Journal of Physical Exercise Research
https://journal.sainspenapublisher.com/jpers E-ISSN: 3124-5099

REVIEW ARTICLE

Comparison of Maximal Oxygen Consumption (VO_2Max) Examination Using Submaximal and Maximal Exercise Tests in Young Non-Athlete Adults: A Literature Review

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Received: 16 November 2025
Accepted: 17 November 2025
DOI: https://doi.org/10.68773/jpers.v1i01.6

Abstract:
Background: Maximal oxygen consumption (VO_2Max) is an important indicator of cardiorespiratory fitness related to physical endurance and cardiovascular health. In young, non-athlete adults who tend to lead a sedentary lifestyle, measuring VO_2Max can be a preventive measure in assessing and improving fitness. VO_2Max testing can be performed using submaximal or maximal exercise tests, each with its own advantages and limitations. Objective: To analyze the results and comparison of VO_2Max testing using submaximal and maximal exercise tests in young, non-athlete adults. Methods: A systematic literature review of 10 articles from PubMed and Google Scholar was conducted. The study designs included cross-sectional, cohort, case-control, and quasi-experimental studies. Data extracted included respondent characteristics, exercise test type, and VO_2Max measurement results. Results: Submaximal tests such as the 6-Minute Walking Test (6-MWT), Step Test, and Beep Test showed VO_2Max values in the poor to moderate range. In contrast, maximal tests such as the Treadmill Test and the Cooper 12-Minute Test yield higher VO_2Max values (in the good–very good category). Differences are influenced by gender, age, physical activity, and body mass index. Conclusion: VO_2Max values from submaximal tests are lower than maximal tests. Submaximal tests are safer and more practical for initial fitness screening in non-athletes, while maximal tests are more accurate for comprehensive assessments of cardiorespiratory fitness.
Keywords: VO_2Max; submaximal test; maximal test; young adults; non-athletes.

1. Introduction

Cardiorespiratory fitness, a health-related component of physical fitness, refers to the ability of the circulatory and respiratory systems to supply oxygen to the muscular system during physical activity (Geetha et al., 2020). Longitudinal studies have found that the decline in cardiorespiratory fitness over time ranges from 5 to 20% per decade from age 30 onwards (Rorato et al., 2016), with older age groups showing a sharper rate of decline (Raguso et al., 2006). CFR is associated with cardiovascular disease and all-cause mortality in men and women (Satoru Kodama et al., 2009). Furthermore, in older adults, a satisfactory CFR is essential for quality of life, functional preservation, and independence. Cardiorespiratory fitness is a crucial component in maintaining heart and lung health and is a key indicator of the body's functional condition.

One of the parameters used to assess fitness is maximal oxygen consumption or VO_2Max, which describes the maximum amount of oxygen the body can use during intense physical activity. The higher a person's VO_2Max value, the better their body's ability to transport and use oxygen to produce aerobic energy. According to the American Heart Association (AHA), VO_2Max can be used as a clinical vital sign that reflects fitness status and the risk of cardiovascular disease. However, despite its importance, awareness of VO_2Max testing in young adults remains low. In Indonesia, approximately 43.9% of young adults have a poor

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VO_2Max category and 37.4% have a very poor VO_2Max. Therefore, VO_2max not only describes the level of fitness but also reflects the body's physiological ability to maintain continuous physical activity (Komala et al., 2025).

This condition indicates low levels of physical activity in the productive age group, which should have optimal aerobic capacity. Sedentary behavior is increasing rapidly in young adults due to changes in modern lifestyles, particularly work and academic activities that require prolonged sitting and exposure to digital technology. According to the American College of Sports Medicine (2018), a sedentary lifestyle increases the risk of cardiometabolic disorders, decreased muscle function, and decreased endurance. A decrease in VO_2Max of 1% per year can occur if not balanced with regular physical activity. VO_2Max testing can be performed using two main approaches: maximal testing and submaximal testing. Maximal testing, such as the treadmill test or cycle ergometer test, requires individuals to exercise at their maximum capacity and is considered the gold standard for assessing cardiorespiratory fitness (Dugas et al., 2023).

In contrast, submaximal tests such as the 6-Minute Walking Test (6-MWT), Step Test, or Beep Test are more practical, safe, and suitable for non-athlete individuals who are not accustomed to strenuous activity, but the results tend to provide a lower estimate of VO_2Max (Sayar et al., 2024). Several studies have reported that the results of VO_2Max measurements using submaximal tests differ significantly from those using maximal tests. For example, research by Ronan & Shafer, 2019 found that the 5-Minute Pyramid Test method as a submaximal field test tends to underestimate the results compared to the treadmill test. With the increasing prevalence of a sedentary lifestyle among young non-athlete adults, a deeper understanding is needed regarding the comparison of VO_2Max measurement results from the two methods. This study aims to analyze the differences in VO_2Max examination results using submaximal and maximal exercise tests in young non-athlete adults as a basis for recommendations for physiotherapists in determining appropriate, safe, and effective fitness assessment methods.

2. Materials and Methods

This study is a systematic literature review of scientific articles obtained from the PubMed and Google Scholar databases. The keywords used were "VO_2Max," "submaximal exercise test," and "maximal exercise test." Articles meeting the inclusion criteria included:

1. A young adult population (20–40 years old) with non-athletes;

2. A cross-sectional, cohort, case-control, or quasi-experimental study design;

3. Articles published in the last five years (2019–2024).

A total of 8,850 articles were identified, 175 were screened based on title and abstract, and 10 articles met the inclusion criteria for full review. Data collected included sample size, age, gender, exercise test method, and VO_2Max measurement results.

3. Results

- An analysis of 10 articles showed that:
- Submaximal testing yielded an average VO_2Max between 21–35 mL/kg/minute, categorized as poor to fair.

- Maximal testing yielded higher results, between 40–60 mL/kg/minute (categorized as good–very good).
- Factors influencing the results included gender, age, body mass index, and physical activity level.

4. Discussion

The difference in results between submaximal and maximal tests is due to several physiological and methodological factors. The physiological response to maximal exercise intensity requires an increase in cardiac output and pulmonary ventilation until a VO_2 plateau is reached, reflecting true aerobic capacity. In contrast, submaximal tests estimate VO_2max based on a linear relationship between heart rate and workload. Because non-athletes are less likely to reach maximal physiological conditions, the measurement results are lower. Individual Factors: Gender, age, and physical activity habits influence VO_2max. Limitations and Advantages: Submaximal tests offer advantages such as high safety, low cost, and ease of implementation, making them suitable for non-athlete populations or patients with cardiac risk. However, their validity is lower than that of maximal tests using a gas analyzer or a treadmill with a variable speed (Dugas et al., 2023).

The mechanisms by which exercise improves the health status of sedentary populations may involve several aspects. First, exercise reduces systemic inflammation by promoting fat breakdown and reducing adipose tissue accumulation (Ribeiro et al., 2017). Long-term aerobic exercise can improve blood supply to adipose tissue by increasing angiogenin expression in adipose tissue, thereby reducing the hypoxia-induced inflammatory response. Second, strength training helps improve metabolic disorders by increasing skeletal muscle mass and improving insulin sensitivity (Heijden et al., 2010). In addition, HIIT, as an efficient exercise mode, can significantly improve cardiopulmonary function and metabolic adaptability through short-duration high-intensity exercise stimulation (Ostrom et al., 2022).

Implications for Physiotherapy and Public Health In physiotherapy practice, VO_2Max measurement is essential for developing an aerobic training program tailored to individual capacity. The use of submaximal tests such as the 6-MWT can be an indicator of the rehabilitation progress of patients with respiratory or cardiovascular disorders. Maximal tests, on the other hand, are more appropriate for athlete evaluation, research, or high-intensity exercise-based interventions. The Context of Young Non-Athlete Adults Young non-athletes generally have not yet developed physiological adaptations to intensive training. Therefore, submaximal tests are more realistic for use in fitness screening contexts, while maximal tests can be used selectively to determine aerobic training targets. Therefore, the combination of both methods can provide more comprehensive data: submaximal tests for initial fitness detection and maximal tests for confirmation or follow-up monitoring.

Research Limitations

This study's limitations include a systematic review of maximal oxygen consumption (VO_2Max) measurements using submaximal and maximal exercise tests in young, non-athlete adults. However, experimental testing is needed to confirm this.

Directions for Future Research

Future research needs to conduct experimental tests and laboratory checks to see the comparative results of several tests.

5. Conclusions

VO_2Max values obtained from submaximal testing tend to be lower than maximal testing in young, non-athlete adults. Nevertheless, submaximal testing remains highly practical due to its safety, ease of implementation, and suitability for community fitness screening. Maximal testing remains the standard method for accurate fitness assessment, particularly in trained populations.

Acknowledgement

We would like to express our gratitude to the many parties involved in this research and the success of this research so that the results of this research can be published in this manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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