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Effectiveness of Fartlek Training on Maximum Oxygen Consumption and Resting Pulse Rate in Relay Runners

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ABSTRACT
Background: Relay running requires a combination of high-intensity effort, aerobic support, cardiovascular efficiency, and rapid recovery between repeated efforts. Fartlek training, or "speed play," alternates running intensity within a continuous session and may therefore match the physiological demands of relay athletes. Objective: To evaluate the effect of a six-week Fartlek training program on maximum oxygen consumption (VO_2max) and resting pulse rate (RPR) in relay runners and to compare the magnitude of adaptation with conventional high-intensity interval training. Methods: A randomized controlled, parallel-group study was conducted with 40 relay runners aged 18–30 years. Participants were allocated to a Fartlek Training Group (n=20) or a Conventional Training Group (n=20). Training was undertaken three times per week. VO_2max was estimated using the Queen College Step Test and RPR was measured using a pulse oximeter after a standardized quiet-rest period. Pre-test and post-test values were analyzed with paired t-tests, between-group comparisons with independent t-tests, and practical magnitude with Cohen's d. Results: The Fartlek group increased VO_2max from 44.82±6.21 to 48.91±5.84 ml/kg/min (+4.09; +9.13%; $p<0.001$) and reduced RPR from 72.45±5.23 to 66.20±4.81 bpm (−6.25; −8.63%; $p<0.001$). The conventional group also improved significantly, with VO_2max increasing by 2.46 ml/kg/min (+5.45%) and RPR decreasing by 3.45 bpm (−4.81%) (both $p<0.001$). Absolute post-test differences were not statistically significant; however, change-score analysis favored Fartlek training for VO_2max ($p=0.016$, $d=0.80$) and RPR ($p=0.013$, $d=-0.83$). Conclusion: Six weeks of structured Fartlek training produced significant and practically meaningful improvements in aerobic capacity and resting cardiovascular efficiency in relay runners, with greater change-score improvements than conventional interval training.

Keywords: Fartlek training; maximum oxygen consumption; resting pulse rate; relay runners; VO_2max; randomized controlled trial.

1. INTRODUCTION
Performance in relay running depends on more than sprint speed alone. Athletes must repeatedly tolerate high-intensity work while recovering effectively between efforts, and the relative contribution of aerobic metabolism becomes increasingly important as running distance and recovery demands increase. Maximum oxygen consumption (VO_2max) is a central indicator of aerobic capacity, while resting pulse rate (RPR) reflects cardiovascular efficiency and autonomic adaptation. Both measures are therefore relevant to the preparation and monitoring of relay runners [2–5].

Fartlek training was developed as a variable-intensity endurance method in which faster surges are interspersed with easier running within a continuous session. Unlike rigid interval training, Fartlek sessions allow intensity to vary according to perceived effort and, when applicable, terrain. This combination of sustained aerobic work and intermittent high-intensity effort can stimulate both oxidative and glycolytic energy systems and may reduce the monotony associated with highly standardized training [1,6,7].

Physiologically, improvements in VO_2max following endurance and high-intensity training are associated with adaptations in cardiac output, stroke volume, skeletal-muscle oxidative capacity, capillary supply, and mitochondrial function [9,10,14,15]. Reductions in resting heart rate after endurance training are commonly related to increased parasympathetic influence and improved stroke-volume efficiency [11]. Because relay events impose repeated high-intensity demands with incomplete or variable recovery, a training method that develops aerobic capacity while repeatedly changing running intensity has a strong theoretical rationale [3,16].

Previous work has demonstrated beneficial effects of Fartlek training in soccer players, recreational football players, and other athletic populations [12,13]. However, the thesis on which this article is based identified a specific evidence gap regarding relay runners and the simultaneous evaluation of VO_2max and resting pulse rate. The present study therefore compared a structured Fartlek intervention with conventional high-intensity interval training in relay runners.

1.1 Aim and Objectives

The aim was to evaluate the effects of Fartlek training on maximum oxygen consumption and resting pulse rate in relay runners.

- To determine the effect of Fartlek training on VO_2max in relay runners.
- To determine the effect of Fartlek training on resting pulse rate in relay runners.
- To compare physiological changes produced by Fartlek training with those produced by conventional high-intensity interval training.

1.2 Hypothesis

The null hypothesis stated that Fartlek training would have no effect on maximum oxygen consumption and resting pulse rate in relay runners. The alternate hypothesis stated that Fartlek training would affect these physiological outcomes.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

The investigation used an experimental randomized controlled, parallel-group, two-arm design. Participants were recruited from People's University, Bhopal, Madhya Pradesh, India. Forty eligible relay runners were randomly allocated using a computer-generated sequence to either the Conventional Training Group (n=20) or the Fartlek Training Group (n=20). The overall study period included recruitment, screening, baseline assessment, training, post-intervention assessment, data analysis, and interpretation; the training intervention itself was described in the thesis as a six-week program.

2.2 Participants

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Both male and female relay athletes aged 18–30 years were eligible. Participants were required to provide written informed consent and to have at least one year of continuous participation in organized athletic training and competition. Exclusion criteria included unwillingness to participate, serious uncontrolled medical conditions, current or recent musculoskeletal injury or persistent back pain, neurological deficits affecting motor control or autonomic function, and cardiovascular or systemic illness capable of influencing exercise capacity or heart-rate responses.

2.3 Ethical Considerations

The research protocol received prior approval from the Ethical Committee of People's College of Paramedical Sciences and Research Centre (PCPS&RC), People's University, Bhopal. Participants received information regarding the study purpose, procedures, potential risks and benefits, and their right to withdraw. Written informed consent was obtained before study-related procedures, and the thesis states that the work was conducted in accordance with the Declaration of Helsinki.

2.4 Outcome Measures

The two primary outcomes were maximum oxygen consumption (VO_2max) and resting pulse rate (RPR). Both outcomes were assessed at baseline and after completion of the intervention.

2.4.1 Maximum Oxygen Consumption (VO_2max)

VO_2max was estimated using the Queen College Step Test on a 16.25-inch (41.3-cm) step bench. Male participants stepped for three minutes at 24 cycles per minute, maintained with a 96-beat-per-minute cadence, while female participants stepped for three minutes at 22 cycles per minute, maintained with an 88-beat-per-minute cadence. Post-exercise radial pulse was recorded during the first minute of recovery. The thesis used the following sex-specific prediction equations: males, VO_2max (ml/kg/min) = 111.33 − [0.42 × post-exercise heart rate]; females, VO_2max (ml/kg/min) = 65.81 − [0.1847 × post-exercise heart rate].

2.4.2 Resting Pulse Rate

RPR was measured non-invasively using a finger pulse oximeter. Participants sat quietly for at least 10 minutes in a comfortable environment before measurement. The sensor was placed on the index finger and the pulse rate was recorded in beats per minute after the displayed value stabilized.

Figure 1. Measurement of resting pulse rate

2.5 Training Interventions

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Both groups trained three times per week with recovery between sessions. The Fartlek program included a 10–15 minute low-intensity warm-up with dynamic stretching, a 20–30 minute continuous variable-intensity main session, and a 10–15 minute cool-down with walking and static stretching. During the main session, participants alternated high-intensity running at approximately 80–90% of age-predicted maximum heart rate with active recovery at approximately 50–60% of maximum heart rate. The sequence and duration of surges were deliberately flexible and guided by perceived effort and, when applicable, terrain.

The Conventional Training Group completed a six-week conventional high-intensity interval training program. The session structure was comparable in overall format and included warm-up, main training, and cool-down, but the main component used interval-based rather than continuous variable-pace training. Training logs were maintained to document attendance, session duration, perceived intensity, distance covered, and adverse events.

2.6 Statistical Analysis

Continuous variables were summarized using mean and standard deviation. Normality was examined with the Shapiro–Wilk test and supported by visual assessment in the thesis. Paired t-tests were used for pre-test to post-test comparisons within each group, while independent samples t-tests were used for between-group comparisons. Absolute change scores (Δ = post-test − pre-test) were compared between groups to evaluate differential adaptation. Cohen's d was used to describe practical effect magnitude, with approximately 0.20, 0.50, and 0.80 interpreted as small, medium, and large effects. Statistical significance was set at two-tailed $p<0.05$.

3. RESULTS

3.1 Participant Flow, Compliance, and Baseline Characteristics

All 40 randomized participants completed both pre-test and post-test assessments and were included in the per-protocol analysis. Mean attendance was 94.2% in the Fartlek group and 92.8% in the Conventional group. No adverse event requiring participant withdrawal was reported. Baseline demographic and anthropometric characteristics were comparable between groups.

Table 1. Baseline Demographic and Anthropometric Characteristics of Participants

Variable	Fartlek Training Group (n=20)	Conventional Training Group (n=20)	Total Sample (n=40)
Age (years)	23.4 ± 3.1	24.1 ± 2.8	23.8 ± 2.9
Male, n (%)	12 (60%)	11 (55%)	23 (57.5%)
Female, n (%)	8 (40%)	9 (45%)	17 (42.5%)
Height - Male (cm)	174.2 ± 5.8	175.1 ± 6.2	174.6 ± 5.9
Height - Female (cm)	162.4 ± 4.9	163.1 ± 5.3	162.7 ± 5.0
Weight - Male (kg)	68.5 ± 7.2	69.8 ± 8.1	69.1 ± 7.6
Weight - Female (kg)	55.2 ± 5.1	56.4 ± 4.8	55.8 ± 4.9

BMI - Male (kg/m²)	22.6 ± 1.9	22.8 ± 2.1	22.7 ± 2.0
BMI - Female (kg/m²)	20.9 ± 1.4	21.2 ± 1.6	21.1 ± 1.5

Values are Mean ± SD unless otherwise stated. BMI = body mass index.

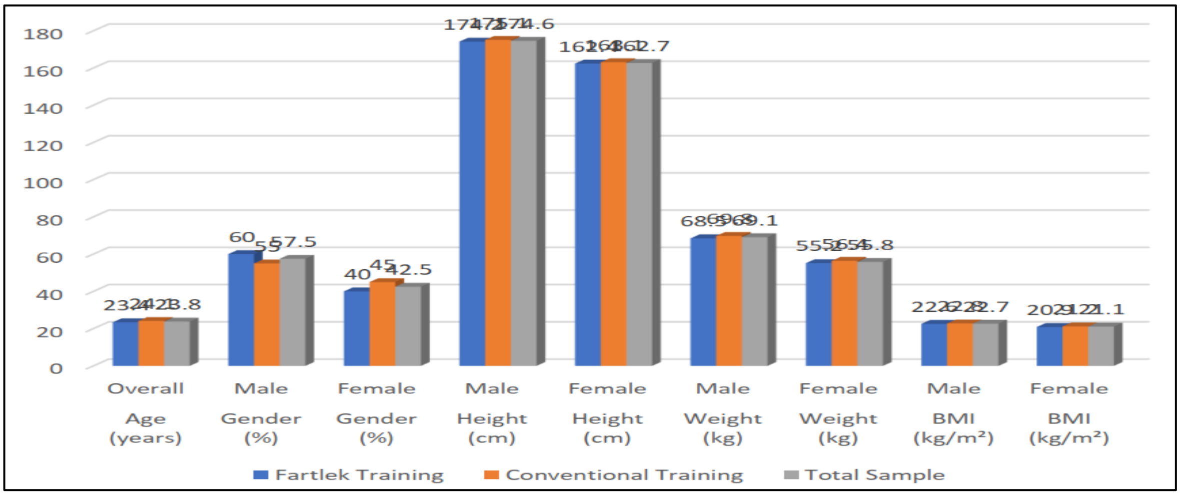

Figure 2. Baseline Demographic and Anthropometric Characteristics of Participants

3.2 Normality and Baseline Outcome Comparability

Shapiro–Wilk p-values for VO_2max and RPR at both time points were greater than 0.05 (range 0.294–0.812), supporting the use of parametric tests. Baseline VO_2max and RPR were also statistically similar between groups: VO_2max 44.82±6.21 versus 45.12±5.94 ml/kg/min ($p=0.877$), and RPR 72.45±5.23 versus 71.80±5.01 bpm ($p=0.691$) for the Fartlek and Conventional groups, respectively.

Table 2. Baseline Comparison of Primary Outcomes

Outcome	Fartlek Group Mean ± SD	Conventional Group Mean ± SD	t (df=38)	p-value
VO_2max (ml/kg/min)	44.82 ± 6.21	45.12 ± 5.94	−0.156	0.877
RPR (bpm)	72.45 ± 5.23	71.80 ± 5.01	0.401	0.691

3.3 Within-Group Effects of Training

The Fartlek Training Group showed statistically significant improvements in both primary outcomes. Mean VO_2max increased by 4.09 ml/kg/min, representing a 9.13% improvement, while RPR decreased by 6.25 bpm, representing an 8.63% reduction. Both changes were significant at $p<0.001$. The Conventional Training Group also improved significantly, but the changes were smaller: VO_2max increased by 2.46 ml/kg/min (+5.45%) and RPR decreased by 3.45 bpm (−4.81%), both $p<0.001$.

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Table 3. Pre-Test to Post-Test Changes Within the Two Training Groups

Group / Outcome	Pre-Test Mean ± SD	Post-Test Mean ± SD	Mean Difference	% Change	t	p-value
Fartlek - VO_2max	44.82 ± 6.21	48.91 ± 5.84	+4.09	+9.13%	8.327	<0.001
Fartlek - RPR	72.45 ± 5.23	66.20 ± 4.81	−6.25	−8.63%	7.914	<0.001
Conventional - VO_2max	45.12 ± 5.94	47.58 ± 5.76	+2.46	+5.45%	5.891	<0.001
Conventional - RPR	71.80 ± 5.01	68.35 ± 4.95	−3.45	−4.81%	4.772	<0.001

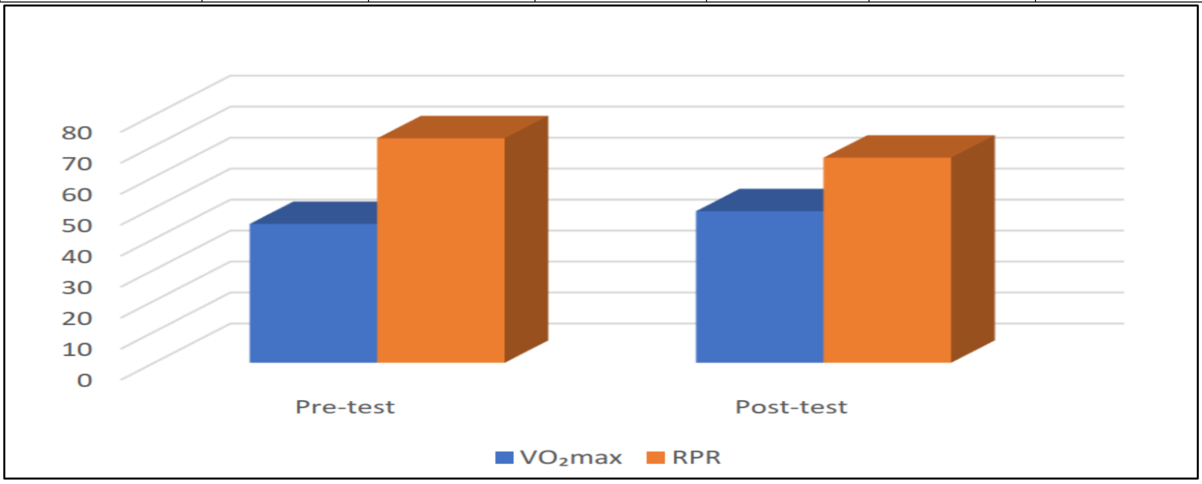

Figure 3. Effect of Training on VO_2max and Resting Pulse Rate (RPR): A Pre-test and Post-test Comparison

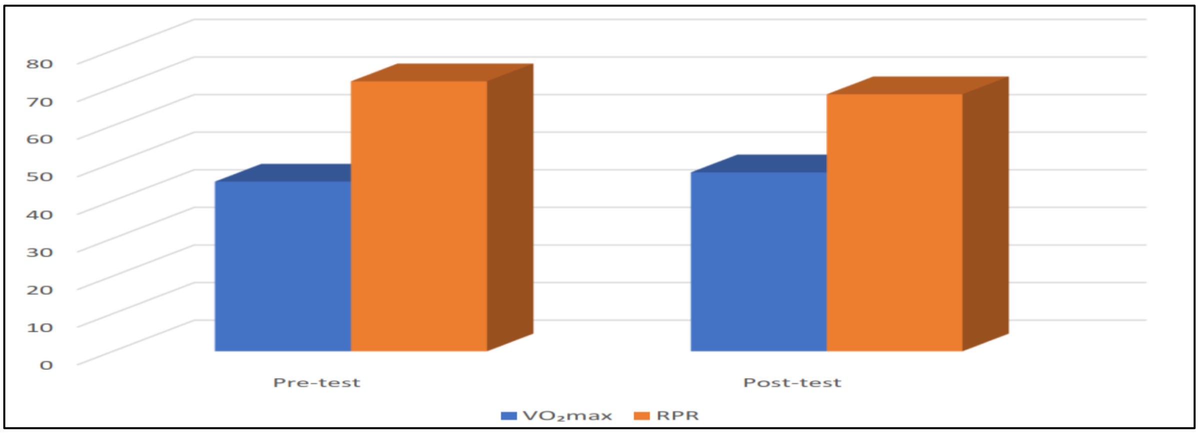

Figure 4. Effect of Conventional Training on VO_2max and Resting Pulse Rate (RPR): A Pre-test and Posttest Comparison

3.4 Between-Group Post-Test Comparison and Change-Score Analysis

At post-test, the Fartlek group had a numerically higher VO_2max and lower RPR than the Conventional group, but the absolute post-test differences did not reach statistical significance.

VO_2max was 48.91±5.84 versus 47.58±5.76 ml/kg/min ($p=0.473$), and RPR was 66.20±4.81 versus 68.35±4.95 bpm ($p=0.172$). In contrast, change-score analysis demonstrated significant differential improvement in favor of Fartlek training. The Fartlek group gained 1.63 ml/kg/min more VO_2max than the Conventional group ($p=0.016$) and achieved a 2.80 bpm greater reduction in RPR ($p=0.013$).

Table 4. Between-Group Comparisons of Post-Test Values and Change Scores

Comparison / Outcome	Fartlek Mean ± SD	Conventional Mean ± SD	Difference	t (df=38)	p-value
Post-test VO_2max	48.91 ± 5.84	47.58 ± 5.76	+1.33	0.725	0.473
Post-test RPR	66.20 ± 4.81	68.35 ± 4.95	−2.15	−1.393	0.172
Δ VO_2max	+4.09 ± 2.19	+2.46 ± 1.87	+1.63	2.532	0.016*
Δ RPR	−6.25 ± 3.53	−3.45 ± 3.23	−2.80	−2.617	0.013*

*Significant at $p<0.05$. Δ = post-test − pre-test.

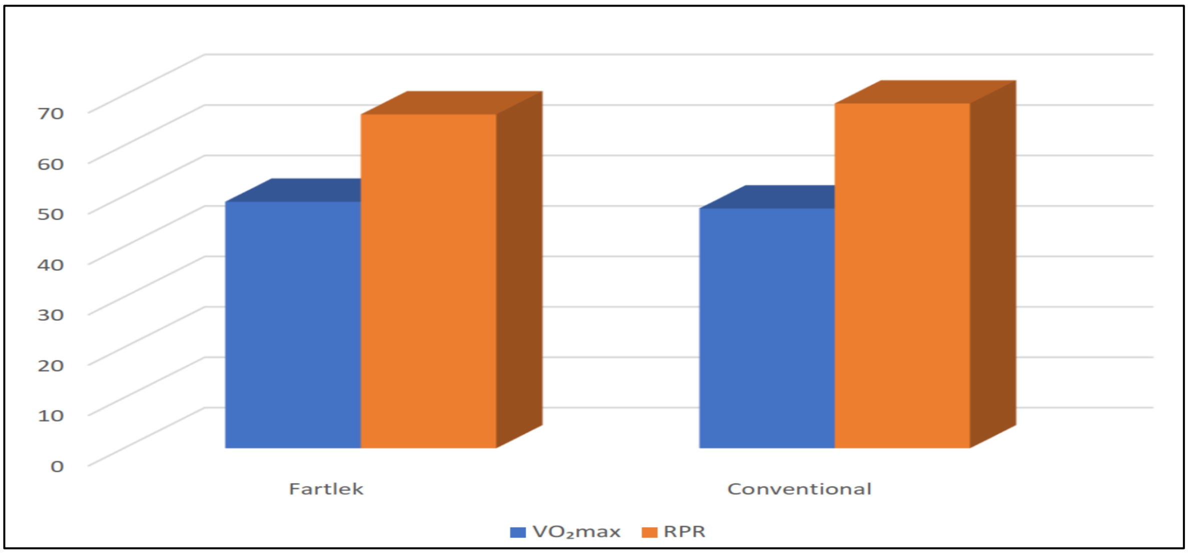

Figure 5. Comparison of Post-test Mean Values of VO_2max and Resting Pulse Rate (RPR) between Fartlek and Conventional Training Groups

3.5 Effect Sizes

Both interventions produced large within-group effects. For Fartlek training, Cohen's d was 1.86 for VO_2max and −1.77 for RPR; for conventional training, the corresponding values were 1.32 and −0.97. The direct post-test between-group effects were small, whereas the between-group effects based on change scores were large ($d=0.80$ for VO_2max and $d=-0.83$ for RPR).

Table 5. Cohen's d Effect Sizes

Comparison	VO_2max	RPR
Within-group: Fartlek pre vs post	1.86 (Large)	−1.77 (Large)

Within-group: Conventional pre vs post	1.32 (Large)	−0.97 (Large)
Between-group: post-test	0.23 (Small)	−0.44 (Small)
Between-group: change scores	0.80 (Large)	−0.83 (Large)

4. DISCUSSION

The principal finding of this randomized study is that a six-week Fartlek program significantly improved both VO_2max and resting pulse rate in relay runners. Although conventional high-intensity interval training was also effective, the magnitude of change was greater in the Fartlek group. This distinction was clearest in the change-score analysis, which demonstrated statistically significant and large between-group effects for both primary outcomes.

The 9.13% improvement in VO_2max observed in the Fartlek group is physiologically plausible and consistent with the broader evidence that exposure to high aerobic intensities can improve maximal oxygen uptake [2,5]. Fartlek training combines continuous running with spontaneous or perception-guided surges, allowing athletes to accumulate aerobic work while repeatedly reaching higher intensities. Such training may stimulate central cardiovascular adaptation while also increasing oxidative enzyme activity, capillary development, and mitochondrial function in working skeletal muscle [9,10,14,15].

The observed increase in VO_2max falls between improvements reported in other Fartlek studies cited in the thesis. Salameh reported a 16.03% increase in VO_2max among soccer beginners after an eight-week Fartlek program [12], whereas other athletic populations have shown more modest gains. Differences in intervention duration, starting fitness, sport background, and testing method are likely contributors. The relay runners in the present study had at least one year of organized athletic training, and trained participants commonly demonstrate smaller relative improvements than untrained individuals because baseline aerobic capacity is already higher [2].

RPR decreased by 6.25 bpm (8.63%) after Fartlek training. A reduction in resting heart rate is a recognized adaptation to endurance conditioning and is commonly associated with increased parasympathetic influence, reduced sympathetic drive at rest, and improved stroke volume [11,17]. The present result is also consistent with the thesis-cited work of Desai and Poovishnudevi, who reported significant reductions in resting pulse rate following Fartlek training in recreational football players [13], and with Salameh's report of a 13.97% reduction in resting heart rate among soccer beginners [12].

The Conventional Training Group showed meaningful improvements in both outcomes, confirming that conventional high-intensity interval work is itself an effective cardiovascular stimulus. This agrees with evidence that high-intensity aerobic intervals can improve VO_2max more effectively than lower-intensity continuous training [5,19,20]. The absence of statistically significant differences in absolute post-test values should therefore not be interpreted as absence of a Fartlek advantage. Both groups began at similar physiological levels and both received potent interventions, which narrowed end-point separation. With only 20 participants per group, small absolute post-test differences were difficult to detect statistically.

The analysis of change scores provides the strongest comparative evidence in this dataset. The Fartlek group improved VO_2max by 1.63 ml/kg/min more than the Conventional group and reduced RPR by 2.80 bpm more. These differences were statistically significant and were accompanied by large effect sizes. The variable-intensity nature of Fartlek training may expose athletes to a broader range of work demands within one continuous session. For relay runners, this is especially relevant because their event demands require both high-intensity effort and aerobic recovery between efforts [3,16].

The training method may also have practical value beyond physiology. Fartlek sessions are flexible, can be adapted to outdoor terrain and facility limitations, and may reduce monotony compared with fixed work-to-rest intervals. The thesis participant-perception observations indicated that Fartlek sessions were viewed as engaging, although these qualitative responses were not subjected to formal statistical analysis. Accordingly, psychological or adherence advantages should be treated as supportive rather than definitive findings.

From an applied perspective, the combination of improved VO_2max and lower RPR suggests enhanced cardiorespiratory fitness and cardiovascular efficiency. These adaptations can support recovery kinetics and repeated high-intensity performance, both of which are relevant to relay competition [16]. However, the study did not directly measure relay leg times, exchange performance, race outcomes, or repeated-sprint performance; therefore, the present article should not claim direct competitive performance improvement.

5. PRACTICAL IMPLICATIONS

- A structured Fartlek program performed three times per week can be considered as a practical conditioning option for relay runners seeking improvement in aerobic capacity and resting cardiovascular efficiency.
- The study protocol used 20–30 minutes of variable-intensity running within sessions, alternating approximately 80–90% of maximum heart rate with 50–60% active-recovery intensity.
- Resting pulse rate can provide a simple, low-cost monitoring indicator when interpreted alongside training load, symptoms, and other recovery information.
- Because the change-score improvements were larger with Fartlek training, coaches may consider using it within periodized conditioning rather than relying exclusively on fixed interval formats.

6. LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

- The sample size was modest (n=40) and the intervention duration was six weeks, which may have limited statistical power for detecting differences in absolute post-test values.
- VO_2max was estimated indirectly with the Queen College Step Test rather than measured with direct gas analysis.
- The study did not include direct relay-performance outcomes such as race time, relay-leg time, or repeated-sprint performance.
- Potential moderators such as training history beyond the minimum eligibility criterion, nutritional status, sleep, genetic factors, and psychological characteristics were not formally modeled.

- Participants were drawn from a specific Bhopal-based setting; replication in larger and more diverse competitive samples would strengthen generalizability.

7. CONCLUSION

The study demonstrates that a six-week organized Fartlek training program significantly increased maximum oxygen consumption and reduced resting pulse rate in relay runners. Conventional high-intensity interval training also produced significant benefits, but the Fartlek group achieved greater improvements when changes from baseline were compared directly. The between-group change-score effects were large for both VO_2max and RPR, supporting the alternate hypothesis. These findings support the inclusion of Fartlek training within periodized conditioning programs for relay runners when the objective is to develop cardiorespiratory fitness and cardiovascular efficiency. Because direct competitive performance was not measured, future studies should determine whether these physiological gains translate into faster relay performance and improved repeated-effort capacity.

NOTE REGARDING FIGURES

No new or model-generated figure has been inserted in this research article. Every figure position above refers to an existing graph in the main thesis. Copy and paste the specified thesis graph exactly at the marked position, without changing data, labels, wording, or graphical design.

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