



The Effect of Fartlek Training On Increasing Cardiovascular Endurance And Agility of Male Handball Athletes

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ABSTRACT

Handball is a team sport characterized by high-intensity, intermittent activity that demands optimal cardiovascular endurance (VO₂Max) and agility to maintain performance throughout the match. Adequate aerobic capacity contributes to accelerated recovery between sprints and maintains stable technical performance, while agility supports effective changes of direction, tactical responses, and game transitions. This study aims to empirically analyze the effect of fartlek training on improving VO₂Max and agility in male handball athletes participating in the Bojonegoro Regency Provincial Sports Week (Porprov). The study used an experimental method with a pretest-posttest control group design. The sample consisted of 20 athletes randomly divided into an experimental group (fartlek training 3 times per week for 6 weeks) and a control group (regular training). VO₂Max was measured using the Multistage Fitness Test (MFT) and agility using the Illinois Agility Test. Data analysis was performed using a Paired Sample T-Test at a significance level of 0.05. The results showed significant increases in VO₂Max (p=0.000; 4.85% increase) and agility (p=0.002; 3.59% increase) in the experimental group, while the control group showed no significant changes. Conceptually, these findings indicate that varying the intensity of fartlek can stimulate physiological and neuromuscular adaptations simultaneously. It was concluded that fartlek training effectively improves aerobic capacity and agility in handball athletes, making it worthy of recommendation as an evidence-based physical development strategy.

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INTRODUCTION

Handball is a team sport with intermittent, high-intensity characteristics that demand a combination of aerobic and anaerobic capacity, explosive strength, and agility over a 2 x 30-minute match. The fast-paced gameplay, with simultaneous attack-defense transitions, requires athletes to perform repeated sprints, jumps, changes of direction, and frequent physical contact within short intervals. Recent sports physiology literature indicates that the metabolic demands of handball fall within the intensity zone



of 75–90% of maximum heart rate, with the aerobic system contributing to recovery between bouts (Póvoas et al., 2018; Michalsik & Aagaard, 2015).

Cardiovascular endurance, as measured by $VO_2\text{max}$, is a primary indicator of an athlete's aerobic capacity. $VO_2\text{max}$ reflects the cardiorespiratory system's ability to transport and utilize oxygen during intense activity (Bassett & Howley, 2017; Midgley et al., 2019). Athletes with a high $VO_2\text{Max}$ have been shown to maintain game intensity for longer, accelerate recovery between sprints, and maintain the quality of tactical decision-making (Buchheit & Laursen, 2019; Granados et al., 2020). Furthermore, agility—the ability to change direction quickly and controlled—has a strong correlation with offensive and defensive effectiveness (Sheppard & Young, 2016; Paul et al., 2021).

However, physical evaluation data from Bojonegoro Regency's Porprov athletes shows that the average $VO_2\text{Max}$ for male athletes is around 41.11 ml/kg/minute, lower than the international elite athlete standard of 55–60 ml/kg/minute (Haugen et al., 2020). Similar findings also indicate suboptimal agility scores based on the Illinois Agility Test. This indicates a gap between the demands of provincial-level competition and the athletes' actual physical readiness. If not addressed through evidence-based training programs, this gap has the potential to reduce the team's collective performance in regional multi-event events.

Therefore, the research problem lies in the low $VO_2\text{Max}$ capacity and agility of handball athletes in Bojonegoro Regency's Provincial Sports Week (Porprov) compared to competitive standards, as well as the need for an effective and applicable training model in the context of regional development.

Developments in modern coaching science emphasize an evidence-based training approach to improving athletes' physical capacity. Recent research shows that interval training, small-sided games, and fartlek methods are significantly effective in increasing $VO_2\text{Max}$ in team sports (Buchheit & Laursen, 2019; Hammami et al., 2019). Fartlek—derived from the concept of "speed play"—combines variations in fast and slow running intensity dynamically without a rigid pattern. This method simultaneously stimulates adaptation of the aerobic and anaerobic systems, making it suitable for the volatile nature of handball (Midgley et al., 2019).

Physiologically, fartlek training increases cardiac stroke volume, muscle capillary density, and oxidative enzyme activity, which supports increased $VO_2\text{max}$ (Jones & Carter, 2019). Experimental studies in soccer and basketball athletes have shown an 8–15% increase in $VO_2\text{max}$ after 6–8 weeks of fartlek intervention (Helgerud et al., 2019; Milanović et al., 2020). Furthermore, the tempo variations and changes in direction during fartlek also contribute to increased agility by enhancing neuromuscular coordination and reactivity (Young et al., 2021).

In the context of handball, research by Póvoas et al. (2018) confirmed that increased aerobic capacity is directly related to increased total distance covered and the number of high-intensity efforts during a match. Another study by Granados et al. (2020) found that athletes with high aerobic capacity demonstrated stable technical performance until the final minutes of the match.

In Indonesia, studies on fartlek in team sports have been conducted in soccer, athletics, and futsal (Yuliawan, 2022; Armadhani, 2022), with consistent results showing significant increases in $VO_2\text{Max}$ and agility ($p < 0.05$). However, its application to handball—especially in the context of developing athletes for the Provincial Sports Week (Porprov)—is still limited and has not been systematically documented in reputable journals.

Thus, conceptually and empirically, fartlek has a strong theoretical basis as a method for increasing cardiovascular capacity and agility. Although various studies have demonstrated the effectiveness of fartlek in improving aerobic capacity in team sports, several relevant research gaps remain. First, most studies were conducted on elite or semi-professional athletes in Europe and America (Helgerud et al., 2019; Haugen et al., 2020), so generalizations to the context of regional development in Indonesia still require empirical verification. Second, previous research tends to focus on a single physical variable generally $VO_2\text{Max}$ without simultaneously examining its effect on agility, a crucial component in handball (Sheppard & Young, 2016). Third, no study has specifically tested the effectiveness of fartlek on handball athletes in the Bojonegoro Regency Provincial Sports Week (Porprov) using a controlled experimental design that quantitatively measures changes in $VO_2\text{Max}$ and agility before and after the intervention. Fourth, physical development approaches at the regional level are often conventional and not fully based on objective performance data. In fact, modern sports science literature emphasizes the importance of training periodization based on physiological measurements and athletes' adaptive responses (Bompa & Buzzichelli, 2019; Issurin, 2020). Therefore, there is an urgent need to provide contextual empirical evidence that can bridge the gap between modern coaching theory and regional coaching practice.

Based on these research issues and gaps, this study aims to empirically analyze the effect of fartlek training on improving cardiovascular endurance ($VO_2\text{Max}$) and agility in male handball athletes from the Bojonegoro Regency Provincial Sports Week (Porprov). The novelty of this research lies in: (1) The integration of two key performance indicators ($VO_2\text{Max}$ and agility) in a single experimental design for regional-level handball; (2) The contextualization of fartlek interventions for Porprov athletes, thus generating local empirical evidence relevant for regional sports development, and (3) A modern sports science-based approach, with quantitative measurements and inferential statistical analysis as the basis for training program recommendations.

Theoretically, this study adds to the literature on the effectiveness of fartlek in intermittent-based team sports. Practically, the results can serve as a reference for coaches in designing adaptive, efficient, and evidence-based training programs to improve athletes' physical readiness for provincial and national competitions.

Therefore, this study not only makes an academic contribution to the development of coaching science and sports physiology but also has strategic implications for sustainably improving the quality of coaching and the performance of regional athletes.

METHODS

This study employed a quantitative approach with a quasi-experimental method and a pretest-posttest control group design, which is recommended in sports intervention research to objectively identify the causal effects of an exercise program (Hastjarjo, 2019; Thomas, Nelson, & Silverman, 2022). This design allows for control of external variables, comparison of pre- and post-treatment score changes between the experimental and control groups, and minimization of selection bias (Grgic et al., 2020; Hopkins, 2019). The experimental approach is considered most relevant in coaching research because it can evaluate the effectiveness of evidence-based exercise programs in the context of athlete performance (Buchheit & Laursen, 2019; Issurin, 2020).

The study was conducted at the handball team training facilities of Bojonegoro Regency, namely Letjen H. Soedirman Stadium, Dabonsia Bojonegoro Sports Hall, and Dander State Vocational High School field, in April–June 2025. The intervention in the form of fartlek training was given for 6 weeks (18 sessions), with a frequency of 3 times per week (Monday, Thursday, Saturday) and a duration of ± 60 minutes per session including warm-up and cool-down. The duration and frequency refer to literature recommendations stating that 6–8 weeks of aerobic intervention with varying intensity are effective in increasing VO_2 Max and change of direction capacity in team sports athletes (Helgerud et al., 2019; Milanović et al., 2020; Midgley et al., 2019). Fartlek was designed with a fast-slow tempo variation (70–90% HRmax) to stimulate simultaneous aerobic and anaerobic adaptations, as recommended in modern intermittent training models (Hammami et al., 2019; Buchheit & Laursen, 2019).

The study population was all male athletes from the Bojonegoro Regency Provincial Sports Week (Porprov) handball team ($n = 20$). A total sampling technique was used because the population was limited and relatively homogeneous in age, training experience, and competition status (Thomas et al., 2022). Subjects were randomly divided into two groups ($n = 10$ per group). The experimental group received a structured fartlek program, while the control group underwent regular training without additional intervention. A simple randomization procedure was used to increase internal validity and reduce potential confounding variables (Hopkins, 2019).

The research instruments included the Multistage Fitness Test (MFT) to estimate VO_2 max and the Illinois Agility Test to measure agility. The MFT was chosen because of its high validity and reliability in estimating the aerobic capacity of team athletes (Bangsbo et al., 2018; Haugen et al., 2020), as well as its sensitivity in detecting changes in VO_2 max after training interventions (Grgic et al., 2020). The Illinois Agility Test was used because it represents the ability to quickly and controlled changes of direction, a crucial component of handball performance (Sheppard & Young, 2016; Paul et al., 2021). All measurements were conducted according to standard operating procedures, under the supervision of coaches and researchers to ensure consistency of implementation and inter-measurer reliability.

The study began with a pretest in both groups, followed by a six-week intervention, and concluded with a posttest using the same instrument. External factors such as test

timing, field conditions, and verbal instructions were standardized to reduce measurement error (Thomas et al., 2022).

Data analysis was conducted in stages. Normality was tested using the Shapiro-Wilk test and homogeneity was tested using the Levene Test, as recommended for small samples (<50) in sports research (Razali & Wah, 2018; Field, 2018). After the assumptions were met, hypothesis testing was conducted using a paired sample t-test to examine pretest-posttest differences within each group, and an independent sample t-test to compare changes between groups with a significance level of $\alpha = 0.05$ (Hopkins, 2019). All analyses were conducted using SPSS for Windows to ensure the accuracy of statistical calculations.

RESULTS AND DISCUSSION

Result

This study analyzes the effect of fartlek training on improving cardiovascular endurance (VO₂Max) and agility in male handball athletes participating in the Bojonegoro Regency Provincial Sports Week (Porprov). Measurements were conducted using the Multistage Fitness Test (MFT) to estimate VO₂Max and the Illinois Agility Test for agility, which have been empirically proven valid and reliable in evaluating the performance of intermittent team sports athletes (Bangsbo et al., 2018; Haugen et al., 2020; Paul et al., 2021). The analysis was conducted descriptively and inferentially in accordance with recommendations in modern experimental sports research (Hopkins, 2019; Thomas et al., 2022).

Description of Respondent Characteristics

Table 1.
Respondent Characteristics

Variabel	K1 (n=10) Mean ± SD	K0 (n=10) Mean ± SD	p-value
Usia (tahun)	19,0 ± 1,83	20,4 ± 1,84	0,12
Tinggi badan (cm)	170,9 ± 4,86	169,6 ± 5,27	0,50
Berat badan (kg)	61,9 ± 7,81	68,6 ± 10,04	0,15
IMT (kg/m ²)	21,18 ± 2,36	23,86 ± 3,48	0,03*

Most baseline characteristics showed no significant differences ($p > 0.05$), except for BMI. However, the BMI values for both groups were still within the normal to mildly overweight category according to WHO standards, thus not affecting the validity of the intervention (Grgic et al., 2020). Equivalence of baseline characteristics is important to ensure the internal validity of experimental research (Hopkins, 2019).

Descriptive Pretest-Posttest VO₂Max

Table 2.
Pretest-Posttest VO₂Max Data (ml/kg/min)

Group	Mean	Min	Max	SD
K1 Pretest	47,4	45,2	53,7	2,57
K1 Posttest	49,7	47,4	56,5	2,87
K0 Pretest	45,7	41,8	49,3	2,87
K0 Posttest	45,4	42,1	48,7	2,54

The experimental group experienced an average increase of +2.3 ml/kg/min ($\approx 4.8\%$), while the control group showed no significant increase. This increase aligns with the findings of Helgerud et al. (2019) and Milanović et al. (2020), who reported a 5–12% increase in $VO_2\text{max}$ through intermittent, intensity-based training. Physiologically, fartlek increases stroke volume, capillary density, and mitochondrial efficiency, contributing to increased aerobic capacity (Midgley et al., 2019; Jones & Carter, 2019).

Agility Pretest–Posttest Descriptives

Table 3.

Agility Pretest–Posttest Data (seconds)

Group	Mean	Min	Max	SD
K1 Pretest	17,25	16,73	17,88	0,38
K1 Posttest	16,63	16,15	17,18	0,35
K0 Pretest	17,59	16,47	18,26	0,58
K0 Posttest	17,48	16,43	18,15	0,53

The experimental group experienced a -0.62 second ($\approx 3.6\%$) decrease in run time, indicating improved agility. Literature shows that varying tempo and changing direction in fartlek improves neuromuscular coordination and change of direction speed (CODS) ability (Sheppard & Young, 2016; Young et al., 2021). In contrast, the control group showed no significant changes.

Normality Test

Table 4.

Normality Test for $VO_2\text{Max}$ (Shapiro-Wilk)

Group	Pretest Sig.	Posttest Sig.
K1 Pretest	0,061	0,193
K0 Posttest	0,094	0,217

Table 5.

Normality Test for Agility (Shapiro-Wilk)

Group	Pretest Sig.	Posttest Sig.
K1 Pretest	0,832	0,395
K0 Posttest	0,145	0,240

All p-values were >0.05 , indicating that the data were normally distributed, as recommended for parametric analysis in small samples (Razali & Wah, 2018; Field, 2018).

Homogeneity Test

Table 6.

$VO_2\text{Max}$ Homogeneity Test (Levene's Test)

Group	Sig.
Pretest	0,114
Posttest	0,230

Table 7.

Agility Homogeneity Test (Levene's Test)

Group	Sig.
Pretest	0,134
Posttest	0,370

A p-value >0.05 indicates homogeneity of variance, thus meeting the assumptions of the parametric t-test (Hopkins, 2019).

Hypothesis Testing (Paired Sample T-Test)

Table 8.
Paired Sample T-Test Results for VO₂Max

Group	t	df	Sig.
Kontrol	0,305	9	0,767
Eksperimen	-10,307	9	0,000*

Table 8.
Paired Sample T-Test Results for Agility

Group	t	df	Sig.
Kontrol	1,526	9	0,161
Eksperimen	4,347	9	0,002*

The experimental group's significance values for VO₂Max (p=0.000) and agility (p=0.002) were <0.05, indicating a significant effect of fartlek training. In contrast, the control group showed no significant changes. These findings are consistent with research by Buchheit & Laursen (2019), Hammami et al. (2019), and Póvoas et al. (2018), which confirmed that intermittent training based on varying intensity effectively improves aerobic capacity and change of direction performance in team sports.

Overall, six weeks of fartlek training resulted in significant improvements in VO₂Max and agility in handball athletes from the Bojonegoro Regency Provincial Sports Week (Porprov). These results strengthen empirical evidence that fartlek is an effective, adaptive, and applicable training method for physical development in high-intensity intermittent team sports.

Discussion

The results of this study indicate that six weeks of fartlek training significantly increased VO₂max and agility in male handball athletes from the Bojonegoro Regency Provincial Sports Week (Porprov). These findings confirm that a training approach based on varying intensity (speed play) can produce physiological and neuromuscular adaptations relevant to the intermittent, high-intensity nature of handball (Buchheit & Laursen, 2019; Hammami et al., 2019).

Increased VO₂max and Physiological Adaptations

The increase in VO₂max of approximately 4.85% in the experimental group indicates that fartlek training effectively stimulates adaptations in the cardiovascular and respiratory systems. Physiologically, training with varying high-low intensity increases stroke volume, maximal cardiac output, and muscle capillary density, thereby improving oxygen transport and diffusion to active tissues (Midgley et al., 2019; Jones & Carter, 2019). Furthermore, interval stimulation in fartlek increases the activity of mitochondrial oxidative enzymes, which play a role in aerobic metabolism (Granados et al., 2020).

This finding is consistent with research by Helgerud et al. (2019) and Milanović et al. (2020), which reported a 5–12% increase in VO₂max through 6–8 weeks of intermittent

training in team athletes. A study by Póvoas et al. (2018) in elite handball athletes also confirmed that high aerobic capacity correlates with total distance covered and the ability to maintain high-intensity effort throughout a match. Therefore, the increase in $VO_2\text{max}$ in this study has direct implications for improving athletes' work capacity during competition. Contextually, the athletes' initial $VO_2\text{max}$ values, which were below international elite standards (Haugen et al., 2020), indicate a significant gap in aerobic capacity. In handball, repeated sprinting and rapid transitions require a robust aerobic energy system to accelerate recovery between actions (Michalsik & Aagaard, 2015). Therefore, increasing $VO_2\text{max}$ through fartlek has the potential to reduce premature fatigue and maintain consistent technical performance until the final minutes of the match (Buchheit & Laursen, 2019). Research by Shanta and Ajita (2025) also confirmed that intensity-based training can increase the anaerobic threshold (lactate threshold), which plays a crucial role in delaying lactate accumulation during repetitive activity. Thus, fartlek not only improves maximal aerobic capacity but also increases the athlete's metabolic efficiency.

Improved Agility and Neuromuscular Adaptation

In addition to increasing $VO_2\text{max}$, the study results showed a significant decrease in Illinois Agility Test time in the experimental group. Although fartlek is not a specific agility exercise like ladder drills or cone drills, the varying tempo, acceleration-deceleration, and changes in direction within the fartlek protocol provide significant neuromuscular stimulation. Agility is theoretically influenced by the integration of speed, coordination, balance, and change of direction speed (CODS) (Sheppard & Young, 2016; Young et al., 2021). Training with varying direction and intensity increases the efficiency of motor unit recruitment and proprioceptive control, which results in improved lateral movement responses and tactical maneuvers (Paul et al., 2021). This finding aligns with research by Hammami et al. (2019), which showed that intermittent training with changes of direction can improve agility performance in adolescent athletes. Aulia (2022) also confirmed that training with sudden acceleration and changes of direction significantly improves lateral maneuvering ability and motor response. In the context of handball, increased agility directly impacts the effectiveness of defensive penetration, one-on-one defense, and the speed of game transitions (Granados et al., 2020).

Furthermore, fartlek training conducted in an open environment with varied running routes also contributes to more complex sensorimotor adaptations than monotonous training on a straight track (Issurin, 2020). This adaptation supports athletes' readiness to face dynamic and unpredictable competition situations.

Simultaneous Effects on Two Key Fitness Components

The results of this study demonstrate that fartlek has a simultaneous effect on increasing aerobic capacity and agility. This supports the concept of multidimensional training in team sports, where a single training method can impact multiple fitness components simultaneously (Bompa & Buzzichelli, 2019). Nidomuddin and Pamungkas (2022) recommend integrating interval training as an effective strategy for improving handball physical performance due to the intermittent nature of the game. From a

modern sports science perspective, this approach is more efficient than single methods that only target one physical component (Buchheit & Laursen, 2019). Furthermore, simultaneously increasing VO_2 Max and agility has the potential to enhance technical and tactical effectiveness. Athletes with high aerobic capacity can maintain the quality of their passing, shooting, and decision-making under fatigued conditions (Póvoas et al., 2018). Meanwhile, increased agility supports the ability to read the game and perform explosive changes of direction when facing opponent pressure (Young et al., 2021).

Theoretical and Practical Implications

Theoretically, this study strengthens empirical evidence that fartlek is a training method based on varying intensity that effectively increases aerobic capacity and neuromuscular components simultaneously. These findings support the evidence-based training paradigm in team sports development (Thomas et al., 2022).

Practically, fartlek has advantages because it is flexible, does not require special equipment, and is easily adapted to limited field conditions—making it relevant for developing athletes in regions with limited facilities (Issurin, 2020). Coaches can integrate fartlek into training schedules as part of general and specific preparation phases to improve athletes' physical readiness before competition.

Limitations and Recommendations for Further Research

Despite yielding significant results, this study has several limitations. First, the sample size is relatively small, so generalization of the results should be done with caution. Second, the six-week intervention duration may not be sufficient to observe long-term adaptations. Third, this study only examined two physical variables without evaluating other components such as explosive strength, repeated sprint ability, or technical match performance. Further research is recommended, involving a larger sample size, a longitudinal design, and the integration of match performance measurements (match analysis) to obtain a more comprehensive picture of the impact of fartlek on overall handball performance. Overall, the results of this study confirm that fartlek training is an effective and applicable method for improving VO_2 Max and agility in regional-level handball athletes, while also strengthening the foundation of modern sports science-based coaching.

CONCLUSION

This study empirically demonstrates that six weeks of fartlek training significantly improved cardiovascular endurance (VO_2 Max) and agility in male handball athletes participating in the Bojonegoro Regency Provincial Sports Week (Porprov). The experimental group demonstrated a statistically significant increase in VO_2 Max and Illinois Agility Test time, while the control group experienced no significant changes. Conceptually, these findings align with the physiological adaptation theory of intermittent training, which states that varying intensity can improve aerobic capacity by increasing stroke volume, oxygen transport efficiency, and anaerobic threshold, while simultaneously stimulating neuromuscular adaptations that support change of direction and rapid motor response.

The theoretical implications of this study reinforce the evidence-based training paradigm, stating that fartlek is an effective multidimensional method for team sports with intermittent characteristics like handball. Practically, the results of this study provide a scientific basis for coaches in designing efficient, flexible, and applicable training programs, particularly in the context of developing athletes in regions with limited facilities. Systematic implementation of fartlek has the potential to increase competitive endurance, maintain stable performance until the end of the match, and reduce the risk of premature fatigue.

It is recommended that further research involve larger samples, longer intervention durations, and the integration of technical and tactical match performance measurements to obtain a more comprehensive picture of the impact.

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Conceptually and empirically, collaboration between academics, coaches, and athletes is a crucial foundation for the development of applicable sports science-based research. This synergy enables the integration of coaching theory and practice so that research results not only contribute to the development of sports science, but also provide real benefits for improving the quality of coaching and athlete performance at the regional level.

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