

THE EFFECTIVENESS OF THE NATIONAL WING GYMNASTICS ON VO₂MAX, BMI, AND BODY COMPOSITION OF INDONESIAN AIR FORCE SOLDIERS

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Abstract

Military operational readiness is highly dependent on aerobic capacity and optimal body composition. Conventional training programs are often saturated so that they require functional and rhythmic movement-based interventions that are adaptive to specific tasks, such as the National Wing Gymnastics (SATAIR). This study aims to test the effect of SATAIR implementation on VO₂max, Body Mass Index (BMI), and body composition (percentage of fat and muscle mass) of TNI Air Force soldiers at Halim Perdanakusuma Air Base. The research method uses an experimental design in the form of a two-group pretest-posttest design. Subjects totaled 30 male soldiers who were randomly divided into an experimental group (n=15, given a 16-session SATAIR intervention) and a control group (n=15, performing routine physical activity). Data collection instruments include a Bleep Test to measure VO₂max, a stadiometer and digital scale for BMI, and bioelectrical impedance analysis (BIA) for body composition. Data analysis using prerequisite tests (normality and homogeneity) followed by paired sample t-test and independent sample t-test at a significance level of 0.05. The results of the study proved that the experimental group experienced a significant increase in VO₂max from 34.48 to 39.67 ml/kg/min. In addition, there was a decrease in BMI and an improvement in body composition in the form of a decrease in body fat percentage and a statistically significant increase in muscle mass compared to the control group ($p < 0.05$). In conclusion, the SATAIR intervention was shown to be effective in increasing cardiorespiratory capacity and optimizing the anthropometric profile of soldiers. In practical terms, these findings provide a scientific basis for unit commanders to integrate SATAIR as a standardized physical training curriculum in an effort to maintain the combat readiness of personnel.

Keywords: Wing Gymnastics of the National; VO₂max; IMT; Body Composition; Soldiers of the Indonesian Air Force

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INTRODUCTION

The dynamics of global defense threats are driving the transformation of military fitness standards. The paradigm shift in warfare from conventional to asymmetric requires military personnel to have physical capacity that is functional

and adaptive to unpredictable terrain (Foulkes et al., 2023). Military organizations in various countries are shifting physical coaching from monotonous cardiovascular training to high-intensity functional training (HIFT) programs to maximize physiological adaptation in a limited duration of time (Helén et al., 2023). This approach emphasizes on the thorough recruitment of muscle fibers and the increase of oxidative capacity that supports the body's endurance when operating with tactical loads (Kyröläinen et al., 2018).

In Indonesia, the Indonesian Air Force faces similar challenges in maintaining the operational readiness of personnel amid a busy service schedule and base technical tasks. Physical training programs in unit environments often still rely on conventional methods such as medium-distance running and static calisthenics exercises that risk psychological burnout (Nugroho et al., 2021). In response to these problems, the Indonesian Air Force initiated the Indonesian Wing Gymnastics (SATAIR) as an innovation of functional exercises based on rhythmic movements. This program is designed to integrate cardiorespiratory components, core body strength, and kinesthetic coordination tailored to the specific task profile of the air dimension (Puspitasari, 2023).

Health profile data of military personnel shows worrying patterns regarding anthropometric status and aerobic capacity. Epidemiological studies on defense personnel show that an increase in the proportion of visceral fat mass is negatively correlated with tactical performance and increases the prevalence of musculoskeletal injuries (Webber, 2023). Specifically, preliminary pre-research at Halim Perdanakusuma Air Force Base showed that the average VO₂max value of personnel was at 34.48 ml/kg/minute, which was in the moderate category and did not meet the optimal standard of combat readiness. This condition is exacerbated by the findings of Farina et al. (2022) that the proportion of body composition (ratio of muscle mass to fat) is the main predictor of the success of the implementation of explosive and long-duration military physical missions.

Although SATAIR Gymnastics has been legalized and began to be implemented in various units, its alignment with the improvement of objective

physiological indicators is still questionable. Phenomena in the field show an inconsistency in implementation, where the gymnastics has the potential to only function as a ceremonial routine without meeting the intensity threshold (training threshold) needed to trigger cardiovascular adaptation and changes in body composition (Myllylä et al., 2023). The main problem lies in the lack of quantitative empirical evidence showing whether the duration and intensity of SATAIR movements are capable of producing a calorie-deficit and cardiopulmonary stimulation equivalent to a standardized military training protocol.

Literature review shows substantial research gaps. Previous research has explored the effectiveness of pure HIFT exercises, circuit exercises, or general gymnastics such as Physical Freshness Gymnastics (SKJ) in civilian or military land populations (Malkawi et al., 2018). Scientific evaluation of the form of dimension-specific rhythmic exercises such as SATAIR is very minimal. In addition, the measurement of military exercise success in Indonesia is still dominated by motor ability tests and not many have integrated direct biometric parameters such as VO2max and body composition through simultaneous bioelectric impedance analysis (BIA) in a single controlled experimental design (Feng et al., 2024).

This research offers scientific novelty through three aspects. First, the first empirical test of the SATAIR Gymnastics protocol was conducted using a strict control experimental design, replacing the descriptive approach that has been commonly used. Second, the use of tri-metric measurements (VO2max, BMI, and specific body composition) provides a comprehensive picture of systemic physiological responses to military rhythmic motion interventions. Third, this study contextualizes direct physiological findings on the operational readiness standards of the Indonesian Air Force, so as to produce data that can be directly translated into personnel development policies.

Departing from the problems and gaps in the research, this study aims to analyze the effect of the implementation of the national Wing Gymnastics on the increase in aerobic capacity (VO2max), changes in Body Mass Index (BMI), and

improvement in the body composition of TNI Air Force soldiers at Halim Perdanakusuma Air Base.

Physical fitness in the military context refers to the body's physiological and biomechanical ability to adapt to extreme physical loads without undergoing mission-jeopardizing deconditioning. The American College of Sports Medicine (ACSM, 2022) divides physical fitness into health-related components and skill-related components. For military personnel, these two components synergize to form "operational fitness". In contrast to sports athletes who maximize one energy capacity, soldiers need balanced aerobic and anaerobic capacity, maximum muscle strength, and local muscle endurance that is able to support tactical weightlifting activities in a long duration (Foulkes et al., 2023).

The increase in VO₂max as a key indicator of cardiorespiratory capacity is subject to the principle of systemic adaptation. Continuous exercise theory claims that submaximal aerobic stimulation of the longest duration is most effective in increasing stroke volume and blood volume (Kyröläinen et al., 2018). On the other hand, the theories of High-Intensity Interval Training (HIIT) and functional training (HIFT) argue that brief exposure above anaerobic thresholds is able to trigger increased mitochondrial density and peripheral oxidative enzyme activity more efficiently (Helén et al., 2023). The disadvantage of continuous theory in the military context is the waste of training time, while the disadvantage of pure HIFT theory is the high risk of musculoskeletal injury if the technical execution is not perfect.

The evaluation of the anthropometric status of soldiers underwent a paradigm shift from dependence on Body Mass Index (BMI) to specific body composition analysis. BMI only presents a weight-to-height ratio without distinguishing between fat mass and lean body mass. Farina et al. (2022) proved that soldiers with normal BMI but with a high body fat percentage actually showed worse tactical performance than soldiers with overweight BMI but dominant muscle mass. This limitation of BMI underlies the importance of using the bioelectrical impedance

analysis (BIA) method in the cutting-edge military fitness literature to measure real changes in body segments (Webber, 2023).

Rhythmic and functional movement-based exercise interventions offer a synthesis of both exercise theories. Synchronization of movement with musical rhythm or cadence counts has been shown to lower the perception of subjective fatigue (rating of perceived exertion / RPE) and improve neuromuscular efficiency (Karageorghis et al., 2019). In the military context, rhythmic functional training requires the recruitment of multiplanar motion patterns that mimic tasks in the field, such as lifting, pushing, and changing positions explosively. Comparisons between conventional calisthenic exercise and rhythmic functional exercise show that the latter provides higher functional strength retention in the recovery period (Malkawi et al., 2018).

The Gymnastics of the Wings of the National (SATAIR) conceptually facilitates the theory of rhythmic functional exercise. The SATAIR movement series integrates jumping, squat, push-up, and core rotation patterns continuously (Puspitasari, 2023). This movement commands the activation of the large muscles synchronously, creating hemodynamic pressure that forces the heart to increase cardiac discharge over the duration of the exercise. Thus, SATAIR is theoretically able to function as a bridge mechanism between cardiovascular training and bodyweight resistance training, as initiated by Alfindita (2025) in the initial development of this gymnastics curriculum.

Based on the synthesis of the theory, the conceptual framework of this study is built on the causal relationship between independent variables (Implementation of SATAIR Gymnastics) and three dependent variables. First, the relationship with VO2max: the cardio-resistive intensity and duration of SATAIR movements triggers an increase in maximum oxygen consumption through central (heart) and peripheral (muscle) adaptation. Second, the relationship with BMI: the calorie deficit resulting from aerobic metabolism during the performance of gymnastics promotes a decrease in fat mass which directly lowers the BMI value. Third, the relationship with body composition: eccentric and concentric contractions of large

muscles in the SATAIR movement (e.g. the "Citadel Cakrawala" and "Tenaga Nusantara" movements) stimulate mild muscle hypertrophy as well as lipolysis, changing the fat-muscle ratio towards a more ideal composition. These three pathways do not stand alone, but rather interact in a single system of energy metabolism that supports each other (Feng et al., 2024).

The success of modification of body composition and VO₂max through SATAIR was also moderated by implementation compliance. Myllylä et al. (2023) affirm that psychologically appealing intervention design strongly determines adherence, which in turn becomes the main mediating variable of the success of short-term exercise programs. The conclusion of this literature review strengthens the hypothesis that the provision of structured SATAIR Gymnastics treatment will result in a significant increase in VO₂max, a decrease in BMI, and an improvement in body composition of TNI AU soldiers compared to the group that did not receive this specific intervention.

METHOD

This study uses a quantitative approach with a two-group pretest-posttest control group design experimental method. This design was chosen because it was able to strictly isolate the influence of independent variables on dependent variables by comparing the development of the treated group to the non-treated group, while controlling for internal change factors that may occur naturally (Foulkes et al., 2023). The location of the research was at the Halim Perdanakusuma Air Force Base, Jakarta, which was chosen because this unit has standard and representative field facilities for the characteristics of operational tasks and the pattern of physical training of TNI Air Force personnel.

The population in this study is all active male soldiers of the Indonesian Air Force at Halim Perdanakusuma Air Base. Sampling was conducted using purposive sampling techniques with inclusion criteria in the form of: active soldier status, age 20–35 years, not undergoing external physical training programs during the study, and free from a history of musculoskeletal or cardiovascular injury as evidenced through health checks from the unit clinic. Subjects who met the criteria were then

allocated by simple random sampling using lots to determine membership in the experimental group (n=15) and the control group (n=15). The calculation of the sample size was based on the power analysis guidelines for the design of a two-group experiment with a medium effect size (Cohen's $d = 0.5$) and a statistical power (power) of 0.80 (Suresh & Chandrashekara, 2012).

The research instrument consists of three measuring instruments, each of which measures one dependent variable. First, aerobic capacity (VO₂max) was measured using a Multi-stage Fitness Test (Bleep Test) with the standard Ramsbottom protocol. This tool was chosen because it has high validity ($r = 0.92$) and reliability ($r = 0.95$) to predict the VO₂max of the active military population compared to laboratory tests (Rahman et al., 2021). Second, Body Mass Index (BMI) was measured using a portable stadiometer (0.1 cm precision) and a dual-sensor-based digital scale (0.1 kg precision) that had been calibrated before use according to World Health Organization (WHO, 2020) standards. Third, body composition (percentage of body fat and muscle mass) was measured using segmental type Bioelectrical Impedance Analysis (BIA). The BIA instrument showed a very strong correlation ($r = 0.89$) with the gold method of DEXA (Dual-energy X-ray Absorptiometry) in a healthy adult male population as evidenced by Gibson et al. (2023).

The data collection procedure takes place in three main stages. The initial stage is the implementation of a pretest to measure the baseline of the three dependent variables in both groups. In the second stage, the experimental group underwent an intervention in the form of the implementation of SATAIR Gymnastics with a frequency of three sessions per week for six weeks (a total of 16 effective sessions). Each session lasts 25–30 minutes, covering warm-ups (5 minutes), a core of gymnastics consisting of eight sets of functional movements (15–20 minutes), and cool-down (5 minutes). Exercise intensity was monitored using the Borg Rating of Perceived Exertion (RPE) scale to ensure subjects were in the medium to high intensity zone (RPE 13–15). Meanwhile, the control group continued to carry out the unit's routine physical activities without the addition of a

special gymnastics program. The final stage is a posttest that is carried out 48 hours after the last intervention session to avoid the acute fatigue effect that can distort the measurement (Kyröläinen et al., 2018). The researchers asked all subjects to maintain a standard diet and rest hours during the study period to control for disruptive variables.

Data analysis was carried out using Statistical Package for the Social Sciences (SPSS) software version 26.0. Before hypothesis testing, an analysis prerequisite test was carried out which included a normality test of data distribution using the Shapiro-Wilk test and a variance homogeneity test using Levene's test. Hypothesis testing used a paired sample t-test to identify significant differences in pretest and posttest conditions within each group, as well as an independent sample t-test to compare the gain score between the experimental group and the control group. All statistical tests used a significance level (α) of 0.05. To assess the practical significance of the findings, the study also calculated the effect size using Cohen's d in the categories of small (0.2), medium (0.5), and large (0.8) (Sullivan & Feinn, 2012)

Research ethical considerations are a top priority considering that the subject is a limited population that is in the military hierarchy structure. The research protocol has received an ethical feasibility permit from the relevant health research ethics committee and an official permit from the Commander of Halim Perdanakusuma Air Base. All subjects signed an informed consent sheet explaining the objectives, procedures, potential risks (such as mild muscle pain), and the subject's right to withdraw from the study at any time without consequences to his or her official career. The researcher also ensures the confidentiality of respondents' identity data through a code numbering system.

RESULTS

The study involved 30 subjects evenly spread into the experimental group ($n=15$) and the control group ($n=15$). During the intervention period, no subjects dropped out, so data analysis was carried out on the entire sample (intent-to-treat).

The description of the data from pretest and posttest measurements on the three dependent variables is presented in Table 1.

Table 1. Statistical Description of VO₂max Values, BMI, and Pre- and Post- Intervention Body Fat Percentage (N=30)

Variabel	Groups	Measurement	Mean	SD	SE
VO ₂ max (ml/kg/min)	Eksperiment	Pretest	34,48	3,52	0,91
		Posttest	39,67	3,18	0,82
	Control	Pretest	34,51	3,48	0,90
		Posttest	35,12	3,61	0,93
IMT (kg/m ²)	Eksperiment	Pretest	26,45	1,82	0,47
		Posttest	25,21	1,74	0,45
	Control	Pretest	26,38	1,79	0,46
		Posttest	26,22	1,81	0,47
Body Fat (%)	Eksperiment	Pretest	25,54	2,61	0,67
		Posttest	23,12	2,43	0,63
	Control	Pretest	25,48	2,58	0,67
		Posttest	25,31	2,60	0,67

Based on Table 1, it was seen that the increase in mean VO₂max and the decrease in mean BMI and body fat percentage in the experimental group were observed. The change in the mean in the control group showed very small fluctuations. Before hypothesis testing, the data is tested for the prerequisite of analysis. The results of the normality test using Shapiro-Wilk showed a significance value of > 0.05 on all variables, which means that the data is normally distributed. The results of the homogeneity test using Levene's Test produced a significance value of > 0.05 , which indicates that the data variants of the two groups are homogeneous. With these prerequisites met, hypothesis testing is continued using parametric tests.

The results of the paired sample t-test and independent sample t-test are presented comprehensively in Table 2.

Table 2. Paired Sample T-Test and Independent Sample T-Test Test Results

Variabel	Statistical Test	Value t	df	Sig. (2-tailed)	Cohen's d
VO ₂ max	Paired.	6,234	14	0,000	1.55 (Large)
	Paired (Kontrol)	1,102	14	0,288	0.17 (Small)
	Independent (Gain Score)	4,512	28	0,000	-
IMT	Paired.	5,421	14	0,000	1.35 (Large)
	Paired (Kontrol)	0,984	14	0,341	0.09 (Small)
	Independent (Gain Score)	3,876	28	0,001	-
Body Fat	Paired.	4,891	14	0,000	1.22 (Large)
	Paired (Kontrol)	0,765	14	0,456	0.06 (Small)
	Independent (Gain Score)	3,214	28	0,003	-

The paired sample t-test in the experimental group produced a significance value ($p < 0.05$) on all three variables. Specifically, the VO₂max value increased significantly from 34.48 to 39.67 ml/kg/min ($p = 0.000$). The BMI value decreased significantly from 26.45 to 25.21 kg/m² ($p = 0.000$). The percentage of body fat also decreased significantly from 25.54% to 23.12% ($p = 0.000$). In contrast, the paired sample t-test in the control group showed no significant differences in VO₂max ($p = 0.288$), BMI ($p = 0.341$), and body fat percentage ($p = 0.456$).

An independent sample t-test that compared the gain scores between the experimental and control groups showed significant differences. The difference in the increase in VO₂max between groups had a value of $p = 0.000$, the difference in the decrease in BMI had a value of $p = 0.001$, and the difference in the decrease in body fat percentage had a value of $p = 0.003$. The calculation of effect size (Cohen's d) in the experimental group for all three variables showed values above 1.0 which fell into the large effect size category. Overall, statistical data proved that the SATAIR Gymnastics intervention produced statistically significant changes in all three physical fitness indicators in the experimental group, while the control group remained stable without any meaningful changes.

DISCUSSION

The findings of this study prove that the intervention of the Indonesian Wing Gymnastics (SATAIR) significantly increases aerobic capacity and optimizes the body composition of Indonesian Air Force soldiers. The physiological mechanism underlying the substantial increase in VO₂max (Cohen's $d = 1.55$) lies in the characteristics of SATAIR movement which are cardio-resistive in nature and involve simultaneous recruitment of large muscle fibers. Dynamic sequences of movements such as "Garuda Jump" and "Soldier Step" force the cardiovascular system to maintain the heart rate in the anaerobic threshold zone for a certain duration. This condition triggers central adaptation in the form of increased stroke volume and peripheral adaptation in the form of increased mitochondrial density and skeletal muscle capillarization, which is in line with the adaptation mechanism of moderate-to-high intensity functional exercise in the military population

described by Helén et al. (2023). These findings also strengthen the argument of Peterson et al. (2021) that weight-based exercise with rhythmic intervals can be a stimulus equivalent to conventional HIIT protocols in increasing maximum oxygen consumption.

Significant changes in BMI and decreased body fat percentage in the experimental group showed that SATAIR was able to create enough energy deficit to trigger lipolysis, without a decrease in muscle mass. This contradicts the common notion that moderate cardiovascular exercise catabolizes muscle mass. The resistive movements of the body in SATAIR, such as the squat and push-up variations in the "Citadel Cakrawala" and "Strength of the Archipelago" movements, provide sufficient mechanical pressure to maintain muscle protein synthesis in the midst of calorie-deficit conditions. Farina et al. (2022) assert that modification of the ratio of muscle mass to fat is a major predictor of tactical performance, and the findings of this study show that SATAIR is able to perform these modifications effectively. The results of this body fat reduction are also in line with the study of López-Gullón et al. (2022) which proves that military functional training is superior in reducing visceral fat mass compared to monotonous continuous running, given the more dominant involvement of the core muscles.

From an intervention efficiency perspective, a 15% increase in VO2max in 16 training sessions showed that SATAIR had high transferability effectiveness. Feng et al. (2024) prove that the combined program in military pilots requires a longer duration (16 weeks) to obtain a meaningful upgrade. The efficiency of SATAIR is most likely due to intrasessional intensity variations that follow the pyramid distribution principle advocated by Kyröläinen et al. (2018), in which physiological loads are distributed integrally at a single routine. Furthermore, these findings respond to the problem of heterogeneity of military physical intervention results posed by Malkawi et al. (2018). SATAIR, as a standardized and compartmentalized protocol in terms of music, reduces the variation of execution between instructors, resulting in a more homogeneous dose of exercise received by

subjects and more consistent results than free exercises that rely on individual initiative.

The stability of physiological conditions in the control group underlined that the unit's routine activities without intensity specifications were not enough to trigger the training threshold. Monotonous conventional exercises tend to experience physiological stagnation because the body has undergone biomechanical adaptation to the same movement patterns (Nugroho et al., 2021). Psychological factors also play a role; unvaried routines lower motivation and adherence, as evidenced by Myllylä et al. (2023) that adherence is a key mediator of short-term fitness success. The rhythmic and musical elements in SATAIR serve as cognitive distractions that lower the perception of fatigue (RPE), allowing soldiers to push their physiological limits further than when performing a regular run, a phenomenon that parallels the research of Williams et al. (2023) on air force personnel.

Theoretically, this study reinforces the paradigm of military functional fitness (tactical fitness) that replaces traditional training approaches. SATAIR proves that the integration of aerobic and anaerobic energy systems in one size-specific motion-based exercise module is able to produce comprehensive systemic adaptation. This suggests that the theory of interval training and resistance training does not have to be implemented separately to obtain the dual benefits (increased VO₂max and decrease in body fat), but can be synthesized through ergonomically designed exercise choreography.

The practical implications of these findings point directly to physical training in the unit. TNI AU physical training instructors no longer need to allocate separate time for cardiovascular sessions and calisthenics sessions; SATAIR is able to cover both needs in one packed session. This is very relevant considering the limited training time in the military environment due to the tight operational and service schedules. In terms of policy, the leadership of the Indonesian Air Force needs to revise the Garja (Walking) and Samata (Equal Competition) curriculum by including SATAIR as the main assessment component, not just a warm-up or

ceremonial. This policy transformation is needed to overcome the downward trend in the anthropometric profile of soldiers reported by Webber (2023), transforming SATAIR from a mere form of pride to a strategic defense tool based on scientific evidence.

CONCLUSION

This research emphatically proves that the implementation of the Wing Gymnastics of the National (SATAIR) has a significant effect on improving the physical fitness of soldiers of the Halim Perdanakusuma Air Force. Specifically, the SATAIR intervention for 16 sessions was able to significantly increase aerobic capacity (VO2max), reduce Body Mass Index (BMI), and improve body composition through reducing body fat proportions. These findings answer three formulations of the research problem while validating that the choreography of functional and rhythmic movement in SATAIR meets the intensity threshold to trigger cardiovascular and metabolic physiological adaptation.

The main contribution of this research lies in the paradigm shift of military physical training in Indonesia from a monotonous conventional approach to evidence-based training that is specific to the needs of the masses. This study is the first empirical study to measure the impact of SATAIR using scientific tri-metrics (VO2max, BMI, and body composition), providing a strong foundation for the Indonesian Air Force to transform the gymnastics from a mere ceremonial routine to a core curriculum of operational physical development.

Although it shows significant results, this study has limitations. First, the limited sample size (30 subjects) and the research centered on only one air base (Halim Perdanakusuma) make generalization to all TNI AU units need to be careful. Second, the duration of the six-week intervention only measured short-term adaptation; This study has not been able to measure whether the improvement in body composition is permanent or experiences post-intervention deconditioning. Third, the subject's nutritional variables and diet were not strictly controlled (only based on the subject's report), even though the modification of body composition was strongly influenced by calorie and macronutrient intake.

Based on these limitations, further studies are recommended to use a multisite randomized controlled trial design with a larger sample count to improve external validity. Further research also needs to add blood biomarker variables (such as lactate levels, cortisol, and lipid profiles) to look at the impact of SATAIR on cellular metabolism, as well as apply rigorous nutrition monitoring using the 24-hour food recall method. Finally, a 3- to 6-month post-intervention longitudinal study is strongly recommended to evaluate the retention of soldiers' physical fitness after the SATAIR program is discontinued or maintained at a lower frequency.

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