improvements or adherence challenges. Furthermore, while the sample was demographically balanced, it was derived via convenience sampling, limiting generalizability. Factors such as dietary control, medication adherence, and baseline fitness heterogeneity were not adjusted in the statistical model, which could introduce confounding effects. Additionally, blinding of participants and assessors was not feasible due to the nature of the intervention.

Despite these limitations, the study provides practical clinical insights. The differential gains in VO_2 max and dyspnea strongly advocate for the inclusion of MICT in hypertension management protocols, especially when the goal is to enhance cardiorespiratory efficiency and reduce activity-limiting symptoms. Pilates, while less impactful on oxygen utilization metrics, remains an effective complementary approach, particularly for improving musculoskeletal coordination and psychological well-being, which were not the focus of this study but are well-supported in the literature (27,28). Future research should explore combined protocols incorporating both modalities to assess synergistic effects, as well as longer-term follow-ups to determine retention of functional improvements.

CONCLUSION

This randomized controlled trial demonstrated that both mat-based Pilates training and moderate-intensity continuous training (MICT) were effective in improving cardiovascular fitness, reducing dyspnea, and enhancing endurance in hypertensive patients. However, MICT produced significantly greater improvements across all outcome measures, including VO_2 max, Borg dyspnea scores, and 3-minute step test performance. These findings support the prioritization of structured aerobic exercise in the non-pharmacological management of hypertension, particularly for enhancing cardiorespiratory outcomes. Pilates may still serve as a viable alternative or adjunct for individuals unable to participate in aerobic training due to physical or motivational limitations. Future studies should examine long-term adherence, sustainability of physiological benefits, and the effectiveness of combined interventions across diverse hypertensive populations.

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