

# AGREEMENT BETWEEN MEASURED AND ESTIMATED VO<sub>2</sub>MAX IN DIVISION I COLLEGIATE MALE SOCCER PLAYERS

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## ABSTRACT

**BACKGROUND** Cardiorespiratory fitness is a fundamental aspect of an athlete's overall physical capability and is vital to sports performance. While indirect calorimetry via direct gas exchange is the gold standard method to measure maximal oxygen uptake (VO<sub>2</sub>max), this process requires specialized equipment and trained personnel to administer. Alternatively, field assessments offer a more accessible and cost-effective means for coaches to estimate VO<sub>2</sub>max. Despite these field tests being validated for the general population, there are limited data regarding the agreement between measured and predicted VO<sub>2</sub>max values in high-level soccer athletes. **PURPOSE:** This study investigated the agreement between the multi-stage "yo-yo" fitness test (MSFT) and direct gas exchange analysis in determining VO<sub>2</sub>max. It was hypothesized the MSFT would overestimate VO<sub>2</sub>max due to the indirect nature of the valuation and fewer objective criteria for test termination. **METHODS:** Male collegiate soccer athletes (N=14, age= 21.1±1.2 y) completed both field-based and laboratory VO<sub>2</sub>max assessments one week apart prior to 2024 spring training. The field MSFT was a continuous 20-meter shuttle run (the "yo-yo" test) starting at 8.5 km/h, with speeds increasing by 0.5 km/h each minute until volitional exhaustion. The test was terminated if an individual could not complete two consecutive shuttle runs during the specified time. VO<sub>2</sub>max was estimated using the Ramsbottom equation. For the laboratory assessment, participants completed a graded exercise test where speeds increased every two minutes until volitional exhaustion, while having direct gas exchange measured via metabolic cart (COSMED, Concord, CA). VO<sub>2</sub>max was recorded as the highest 30-second average achieved during the test. Pearson's r with a 95% confidence interval (CI) was used to assess the relationship between estimated and measured VO<sub>2</sub>max. Bland-Altman plots were used to assess mean differences and limits of agreement (LOA) between test results and intraclass correlation coefficients (ICC) with 95% CIs were calculated to compare the agreement between the two tests. **RESULTS:** A significant positive relationship existed between estimated and measured VO<sub>2</sub>max (r = 0.60, P = 0.023, CI: 0.10-0.86). There was moderate agreement between estimated and measured VO<sub>2</sub>max (ICC=0.58, CI: 0.20-0.81) with the MSFT overestimating VO<sub>2</sub>max by 2.9 (LOA: 0.88 to 4.96) ml/kg/min. **CONCLUSION:** While estimated and measured VO<sub>2</sub>max results were correlated, the MSFT consistently overestimated VO<sub>2</sub>max. These data are important to consider when designing training programs or programming wearables based on an athlete's VO<sub>2</sub>max for conditioning or monitoring purposes. **PRACTICAL APPLICATIONS:** It is essential that coaches use a consistent method to assess cardiorespiratory fitness throughout the season since the tests, while related, are not interchangeable. However, the MSFT is a reliable, cost- and time-efficient way to estimate VO<sub>2</sub>max when laboratory equipment is not available.

## INTRODUCTION

- Cardiorespiratory fitness represents a fundamental aspect of an athlete's overall physical capability and sports performance.
- Direct gas exchange measurement of maximal oxygen uptake (VO<sub>2</sub>max) is the gold standard for assessing cardiorespiratory fitness, but it requires specialized equipment and trained personnel.
- In contrast, field tests, such as the multi-stage fitness test (MSFT) offer a more accessible and cost-effective means to estimate VO<sub>2</sub>max but may lack precision and accuracy.

**Purpose:** To investigate the agreement between the MSFT and direct gas exchange analysis in determining VO<sub>2</sub>max.

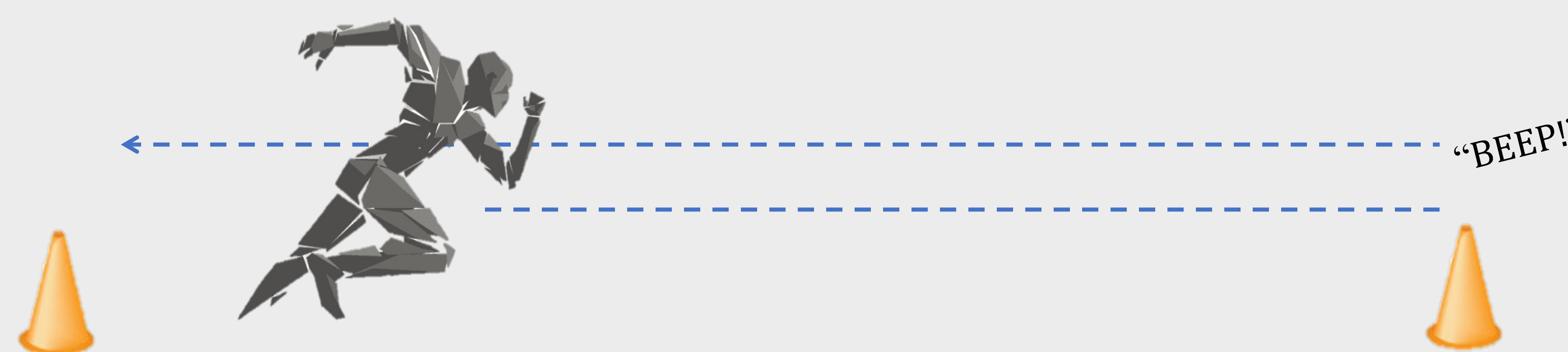


Figure 1: Beep Test

20m

## MAIN FINDING

While there was a positive correlation and modest agreement between VO<sub>2</sub>max values estimated by the MSFT and those measured by gas exchange, the MSFT repeatedly overestimated VO<sub>2</sub>max.

## PRACTICAL APPLICATIONS

- When used appropriately, the MSFT is a relatively effective and efficient way to estimate VO<sub>2</sub>max in cases where laboratory equipment is not available or feasible.
- Coaches should be aware of the regular overestimation of VO<sub>2</sub>max when using the MSFT to assess cardiorespiratory fitness.

## METHODS

**Participants:** Fourteen male collegiate soccer athletes (M<sub>age</sub> = 21.1 ± 1.2 y) completed both field-based and laboratory VO<sub>2</sub>max assessments one week apart prior to spring training.

**Field Assessment (MSFT/Beep Test):** A continuous 20-meter shuttle run starting at 8.5 km/h, with speeds increasing by 0.5 km/h each minute until volitional exhaustion or if an individual can no longer complete two consecutive shuttle runs within the specified time. VO<sub>2</sub>max was estimated using the Ramsbottom equation.

**Laboratory Assessment (direct gas exchange):** Graded treadmill-based exercise test where speeds increase every two minutes until volitional exhaustion. Direct gas exchange was measured using a COSMED metabolic cart. VO<sub>2</sub>max was recorded as the highest 30-second average achieved during the test.

### Statistical Analyses:

- A Pearson's correlation coefficient (r) with a 95% confidence interval (CI) was used to assess the relationship between estimated and measured VO<sub>2</sub>max.
- Bland-Altman plots were generated to visualize mean differences and limits of agreement (LOA) between test results.
- Intraclass correlation coefficients (ICC) with 95% CIs were calculated to compare the agreement between the two tests.
- An alpha level of 0.05 was used to determine significance.



Figure 2: Laboratory VO<sub>2</sub>max assessment set up

## RESULTS

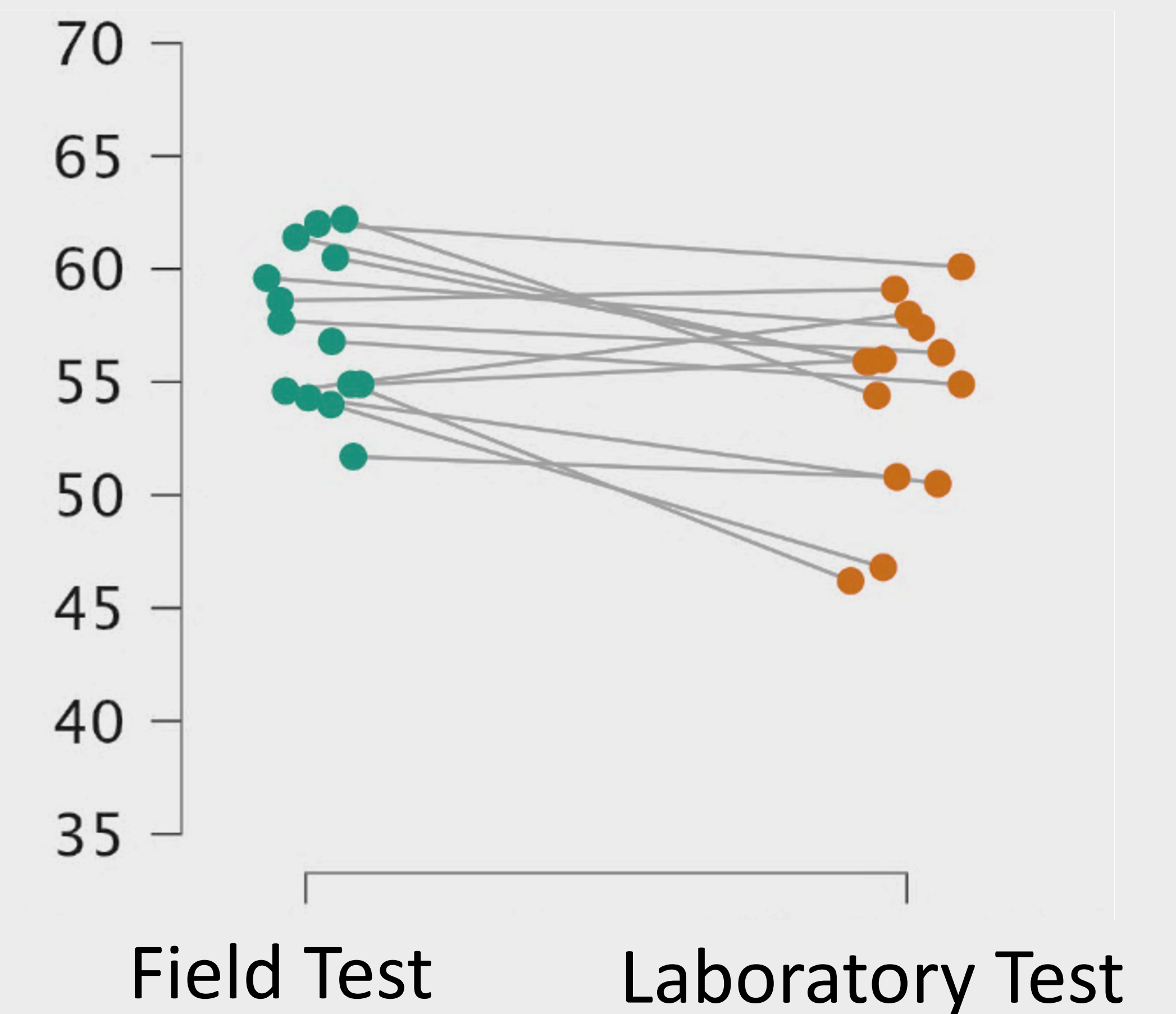


Figure 3: Individual VO<sub>2</sub>max values from the field versus laboratory testing methods (r = 0.60, P = 0.023, CI: 0.10-0.86).

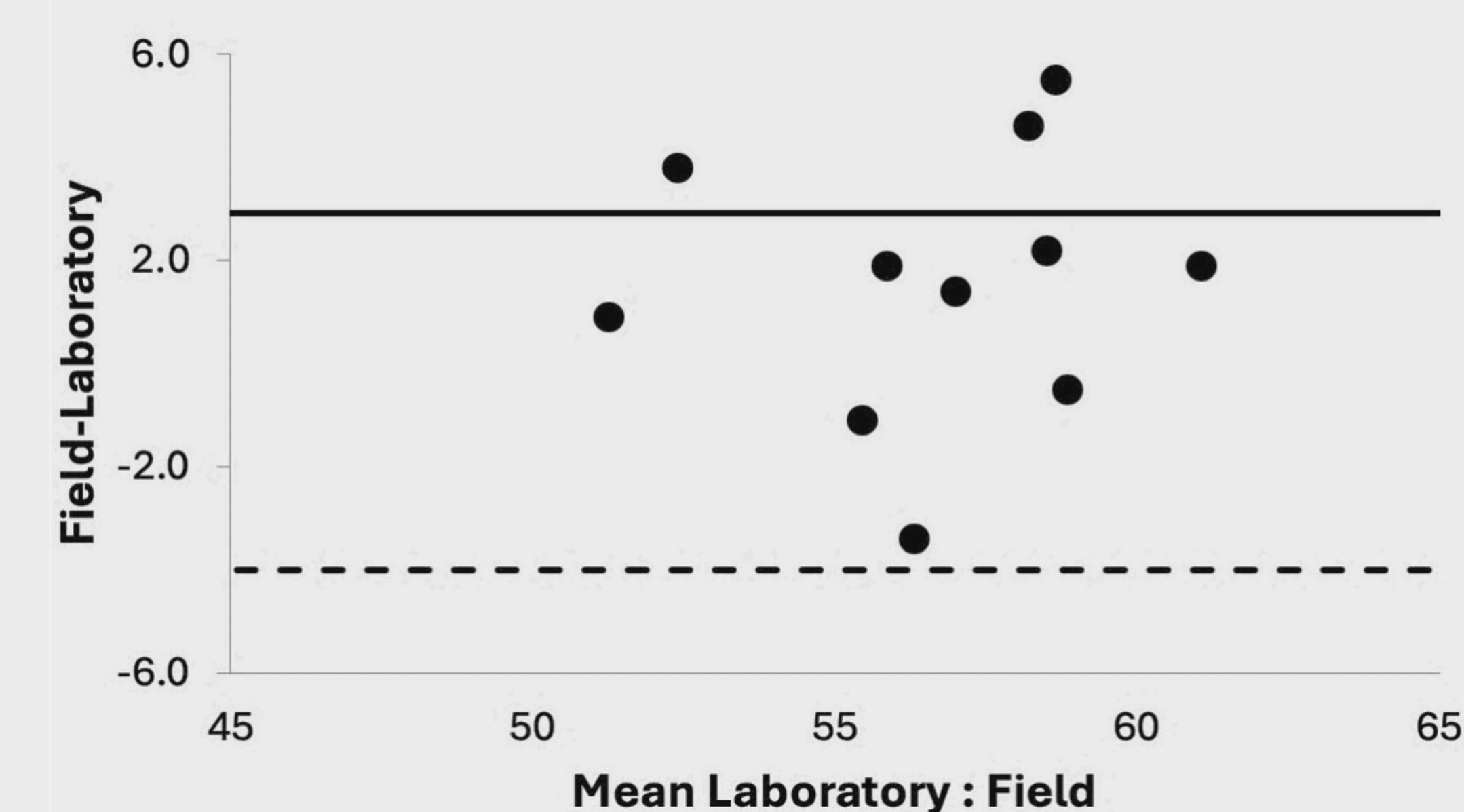


Figure 4: Bland-Altman plots VO<sub>2</sub>max values acquired from the field versus laboratory testing methods (ICC=0.58, CI: 0.20-0.81).

