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Research Article

VO_2max Changes in Sedentary Young Men After Asian Squat Exercise

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Abstract.
Background and Study Aim. Sedentary lifestyle has a significant relationship with cardiorespiratory fitness level (VO2max) in children and adolescents. Resistance training such as Asian squats can improve not only local but also systemic endurance capacity. This study aims to analyze the changes of VO2max in sedentary male adolescents after Asian squat exercise.
Material and Methods. The subjects were 30 sedentary adolescent boys aged 15-17 years old who met the inclusion criteria. The subjects were divided into two groups, 15 control group and 15 experimental group. The control group received no treatment. The experimental group was given Asian squat exercise 3 times a week for 8 weeks.
Results. In the experimental group, significant changes in the form of an increase in VO2max values based on the mean, appeared from week 4 to week 8 ($p = 0.001$) with an effect size of 0.95. There was no significant change from week 0 to week 4, and also from week 0 to week 8. There was no significant change from week 4 to week 8 and also from week 0 to week 8 in the control group. Intergroup comparison showed a significant change in VO2max between the control and experimental groups at week 8 ($p = 0.048$) with an effect size of 0.75.
Conclusions. There was an increase in VO2max after Asian squat training, and there were differences in changes in VO2max between the two groups. Asian squat exercise is a simple, safe, and easy to do resistance exercise.

Keywords: sedentary, Asian squat, VO2max

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Introduction

Indonesia is the fourth-largest country in the world in terms of teenage population size among low and middle-income countries (LMIC) in Southeast Asia, with a population of about 92 million teens [1]. A critical developmental stage where life patterns are established and maintained is adolescence. Early-life behavioural habits have both short- and long-term effects on one's health and well-being.

Teenagers are living more sedentary lives due to technological advancements that have automated tasks that previously required computers and other machinery. Many factors, including technological, social, environmental, and economic advancements, contribute to the rise in sedentary behavior. A lack of sports fields, city parks, or other amenities that promote physical exercise is also associated with low levels of physical activity [2]. A comprehensive review by Andriyani et al. (2020) found that between 12.2% and 52.3% of teenagers participate in physical activity at adequate levels, and between 24.5% and 33.8% spend more than three hours exercising. The degree of physical exercise is also influenced by gender. It is well known that men engage in more physical exercise than women, and that this activity becomes less intense over time. The ability of the heart to pump oxygen to the muscles during physical exercise is known as the respiratory fitness level, which is a measure of physical health. Relative intensity is measured in relation to an individual's VO2max, while absolute intensity is determined by external activities representing the level of respiratory fitness [3,4].

The Cardiopulmonary Exercise Test (CPET) is the gold standard for determining VO2max; however, this method is less flexible when employed on a broad and widespread scale because it involves the use of relatively complex equipment. Another technique that is easy to use, flexible, and has strong validity for VO2max measurement is the step test. As an alternative to CPET for calculating cardiorespiratory fitness (CRF) in office settings, the step test is simple to perform in constrained indoor spaces and requires little equipment. Step tests are appropriate for simultaneous group testing and can also be conducted on school benches [5].

A 2017 study by Haramura et al. demonstrated that a 5-minute continuous bout of moderately intense body mass-based squat exercise can affect the cardiorespiratory response. Improving muscular function and body composition has been the main focus of earlier studies investigating the effects of body mass-based exercise training [6]. Squats, a foundational strength exercise, significantly enhance cardiorespiratory fitness by engaging large lower body muscles (quadriceps, hamstrings, glutes, and calves) to increase heart rate and oxygen demand, providing a cardiovascular workout. High-repetition squats build muscular endurance, supporting longer aerobic activities like running and cycling, while improved calf function enhances circulatory efficiency by boosting blood return to the heart. Squats performed with intensity induce Excess Post-Exercise Oxygen Consumption (EPOC), elevating metabolic rate and stimulating the cardiorespiratory system post-workout. [7]. Exercises like squats are frequently recommended for prehabilitation, rehabilitation, and sports training [8]. Their ability to mimic a wide range of everyday activities makes them a perfect fit for fitness regimens. One variation of the deep squat used by individuals in Asia is the Asian squat, also known as the deep body weight squat [9, 10]. Because it is typically used to finish everyday tasks, it is referred to as a sitting or resting position. One of the many benefits of body mass-based workouts, like the Asian squat used in earlier research, is that they can be performed by a wide range of people in a short amount of time and anywhere [10].

Researchers are interested in learning how body mass-based training affects cardiorespiratory fitness levels in sedentary male adolescents because the current body of research evaluating the impact of this type of training on these individuals has only focused on muscle strength and body composition. The Chester step test was utilised to measure changes in VO2max, a measure of cardiorespiratory fitness levels, and the Asian Squat was used as a body-mass-based exercise in this study.

Materials and Methods

Participants. A total of 30 male students aged 15 to 17 years, categorised as sedentary based on the International Physical Activity Questionnaire (IPAQ), were recruited from Frateran Surabaya Catholic High School. Participants with a history of musculoskeletal diseases (including fractures, tendon ruptures, ligament ruptures, or congenital diseases), neurological disorders (such as epilepsy, vertigo, dyskinesia, spinal cord trauma, and brain trauma), cardiorespiratory diseases (including asthma, heart disease, and vascular disease), and those who regularly used squatting toilets were excluded from the study. Participants were excluded from the study if they failed to adhere to the recommended intervention more than twice consecutively or exceeded 20% of the total suggested sessions (four times).

Research Design. The intervention consisted of Asian squat exercises performed three times a week over a period of eight weeks, amounting to a total of twenty-four training sessions. The treatment group engaged in a progressive exercise regimen, starting with three sets of 8 repetitions in weeks 1 and 2, increasing to 10 repetitions in weeks 3 and 4, 13 repetitions in weeks 5 and 6, and finally 15 repetitions in weeks 7 and 8. A rest period of 2 minutes (120 seconds) was allowed between sets. The control group did not receive any intervention throughout the study. Pre-training and post-test measurements of the participants' VO2max were conducted, with follow-up assessments scheduled for the fourth and eighth weeks, following 12 training cycles. The researcher remained unaware of the group assignments during the single-blind data collection process, which was conducted by an independent assessor.

Statistical Analysis. The Statistical Programme for Social Sciences (SPSS) version 26 programme was used to analyse the data. It included parametric statistical tests, homogeneity tests, normality tests, and descriptive analysis. We also performed a covariate analysis for potentially confounding factors (age, height, weight, body mass index, femur length, tibia length, Mets week 0, nutritional intake).

Results

Table 1 lists the fundamental attributes of study subjects. The subjects' the basic characteristics did not differ significantly from one another (p>0.05). Every research subject's consumption of calories, protein, fat, and carbohydrates was documented in a food journal, which a nutritionist assessor subsequently processed and examined.

Table 1. Sample's characteristics

Characteristic	Intervention group (n=15)	Control group (n=15)	p-value
Age (yr)	15 (15-16)*	15 (15-17)*	0,914[a]
Height (cm)	165,67 ± 5,68†	167,70 ± 4,52†	0,287[b]
Weight (kg)	57 (48-100)*	59 (45-110)*	0,467[a]
BMI (kg/m2)	22,46 ± 4,69†	23,24 ± 6,20†	0,698[b]
Femur length (cm)	50,67 ± 2,82†	50,47 ± 2,67†	0,843[b]
Tibal length (cm)	39,97 ± 1,96†	39,60 ± 2,50†	0,748[b]
Maximum heart rate (times/min)	205 (204-205)*	205 (203-205)*	0,914[a]
Pre-intervention caloric intake (kcal)	1317,91 ± 254,58†	1316,78 ± 291,99†	0,739[b]
Pre-intervention protein intake (gr)	47,48 ± 9,90†	49,99 ± 11,06†	0,991[b]
Pre-intervention fat intake (gr)	45,75 ± 11,49†	48,32 ± 12,33†	0,559[b]
Pre-intervention carbohydrate intake (gr)	173,34 ± 46,29†	165,62 ± 44,65†	0,646[b]
Week-0 VO2max	45,49 ± 7,88†	45,42 ± 9,35†	0,982[b]
Week-0 METS	13,01 ± 2,25†	12,98 ± 2,67†	0,977[b]

Note: *Median (min-max), †Mean±SD, a) Mann Whitney U test; significant if $p < 0.05$, b) Independent t test; significant if $p < 0.05$

VO2max measurements were carried out in both groups (control group and treatment group) three times, at week 0, end of week 4, and week 8. There were no significant changes from week 0 to week 4, or overall from week 0 to week 8 (Table 2).

Table 2. Comparative Test of VO2max After Asian squat Training Week 0, 4, and 8 for Intervention Group

Time of Measurement	Mean ± SD	ANOVA	p Effect size (Cohen's d)**		
			Week 0-4	Week 4-8	Week 0-8
Week 0	45,49 ± 7,89	0.005*	0,193	0,001	0,077
Week 4	43,57 ± 6,15		-	0,95	-
Week 8	49,67 ± 6,68				

Note: *ANOVA same subject, significant if $p < 0.05$, **Paired t test, significant if $p < 0.05$

Table 3 demonstrates that the study's initial confounding variables—age, height, weight, BMI, femur length, tibia length, calorie, protein, fat, and carbohydrate intake—did not significantly affect the results (all variables $p > 0.05$).

Table 3. Analysis of Confounding Variables for Intervention Group VO2max

Confounding factors in the intervention group	F	p-value*
Age	0,328	0,733
Height	0,53	0,614
Weight	0,485	0,638
BMI	0,529	0,615
Femur Length	0,198	0,826
Tibial Length	0,595	0,581
Week 0 METS	2,075	0,207
Pre-intervention caloric intake	0,277	0,767
Pre-intervention protein intake	0,148	0,865
Pre-intervention fat intake	0,194	0,828
Pre-intervention carbohydrate intake	0,433	0,667

Note: *ANCOVA, significant if $p < 0.05$.

The same subject ANOVA test showed that there were no significant changes between weeks 0, 4 and 8 weeks simultaneously in the control group ($p = 0.135$). There were no significant changes from week 4 to week 8 or overall from week 0 to week 8 (Table 4).

Table 4. Comparative Test of VO2max After Asian squat Training Week 0, 4, and 8 for Control Group

Time of Measurement	Mean ± SD	ANOVA	p Effect size (Cohen's d)**		
			Week 0-4	Week 4-8	Week 0-8
Week 0	45,42 ± 9,35				
Week 4	49,19 ± 8,88	0,135	0,032 0,41	0,088 -	0,810 -
Week 8	44,75 ± 6,37				

Note: *ANOVA same subject, significant if $p < 0.05$, **Paired t test, significant if $p < 0.05$

Table 5 shows that confounding variables did not have a significant influence on changes in VO2max in the control group (all variables $p > 0.05$).

Table 5. Analysis of Confounding Variables for Control Group VO2max

Confounding factors in the intervention group	F	p-value*
Age	0,328	0,733
Height	0,53	0,614
Weight	0,485	0,638
BMI	0,529	0,615
Femur Length	0,198	0,826
Tibial Length	0,595	0,581
Week 0 METS	2,075	0,207
Pre-intervention caloric intake	0,277	0,767
Pre-intervention protein intake	0,148	0,865
Pre-intervention fat intake	0,194	0,828
Pre-intervention carbohydrate intake	0,433	0,667

Note: *ANCOVA, significant if $p < 0.05$.

When comparing the two research groups, there was a significant difference in changes in VO2max between the control group and the treatment group at week 8 (p = 0.048) with an effect size of 0.75 (Table 6).

Table 6. Comparison of VO2max of the Two Groups

Time of Measurement	Intervention Group (n=15) Mean±SD	Control Group (n=15) Mean±SD	p*	Effect size (Cohen's d)
Week 0	45,49 ± 7,89	45,42 ± 9,35	0,982	-
Week 4	43,57 ± 6,15	49,19 ± 8,88	0,051	-
Week 8	49,67 ± 6,68	44,75 ± 6,37	0,048	0,75

Note: *Independent t test; significant if $p < 0.05$

Figure 1. Pose of Asian squat.

Discussion

According to the teenage age range, the majority of participants in both groups were 15 years old, which enables them to undergo resistance training with a comparatively lower risk of damage and still maintain a high level of alertness [11,12]. The treatment group's mean body mass index (BMI) was 22.46 ± 4.69 kg/m2, while the control group's BMI was 23.24 ± 6.20 kg/m2. The reason for this discrepancy in the findings could be that one participant in the control group had a BMI of 38.06 kg/m2. However, there was no statistically significant difference in the average BMI between the two groups. Because a person's nutritional intake can impact their VO2max, the subject's daily nutritional intake—which includes calories, protein, fat, and carbohydrates—is documented in the food record [13]. The subject's daily activities are represented by their initial metabolic equivalents (Mets), which indicate the level of activity the individual is capable of performing. When comparing the VO2max of the treatment group and the control group at week eight of this trial, there was a significant change. Between weeks 0 and 8, the treatment group's ANOVA test revealed significant variations in VO2max following Asian squats. The VO2max values in the treatment group significantly rise between week 4 and week 8 if a more thorough investigation of changes over a period of every 4 weeks is conducted. Research by Paoli et al. (2017) compared groups of resistance exercisers using one joint versus several joints. Squats and bench presses are two examples of resistance workouts that work numerous joints. While cardiorespiratory fitness and maximum strength improved significantly in both groups, the multi-joint resistance training group's rise in VO2max was greater than that of the single-joint resistance training group. When comparing the effects of resistance training involving one joint with multi-joint training on VO2max, squats performed at the maximum repetition showed results of 8.3% vs. 13.8%. Barbells and weight plates starting at 1 kg are used for the one repetition maximum of the squat and bench press exercises detailed in this study [14]. The multi-joint resistance training group may have had greater gains because of their higher muscle mass during the exercise, which would have resulted in a higher oxygen consumption. Multi-joint resistance training programmes seemed to be more effective than single-joint resistance training at raising muscle strength and maximum oxygen consumption (VO2max) when total work volume was equated. However, no variations in body composition were seen.

In some studies, the control group does not receive the intervention, which can occur for various reasons. This may be due to a safety phase, where researchers aim to ensure the intervention poses no risks before widespread application [14, 15]. Alternatively, it could be designed to isolate and confirm that the primary factor contributing to observed differences is solely the intervention itself, such as a specific exercise program, rather than other external variables. In this study, VO_2max in the control group was also analyzed using analysis of covariance (ANCOVA) and showed non-significant results. This indicates that the baseline mean VO_2max did not differ significantly between the control group and the intervention group. Therefore, the only variable distinguishing the two groups was the intervention provided, namely the Asian squat exercise.

The findings of this study are also consistent with the systematic review and meta-analysis conducted by Munoz-Martinez et al. on the subject of bench press resistance training. According to a meta-analysis, circuit-based resistance training helps healthy adults achieve higher one-repetition bench press maximums and maximum oxygen consumption. There were discernible variations in the length of the sessions (30 minutes or more vs. less than 30 minutes). The VO2max rise was twice as large in the group that had a shorter session duration (less than 30 minutes) as it was in the group that had a longer session duration [15]. The Asian squat exercise, which required three sets of varying repetitions every two weeks, took the study participants a total of six to ten minutes.

The maximum oxygen consumption increases brought on by resistance exercise in young, healthy individuals were not influenced by the intensity of the exercise, but comparable adaptations could be obtained with lower exercise doses at more frequent exercise intensities than with higher exercise doses at more frequent exercise intensities. rarely (training for endurance). activity training regimens that incorporate aerobic activity, or continuous, sustained exercise at a moderate intensity, have long been recognised to raise VO2max. Recent research has demonstrated that interval training, or repeating short bursts of high-intensity exercise, can be a helpful alternative to aerobic exercise for raising VO2max [16]. In contrast to Scribbans et al.'s research, Milanovic et al.'s study discovered that while both resistance training and high-intensity interval training (HIT) significantly increased VO2max in healthy young to middle-aged adults, HIT produced a larger increase in VO2max than resistance training [17]. Asian squat training does not significantly raise VO2max because it incorporates low to moderate resistance training.

Based on a brief history of the measurement period, the decline in the subject's average VO2max at the end of week 4 was caused by their increased physical activity at school, which promoted muscle exhaustion and consequently decreased their VO2max. Nutritional intake prior to exercise, for example, is one factor that affects VO2max but does not statistically significantly affect the ANCOVA test results.

Week 8 results showed a significant difference in VO2max changes between the two groups in the comparative test (Table 5.6, $p = 0.048$, effect size = 0.75). Increasing muscular oxygen demand during exercise is one mechanism by which resistance training raises VO2max. After completing the muscle strength ram, there was a tendency for the muscle oxygen saturation (% SmO2) to decline. Before the regimen, these values ranged from 68.07 to 77.9%, and after exercise, they varied between 9.50 and 46.09%. An increase in oxygen demand during resistance training is shown by this reduction in %SmO2. Resistance training also raises the oxygen levels in muscles. On the other hand, when exercise intensity rises, so do intramuscular forces, which reduce hyperemia. To keep functioning muscles adequately oxygenated, blood flow to them must increase. Lactic acid production rises as a result, and intramuscular oxygen desaturation occurs. Conversely, increased oxygen demand causes the oxygen delivery system to adapt more, for instance by increasing cardiac output and stroke volume. It has been demonstrated that during exercise, lactic acid production, oxygen desaturation, and restricted blood flow are related [18–20].

Out of 17 trials including young people, only 3 demonstrated a substantial increase in VO2max following resistance training, according to a meta-analysis by Ozaki et al. The fact that the research participants in this study were either healthy, sedentary subjects or had no prior training, which is similar to the research participants in the three studies that demonstrated a significant increase in VO2max, should be taken into consideration [21]. This was also discovered in other investigations, the findings of which were likewise impacted by the sedentary population. variations between individuals who had never been active before and those who had either strength trained or been active before beginning resistance training. When compared to active persons, the effect was three times larger in inactive individuals, and it was two times bigger in previously trained participants. The use of lighter optimum loads in resistance circuit training studies where greater strength gains were observed may be explained by the lower beginning fitness levels of the participants [15].

Due to low data variability, factors that affect VO2max, such as age, dietary consumption, and body anthropometry, did not significantly affect the results of this study. The meta-analysis by Ozaki et al. discovered a substantial negative connection between baseline VO2max and changes in VO2max brought on by resistance training (LR), which is different from the findings of this study. According to these findings, the subject's baseline VO2max determines whether or not the LR causes an increase in VO2max. Absolute and relative VO2max in older persons are known to be lower than in younger adults. There was an inverse relationship between the absolute rise in VO2max and baseline VO2max. In this study, both groups' initial VO2maxes were greater than 40 ml/kg/minute. Lower initial relative VO2max can lead to LR-induced increases in VO2max [21].

This study demonstrates that resistance training can enhance cardiorespiratory fitness and demonstrates that there is a change in VO2max following Asian squat training, as seen by an increase in VO2max in the fourth to eighth week following training. The Asian squat exercise is a straightforward exercise that can be performed with ease and doesn't require special equipment, so it can be suggested as an exercise to improve physical fitness in adolescents based on the benefits and safety of exercise reported by research subjects in the evaluation of subject perceptions. Findings of this study will offer preliminary information on the science underlying how low- to moderate-intensity interval resistance training, like Asian squats, affects the cardiorespiratory fitness of inactive male adolescents. However, more study must be done on different demographics and for additional benefits.

There were several limitations in this study. First, whether moderate, long-term exercise treatments will yield comparable results at the same exercise intensity as the short-term research we examined is still up for debate. Secondly, in order to exclude confounding variables in the training effects, this study did not evaluate the impact of other variables that influence training adaption (muscle mass, body composition, physiological biomarkers of exercise such as lactate levels), nor did it regularly monitor physical activity. Third, it is not yet known if different levels of short-term exercise intensity would cause the same reactions in other populations (such as adolescent girls, active adults, athletes, overweight/obese children, the elderly, populations with illnesses, etc.)..

Conclusions

The study results showed that Asian squat caused a significant in VO2max changes in the comparison of the two groups, but in the intervention group it was not significant overall due to several factors. Asian squat is a straightforward, risk-free, and uncomplicated resistance workout. In order to prevent confounding variables from influencing the effects of training, more research is required that considers the impact of other variables that influence training adaptation, such as muscle mass, body composition, physiological biomarkers of exercise like lactate levels, and regular monitoring of physical activity.

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Conflicts of Interest

The authors declare no conflict of interest in this study.

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