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Strava-Based training program to increase VO2max capacity of undergraduate students

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ABSTRACT

This study aimed to develop and evaluate the effectiveness of a Strava-based endurance training program in improving VO_2max among undergraduate students of the Sports Science Study Program, Universitas Negeri Padang. The research applied a Research and Development (R&D) approach using selected stages of the ADDIE model, combined with a one-group pretest–posttest design. Sixteen students (aged 21–24 years) participated in a 5-week training program conducted 3–4 sessions per week, consisting of continuous running and tempo running at moderate to high intensity. VO_2max was measured using a 2.4 km run test with a validated estimation formula. Results showed an increase in mean VO_2max from 35.10 ml/kg/min (pretest) to 42.18 ml/kg/min (posttest), indicating an improvement of 7.08 ml/kg/min (≈20.2%). A paired sample t-test revealed a significant difference ($p < 0.05$). These findings suggest that the Strava-based training program is effective, although further studies with control groups and larger samples are recommended.

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Introduction

Physical fitness is a key component that determines an individual's ability to perform physical activities efficiently and sustainably. One of the main indicators of physical fitness is maximal oxygen uptake (VO_2max), which reflects the body's capacity to transport and utilize oxygen during high-intensity exercise (Umar, 2014; Bafirman & Wahyuri, 2019). Higher VO_2max values indicate more efficient cardiovascular and respiratory systems in supporting aerobic endurance activities (McArdle, Katch & Katch, 2010; Bompa & Haff, 2009). Therefore, VO_2max is a critical parameter for assessing an individual's aerobic capacity.

Several factors influence VO_2max, including age, sex, lung function, cardiovascular efficiency, hemoglobin concentration, body composition, and training level (Bafirman & Sepdanius, 2023; Kuantaraf, 1992). For example, VO_2max generally decreases with age and is higher in males due to hormonal differences, muscle mass, and hemoglobin levels. On the other hand, regular physical training has been shown to increase VO_2max depending on training intensity and duration (Bafirman & Sepdanius, 2023; Dinata, 2018).

VO_2max measurement can be performed using direct or indirect methods. Direct methods involve specialized equipment, such as treadmills or cycle ergometers connected to a metabolic cart, to measure oxygen consumption and carbon dioxide production accurately (Gibson, 2023). However, these methods are often impractical in field settings due to equipment limitations and high costs.

Indirect methods, such as the 12-minute Cooper Test, 2.4 km run, Balke test, or bleep test, are more practical for estimating VO_2max based on running distance or completion time (Burger et al., 1990; Bafirman & Wahyuri, 2019; Bushman, 2017). In educational and fitness assessment contexts, the 2.4 km run is widely used due to its simplicity and validity in assessing aerobic capacity.

VO_2max can be improved through structured aerobic training programs. Continuous running is one of the most effective methods to enhance aerobic capacity, while variations such as slow continuous running, fast continuous running, fartlek, and tempo runs help develop cardiovascular and aerobic energy metabolism systems (Bafirman & Sepdanius, 2023; Bassett & Howley, 2000).

The FITT principle (Frequency, Intensity, Time, Type) recommends training to increase VO_2max 3–5 times per week at moderate to high intensity with adequate duration to stimulate physiological adaptations (Suharjana, 2013). Applying training principles such as progressive overload, specificity, individualization, variation, and recovery is crucial to achieve optimal results and avoid overtraining (Bafirman & Sepdanius, 2023; Budiwanto, 2013).

With technological advances, the use of digital fitness applications has emerged as an innovative tool in physical education and sports. Strava, developed by Michael Horvath and Mark Gainey in 2009, allows users to record physical activities such as running, cycling, and hiking using GPS, while also analyzing distance, speed, duration, heart rate, and calories burned (Strava, 2020; West, 2015).

Beyond recording activity, Strava provides social features such as feeds, kudos, and segment leaderboards, encouraging healthy competition and motivating consistent training (Spotswood et al., 2020). Implementing Strava in educational research and fitness programs enables real-time monitoring and data-driven evaluation, supporting improvements in VO_2max through structured training programs.

Although previous literature has extensively examined endurance training and aerobic development, studies integrating digital applications like Strava into structured training programs for university students remain limited. This highlights the need for innovative, technology-based approaches to enhance both effectiveness and engagement in endurance training in higher education settings.

Based on theoretical reviews and prior research, VO_2max is a key parameter of physical fitness that can be improved through consistent aerobic training, with continuous running, fartlek, and tempo runs proven to be effective. Digital technology integration, such as using Strava, adds value for monitoring and evaluating training outcomes. Therefore, this study focuses on developing and implementing a Strava-based training program to improve VO_2max as an innovative, efficient, and measurable approach aligned with technological advancements.

Method

This study employed a Research and Development (R&D) approach using the ADDIE design model, focusing specifically on the development and implementation stages. A one-group pretest–posttest design without a control group was used to evaluate changes in aerobic capacity before and after the implementation of the training program. This design was considered appropriate because the main objective was to examine the effectiveness of a Strava-based endurance training program in a real educational setting rather than comparing it with alternative interventions.

Participants consisted of 16 undergraduate students (9 males and 7 females) aged 21–24 years from the Sport Science Study Program at Universitas Negeri Padang, enrolled in the Physical Fitness Management course. Purposive sampling was used to select participants who were physically healthy, had an average ideal body weight, and actively attended lectures and training sessions throughout the study.

The training program lasted five weeks, with 3–4 sessions per week, including continuous running, fartlek, and tempo running exercises. Each session lasted 30–45 minutes and was performed at moderate to high intensity to stimulate aerobic adaptations. Class sessions were directly supervised by the lecturer, while additional sessions outside the classroom were monitored using the Strava mobile application.

Strava was used as a digital tool to record running distance, duration, pace, and heart rate for participants using wearable devices. After each session, participants submitted screenshots of their Strava activity to a WhatsApp group for monitoring attendance, compliance, and training performance.

Aerobic capacity (VO_2max) was assessed using the 2.4 km run test, a valid and practical field-based measure. VO_2max values were calculated using the equation $VO_2max = 85.95 – (3.079 \times \text{run time})$, as proposed by Burger et al. (1990).

Prior to data collection, participants were fully informed about the study objectives, procedures, and data collection process. Ethical approval was obtained from the Faculty of Sports Science Ethics Committee, Universitas Negeri Padang (Approval No: 2508/UN35.3/PG/2025).

Descriptive statistics were used to summarize VO_2max data and classify aerobic fitness levels based on ACSM standards (Bushman, 2017). Data normality was tested using the Shapiro–Wilk test. Differences between pretest and posttest VO_2max were analyzed using a paired-sample t-test with a significance level of $p < 0.05$. All statistical analyses were conducted using SPSS version 24.0.

Results and Discussions

This study involved 16 undergraduate students of the Sport Science Study Program, Universitas Negeri Padang (7 female and 9 male). The research aimed to examine the effectiveness of a Strava-based training program that included continuous running, fartlek, and tempo running to improve students' VO2max capacity. The training program was conducted 3–4 times per week for a total of 16 sessions.

VO2max was measured using a 2.4 km running test before and after the implementation of the training program (Pree Test - Post Test). The estimated VO_2max is calculated based on the completion time using the validated equation proposed by Burger et al (1990): VO2max=85.95−(3.079×RunTime)

After obtaining VO2max values, results were classified into fitness categories using the standard provided by Barbara Bushman (2017, ACSM Guidelines for Exercise Testing and Prescription). The classification divides VO_2max into Very Poor, Poor, Fair, Good, Excellent, and Superior according to age and sex-adjusted norms.

Table 1. VO_2max Classification (Barbara Bushman, 2017, ACSM Guidelines):

Male	Age				
	20-29	30-39	40-49	50-59	60-69
Superior	66.3 +	59.8 +	55.6 +	50.7 +	43.0 +
Excellent	57.1 to 66.2	51.6 to 59.7	46.7 to 55.5	41.2 to 50.6	36.1 to 42.9
Good	50.2 to 57.0	45.2 to 51.5	40.3 to 46.6	35.1 to 41.1	30.5 to 36.0
Fair	44.9 to 50.1	39.6 to 45.1	35.7 to 40.2	30.7 to 35.0	26.6 to 30.4
Poor	38.1 to 44.8	34.1 to 39.5	30.5 to 35.6	26.1 to 30.6	22.4 to 26.5
Very Poor	38.0 or lower	34.0 or lower	30.4 or lower	26.0 or lower	22.3 or lower
Female			Age		
	20-29	30-39	40-49	50-59	60-69
Superior	56.0 +	45.8 +	41.7 +	35.9 +	29.4 +
Excellent	46.5 to 55.9	37.5 to 45.6	34.0 to 41.6	28.6 to 35.8	24.6 to 29.3
Good	40.6 to 46.4	32.2 to 37.4	28.7 to 39.9	25.2 to 28.5	21.2 to 24.5
Fair	34.6 to 34.5	28.2 to 32.1	24.9 to 28.6	21.8 to25.1	18.9 to 24.4
Poor	28.4 to 34.5	24.1 to 28.1	21.3 to 24.8	19.1 to 21.7	16.5 to 18.8
Very Poor	28.5 or lower	24.0 or lower	21.2 or lower	19.0 or lower	16.4 or lower

Baseline VO2max Findings

Before the intervention, most participants fell into the Very Poor and Poor categories, indicating a generally low aerobic fitness level. The mean pretest VO2max was 35.10 ml/kg/min.

Table 2. Pre-Test VO_2max Results

No.	Initials	Gender	Pre-Test (minutes:seconds)	VO2max (ml/kg/min)	Category
1	DA	F	23:02	15.13	Very Poor
2	VA	F	19:42	25.29	Very Poor
3	SZ	F	19:49	24.98	Very Poor
4	GF	F	18:05	30.52	Poor
5	AF	F	18:08	30.22	Poor
6	SS	F	20:41	22.52	Very Poor
7	NM	F	16:00	36.68	Fair
8	AG	M	12:52	46.53	Fair
9	M.Al	M	13:06	45.61	Fair
10	RR	M	10:31	53.62	Good
11	ZZ	M	12:54	46.23	Fair
12	AAS	M	17:31	32.06	Very Poor
13	JAP	M	16:48	34.22	Very Poor
14	TBN	M	19:00	27.44	Very Poor
15	AR	M	13:51	43.45	Poor
16	SR	M	12:40	47.15	Fair

At baseline, the distribution of participants showed that the majority were in the Very Poor and Poor categories. Specifically, 7 students (43.75%) were classified as Very Poor, 3 students (18,75%) as Poor, 5 students (31.25%) as Fair, and only 1 student (6.25%) achieved the Good category. The mean pre-test VO_2max was 35.10 ml/kg/min, reflecting a generally low to moderate aerobic fitness profile among participants. This condition highlights the importance of structured training interventions to elevate aerobic capacity.

After completing the 5-week Strava-based program, substantial improvements were observed. The mean posttest VO2max increased to 42.42 ml/kg/min, reflecting a 20.2% improvement.

Table 3. Post-Test VO_2max Results

No.	Initials	Gender	Pre-Test (min:sec)	VO2max Classification	Category
1	DA	F	17:37	31.75	Poor
2	VA	F	14:45	40.68	Good
3	SZ	F	15:40	37.91	Fair
4	GF	F	16:55	33.91	Poor
5	AF	F	18:04	30.52	Poor
6	SS	F	19:12	26.83	Very Poor
7	NM	F	14:13	42.22	Good
8	AG	M	11:25	50.84	Good
9	M.Al	M	12:10	48.51	Fair
10	RR	M	09:45	55.92	Good
11	ZZ	M	13:26	45.92	Fair
12	AAS	M	13:08	45.61	Fair
13	JAP	M	14:06	42.53	Poor
14	TBN	M	15:31	38.22	Poor
15	AR	M	10:40	53.12	Good
16	SR	M	11:32	50.45	Good

After completing the 5-week Strava-based training program, students demonstrated a substantial improvement in VO2max, with the mean value rising from 35.10 ml/kg/min (pre-test) to 42.18 ml/kg/min (post-test), equivalent to a 20.8% increase. The distribution also shifted positively, as the number of students in the “Good” category increased to 6 (37.5%), while those in the “Very Poor”

category decreased sharply to only 1 (6.25%). These findings confirm both the statistical and practical effectiveness of the Strava-based training in enhancing aerobic fitness among Sports Science students.

The results of this study showed a substantial improvement in the participants' aerobic capacity following the implementation of the Strava-based training program.

Before conducting the inferential analysis, the normality of VO2max data was assessed using the Shapiro–Wilk test:

Table 4. Normality Test (Shapiro–Wilk)

Variabel	Nilai Sig. (p)	Interpretation
Pretest VO_2max	0,956	Normal distribution
Posttest VO_2max	0,974	Normal distribution

Because the significance value (p) > 0.05 in both variables, the data is declared to be normally distributed, thus meeting the assumption to conduct a parametric paired sample t-test.

Table 5. Parametric Paired Sample T-Test.

Pasangan Uji	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Posttest VO_2max *Pretest VO_2max*	7,0806	5,44417	1,36104	5,202	15	0,000

Table 6. Distribution of Participants by VO2max Category

Category	Pre-test (n, %)	Post-test (n, %)
Very Poor	7 (43.75%)	1 (6.25%)
Poor	3 (18,75%)	5 (31,25%)
Fair	5 (31.25%)	4 (25.0%)
Good	1 (6.25%)	6 (37.5%)
Excellent	0	0
Superior	0	0

The paired t-test confirmed that the increase in VO2max was statistically significant (**p < 0.05**).

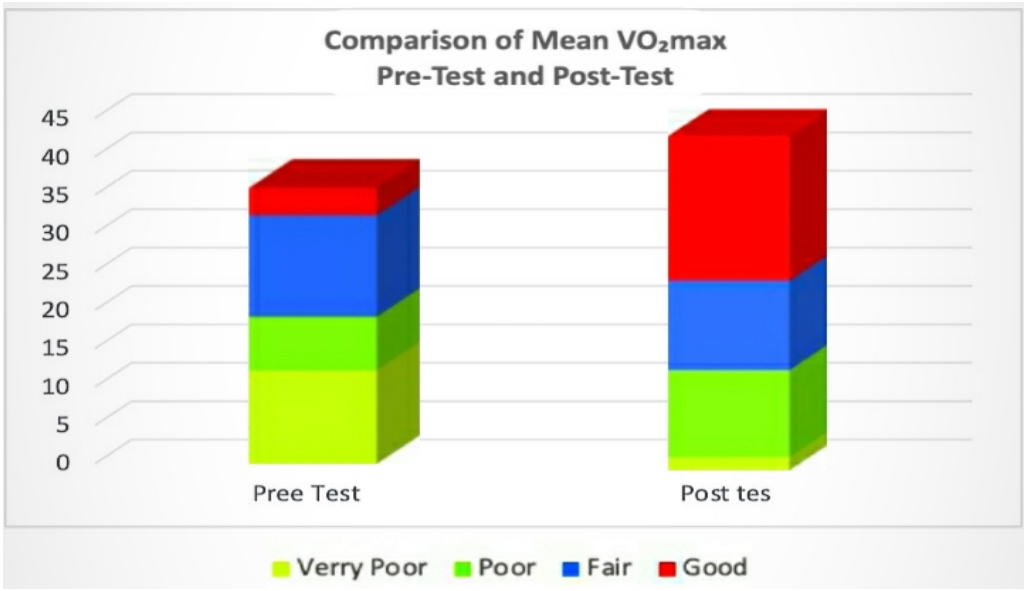

Figure 1. Comparison of Mean *VO2max* Pre- and Post-Test

The bar chart illustrates a clear upward shift in VO2max levels, with post-test values surpassing the threshold for "Fair" and approaching the "Good" classification. This improvement suggests that the

structured training intervention—consisting of continuous running, fartlek, and tempo running—was effective in enhancing aerobic capacity among students.

This study aimed to develop and evaluate a Strava-based endurance training program to improve VO_2max among undergraduate Sport Science students. The results demonstrated a statistically significant increase in VO_2max following the 5-week training intervention, confirming the effectiveness of the program and the feasibility of integrating digital monitoring tools into university-level physical fitness education (ACSM, 2018; Midgley et al., 2008).

The mean VO_2max increased from 35.10 ml/kg/min to 42.18 ml/kg/min, representing a 20.2% improvement. This change aligns with previous research indicating that structured aerobic training over 4–6 weeks can enhance VO_2max by 10–25%, depending on training intensity, frequency, and baseline fitness levels (Midgley et al., 2008; Bassett & Howley, 2000). Continuous running, fartlek, and tempo running effectively stimulate cardiovascular adaptations, improve stroke volume, elevate lactate threshold, and enhance oxidative enzyme activity (Billat, 2001).

In addition to structured training, participants received lifestyle guidance on nutrition, hydration, and rest to support physiological adaptation. While these factors were not experimentally controlled, they complemented the training stimulus and likely contributed to optimal aerobic improvements (American College of Sports Medicine, 2016; Tudor Bompa & Buzzichelli, 2019; Welis, 2023).

The integration of Strava facilitated remote supervision, progress tracking, and accountability. Participants submitted screenshots of their activities through WhatsApp, which increased adherence and motivation, consistent with prior findings on digital tracking tools enhancing self-monitoring and compliance (Ridgers et al., 2018; Glynn et al., 2014). Technology-assisted monitoring addressed challenges such as limited class time and inconsistent supervision, bridging independent practice with structured guidance.

This study demonstrates the practical relevance of app-based training for higher education sport programs. The Strava-based approach is cost-effective, user-friendly, and aligns with students' digital habits, supporting independent learning, autonomy, and responsibility (Cadmus-Bertram et al., 2015; Brickwood et al., 2019). It provides a replicable model for integrating technology into structured endurance programs.

Comparisons with previous studies confirm that digital monitoring improves exercise compliance and performance outcomes (Seiler, 2010; Cadmus-Bertram et al., 2015). The VO_2max improvements observed are comparable to results from blended or hybrid endurance training, which combine supervised and independent practice, reinforcing the effectiveness of technology-supported interventions in educational settings.

Despite these positive outcomes, this study has limitations, including a small sample size (n = 16), a one-group pretest–posttest design without a control group, and partial use of heart rate monitoring. Future research should employ larger, randomized controlled trials, compare app-based versus traditional training, and incorporate full heart rate monitoring for all participants to improve precision and generalizability.

Conclusions

The integration of Strava into a structured endurance training program was shown to significantly improve VO_2max, enhance training adherence, and provide a practical technology-based learning model for sports science education. Over the five-week intervention, participants' VO2max increased notably from 35.10 to 42.18 ml/kg/min indicating substantial gains in aerobic capacity. Strava effectively supported the monitoring of distance, duration, and training intensity, while digital reporting facilitated efficient supervision outside classroom sessions. These findings show that technology-assisted training is easy and practical, and feasible to be applied in higher education environments. Overall, the Strava App-based 5-week training program has proven to be effective and feasible for improving aerobic fitness and offers a promising framework for integrating digital tools

into physical fitness teaching. Future research may involve larger samples, comparison groups, or alternative training models to further strengthen the evidence base.

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