



Assessing the validity and reliability of three field tests for evaluating cardiovascular endurance among College Students

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Abstract

Cardiovascular endurance is a fundamental indicator of physical fitness, particularly relevant in the college student population increasingly predisposed to sedentary behavior. This study assesses the validity and reliability of three widely used field-based tests—6-Minute Walk Test (6MWT), Cooper Test, and Beep Test—in estimating VO₂ max among college students. Using a cross-sectional design and Spearman's correlation analysis, results showed moderate pre-intervention correlation between the 6MWT and Cooper Test ($r=0.3259$), with a decline post-intervention. The Beep Test showed weaker, inconsistent associations. The findings highlight the utility of combined testing approaches while underscoring variation in test response and predictive value.

Keywords: Cardiovascular endurance, VO₂ max, 6-minute walk test, cooper test, beep test, college students, field tests, reliability, validity

Introduction

The college students are often predisposed to sedentary behaviors due to academic and technological demands. So, the assessment of cardiovascular endurance has become increasingly critical, particularly among college students. It is widely recognized as a key determinant of overall physical health and a predictor of the ability to perform daily tasks with minimal fatigue. Cardiovascular endurance, or cardiorespiratory fitness, refers to the ability of the pulmonary, cardiovascular, and muscular systems to transport and utilize oxygen effectively during prolonged physical activity (Dimarucot & Macapagal, 2021).

Many evidences suggests that decreased levels of physical activity among university students have paved the way to a rise in obesity and associated non-communicable diseases. Globally, the Philippines ranked in the 42nd place among 50 countries in the 20-meter shuttle run test, underscoring the poor cardiovascular fitness among its youth. Therefore, these trends highlight the urgent need to monitor and improve the fitness levels among college students to promote a healthy and active lifestyle (Lang *et al.*, 2016).

There are many field-based tests for assessing cardiovascular endurance. But, the 6-Minute Walk Test (6MWT), Cooper Test, and Beep Test are widely regarded for their practical ability and reliability to estimate maximal oxygen uptake (VO₂ max). As VO₂ max serve as the gold standard for measuring the aerobic capacity, the maximal amount of oxygen consumed by the body during exercise is being represented. Given the challenges of directly measuring VO₂ max in laboratory settings, for evaluating cardiovascular endurance in diverse populations, the predictive equations derived from field test results have become essential tools.

The 6-Minute Walk Test (6MWT) is a submaximal exercise test designed to measure functional aerobic capacity. Participants are instructed to walk for six minutes at a self-determined pace, with the total distance covered serving as the primary outcome. This test is particularly suitable for

individuals with limited physical fitness or health conditions due to its simplicity, low physical demand, and minimal equipment requirements (Berghmans *et al.*, 2013) [1]. Studies have demonstrated its utility in assessing aerobic capacity and predicting VO₂ max in both clinical and non-clinical populations.

The Cooper Test, introduced by Kenneth Cooper in 1968, is based on the total distance covered in a 12-minute run/walk test which is used to estimate VO₂ max. it is used in physical education and sports settings for its ease of administration and strong correlation with laboratory-based VO₂ max measurements (Cooper, 1968). The Cooper Test have been proved to be reliable and valid tool for measuring cardiovascular endurance, particularly in young and healthy populations.

The Beep Test, also known as the 20-Meter Multistage Fitness Test, assesses maximal aerobic capacity through progressive shuttle runs at increasing speeds. Participants run back and forth between two markers, synchronized with audio beeps that increase in frequency over time. The test continues until the participant can no longer keep up with the pace, and the final stage reached is used to estimate VO₂ max. This test is widely used globally due to its cost-effectiveness, scalability, and strong predictive validity for VO₂ max (Léger & Lambert, 1982; Mayorga-Vega *et al.*, 2015) [7].

While each of these tests has been studied extensively, combining them provides a comprehensive approach to assessing cardiovascular endurance across various fitness levels. The 6MWT is ideal for submaximal effort and beginners, the Cooper Test is suited for intermediate levels, and the Beep Test effectively measures maximal aerobic capacity. Furthermore, incorporating anthropometric variables such as Body Mass Index (BMI) enhances the accuracy of VO₂ max predictions and provides additional insights into the overall health and fitness of participants.

This study aims to evaluate the validity and reliability of the 6-Minute Walk Test, Cooper Test, and Beep Test as tools

for assessing cardiovascular endurance in college students. By utilizing predictive equations for VO₂ max and analyzing BMI as a key variable, the study seeks to establish a robust framework for evaluating and monitoring cardiovascular fitness in educational settings.

Methodology

Research Design

This study utilized a cross-sectional research design to assess the validity and reliability of three field tests—the 6-Minute Walk Test (6MWT), Cooper Test, and Beep Test—in measuring VO₂ max among college students. The study involved collecting data on participants' cardiovascular endurance using these field tests and comparing the estimated VO₂ max values derived from predictive equations with BMI as an additional variable.

Research Participants

The study was conducted among KG college students aged 18-22 years who voluntarily participated. The inclusion criteria were: Healthy individuals with no known cardiovascular or respiratory conditions. Students who were non-athletes and not undergoing regular endurance training. Participants who completed the Physical Activity Readiness Questionnaire (PAR-Q+ 2019) to ensure their eligibility for moderate-to-vigorous physical activity. Exclusion criteria included: Students with pre-existing medical conditions affecting physical performance. Those with a history of cardiac, pulmonary, or musculoskeletal disorders. Participants who failed to meet the minimum safety requirements in the initial screening.

Anthropometric measurements

Before performing the field tests, the following anthropometric variables were recorded:

Height (cm) and weight (kg) using a digital weighing scale and a stadiometer.

Body Mass Index (BMI) calculated using the formula $BMI = \text{kg/m}^2$.

Each participant completed the 6-Minute Walk Test (6MWT), Cooper Test, and Beep Test in separate sessions.

Data collection procedures

The following protocols were observed for each of the Three field tests:

1. 6-Minute Walk Test (6MWT)

Participants should wear comfortable clothing and appropriate footwear. Before the test, they should rest for at least 10 minutes to establish baseline measurements, including heart rate, blood pressure, and oxygen saturation. Conduct the test on a flat, straight course, ideally 30 meters in length, marked at regular intervals. Ensure the area is free from obstacles and has a comfortable ambient temperature. Explain the test objectives clearly, instructing participants to walk as far as possible for six minutes at a self-paced speed. Encourage them to maintain a steady pace but allow them to slow down, rest, or stop if necessary. Provide standardized encouragement at regular intervals, such as every minute, using phrases like "You're doing well" or "Keep up the good work." Monitor the participant's condition throughout the test for any signs of distress. At the end of six minutes, instruct the participant to stop, and measure the total distance walked. Record post-test vital signs and inquire about any symptoms experienced during the test.

2. Cooper Test (12-Minute Run/Walk Test)

The Cooper Test, established by Dr. Kenneth H. Cooper in 1968, is a widely utilized field assessment designed to estimate an individual's maximal oxygen uptake (VO₂ max), reflecting their aerobic capacity. The test involves participants running as far as possible within a 12-minute period. Engage in a 10–15-minute warm-up comprising light aerobic exercises and dynamic stretching to prepare the cardiovascular and musculoskeletal systems for the upcoming exertion.

Conduct the test on a flat, measured track or field to ensure accuracy in distance measurement. After the warm-up, participants start running upon the initiation signal and continue for 12 minutes, aiming to cover the maximum possible distance.

Encourage participants to adopt a steady pace that they can maintain throughout the duration, avoiding early fatigue.

Following the test, perform a 5-10-minute cool-down involving light jogging or walking, coupled with static stretching to facilitate recovery. The distance achieved can be used to estimate VO₂ max using the formula:

$$VO_2 \text{ Max (ml/kg/min)} = (\text{Distance in meters} - 504.9) / 44.73$$

3. Beep Test (20-Meter Multistage Fitness Test)

The protocol was a modified version of the test by Voss and Sandercock [26]. Participants performed 20-meter shuttle runs, paced by an audible metronome, starting at 8.5 km/h with increments of 0.5 km/h per minute. The test was conducted indoors in the school gym, with groups of up to 30 students and a supervision ratio of five participants per teacher-researcher.

Prior to the pre-test, participants had no practice but completed the test weekly for eight weeks as part of their cardiovascular endurance training. The teacher-researcher encouraged maximal effort, recorded the final shuttle count at volitional exhaustion or after three failures, and converted it into the final running speed.

Heart rates were measured at one-minute intervals—during exercise, rest, and recovery—and used to compute VO₂ max. pre-and post-test VO₂ max values were subjected to statistical analysis.

$$VO_2 \text{ max} = (3.46 \times \text{last completed speed (km/h)}) + 12.2$$

Results

The present study aimed to evaluate the correlation between three different field-based endurance assessments: the Beep test (X), Cooper test (Y), and the Six-Minute Walk Test (6MWT, Z), both before and after an intervention. The Spearman correlation coefficient was used to determine the degree of association among these variables.

Pre-Test Analysis

The Spearman correlation analysis conducted during the pre-intervention phase revealed a moderate positive correlation between the Cooper test and 6MWT ($r = 0.3259$), suggesting that individuals who performed better in the Cooper test also tended to demonstrate greater distances in the 6MWT. Similarly, a moderate positive correlation was observed between the 6MWT and the Beep test ($r = 0.3215$). However, a weak negative correlation was found between the Beep and Cooper tests ($r = -0.22$), indicating that performance in the Beep test may not be directly aligned with Cooper test performance before training.

Post-Test Analysis

Following the intervention, a general decline in the strength of correlations was observed. The correlation between the Cooper test and 6MWT dropped to $r = 0.0792$, indicating a very weak relationship post-training. The correlation between 6MWT and Beep test nearly diminished ($r = -0.0097$), while the negative correlation between the Beep and Cooper tests persisted ($r = -0.1895$). These results suggest that while the pre-test associations indicated moderate alignment between Cooper and 6MWT, such congruence was not retained post-intervention.

The scatter plots and bar charts visually reinforce these findings, illustrating a notable decline in correlation strength across all test combinations post-intervention. The D^2 values (sum of squared differences) support these trends, showing higher values in post-tests for Y & Z and Z & X pairs compared to pre-test values.

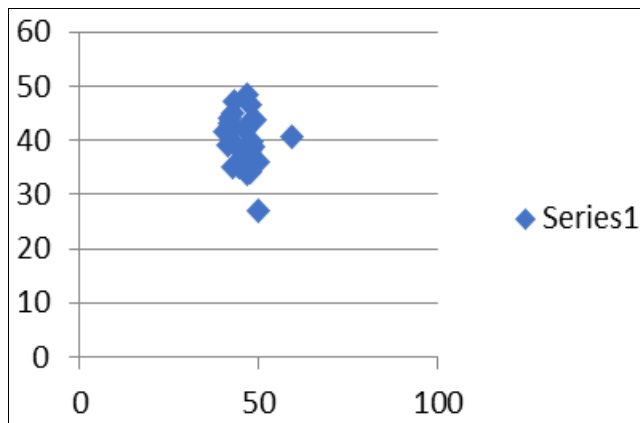


Fig 1 : Beep and Cooper pre-test

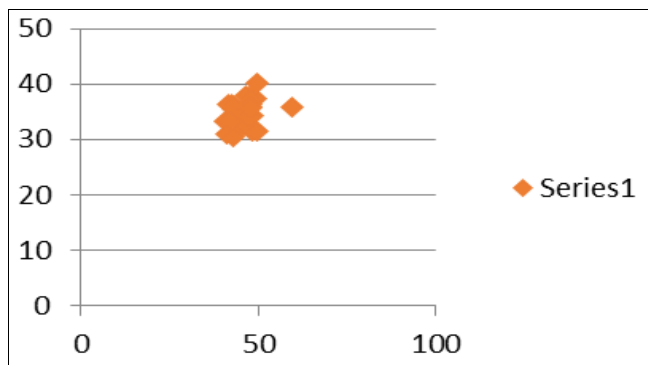


Fig 2: Cooper and 6MWT pre-test

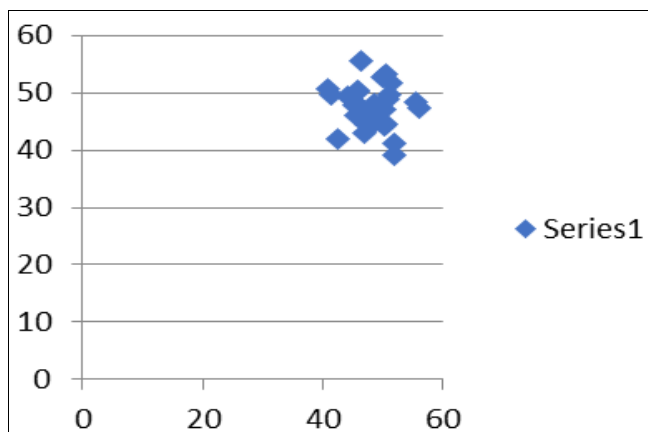


Fig 3: 6MWT and Beep pre-test

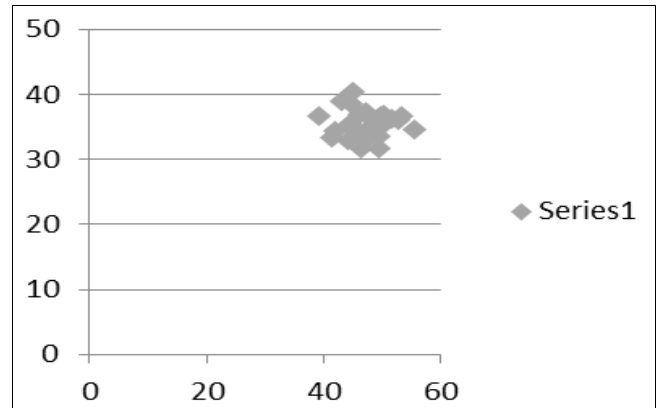


Fig 4: Beep and Cooper post test

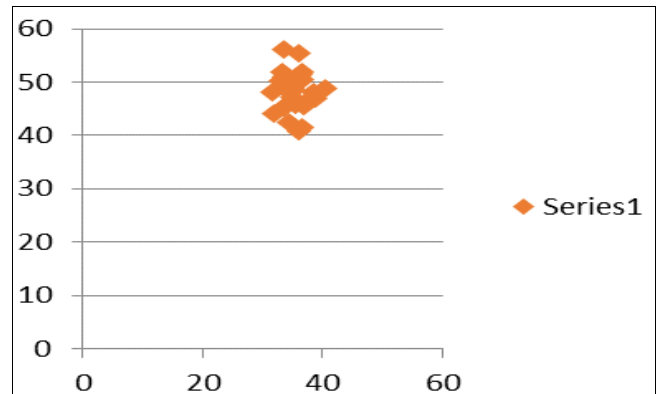


Fig 5: Cooper and 6MWT post test

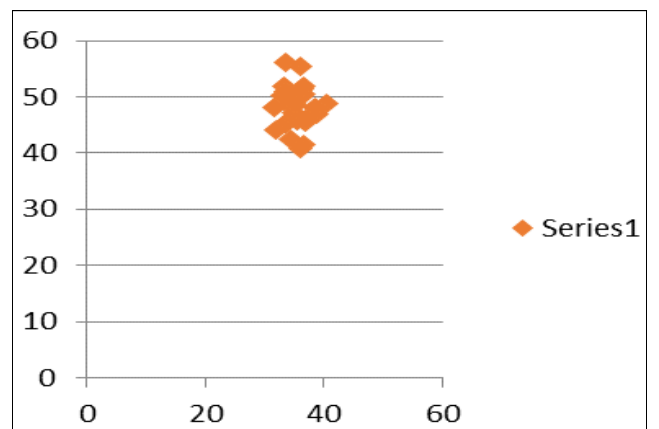


Fig 6: 6MWT and Beep post test

Statistical analysis

Spearman’s correlation

Pre – Test Results

Correlation	D ² - Mean difference	“P” Spearman’s value
X and Y (Beep and Cooper)	5483.5	-0.2200
Y and Z (Cooper and 6MWT)	3030.0	0.3259
Z and X (6MWT and Beep)	3049.5	0.3215

Post – Test Results

Correlation	D ² - Mean difference	“P” Spearman’s value
X and Y (Beep and Cooper)	5122	-0.1895
Y and Z (Cooper and 6MWT)	4138	0.0792
Z and X (6MWT and Beep)	4930	-0.0097

Discussion

Cardiovascular endurance is a critical measure of physical fitness, representing the efficiency of the heart, lungs, and muscles in sustaining prolonged activity. The evaluation of cardiovascular endurance through field tests such as the 6-Minute Walk Test (6MWT), Cooper Test, and Beep Test is widely utilized due to their practical application and correlation with VO₂ max. Each test offers unique insights into an individual's aerobic capacity and serves different populations based on their fitness levels, health status, and testing requirements.

Recent advancements in the assessment of cardiovascular endurance have reinforced the significance of field tests such as the 6-Minute Walk Test (6MWT), Cooper Test, and Beep Test. These evaluations offer practical and reliable means to gauge aerobic capacity across diverse populations, each with unique applications and considerations.

6-Minute Walk Test (6MWT): The 6MWT is extensively utilized to measure functional exercise capacity, particularly in clinical settings. A recent study highlighted its efficacy in predicting adverse events during the test by monitoring continuous physiological parameters, emphasizing its role in patient safety and risk assessment. Additionally, research has demonstrated the test's reliability and repeatability when administered via smartphone applications, suggesting its potential for remote patient monitoring. However, discussions have emerged regarding its psychological impact on participants, with reports suggesting that the test can be perceived as stressful or discouraging, potentially affecting long-term attitudes toward physical activity.

Cooper Test: The Cooper Test remains a widely accepted method for estimating maximal oxygen uptake (VO₂ max). Recent literature continues to support its application in both clinical and athletic settings due to its simplicity and effectiveness. However, its demand for sustained high-intensity effort may limit its suitability for individuals with lower fitness levels or certain health conditions.

Beep Test (20-Meter Multistage Fitness Test): The Beep Test is recognized for evaluating maximal aerobic power through progressive intensity stages. While it is beneficial in sports and military contexts, recent discussions have highlighted its psychological impact, particularly among younger individuals. Reports suggest that the test can be perceived as stressful or discouraging, potentially affecting long-term attitudes toward physical activity. This underscores the need for careful consideration of its implementation to foster a positive experience with fitness assessments.

Conclusion

In conclusion, the Cooper test demonstrated the highest and most consistent positive correlation with the 6-Minute Walk Test during the pre-intervention phase, signifying its relative efficacy in estimating submaximal aerobic capacity in this population. The Beep test, despite being a maximal effort test, showed weaker and more inconsistent associations with both the Cooper test and 6MWT, which may be attributed to the differing physiological demands and pacing strategies required.

The decline in correlation coefficients post-intervention could reflect variations in individual responses to training, differential improvements in test-specific endurance, or

measurement variability. These findings suggest that while the Cooper test may be a more suitable surrogate for assessing functional capacity relative to the 6MWT in pre-intervention settings, its predictive alignment may diminish following intervention due to divergent physiological adaptations.

Further research with larger sample sizes and controlled training regimens is recommended to validate these findings and to determine the most appropriate field tests for assessing cardiorespiratory fitness improvements across diverse populations.

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