Validity and Test-Retest Reliability of a Speed-Based Maximal Oxygen Uptake ($\dot{V}O_{2max}$) Treadmill Running Protocol

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INTRODUCTION

- Maximal oxygen uptake ($\dot{V}O_{2max}$) is the criterion measure of cardiorespiratory fitness.
- $\dot{V}O_{2max}$ is routinely assessed by graded exercise tests (e.g., Astrand Running Test or Bruce Protocol).
- However, speed-based running tests may be advantageous to reduce potential injuries, offset grade-dependent gait alterations, and to improve task-specificity for certain types of athletes.

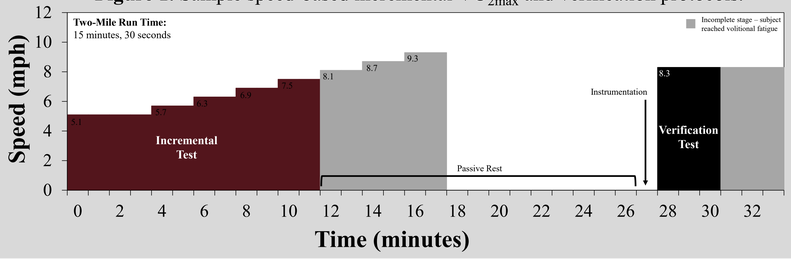
PURPOSE: To determine: 1) the agreement between a speed-based $\dot{V}O_{2max}$ incremental running test and a supramaximal verification test and 2) evaluate test-retest reliability of the incremental and verification tests.

METHODS

DESIGN

- Participants completed two separate laboratory visits consisting of a speed-based incremental $\dot{V}O_{2max}$ test and a supramaximal verification trial (110% of the maximum incremental speed).
- Both tests were performed until volitional exhaustion.
- Tests were separated by 15 minutes of passive rest, and test visits were separated by at least 48 hours.
- Incremental speeds were calculated from the participant's self-reported two-mile run time.

Figure 1. Sample speed-based incremental $\dot{V}O_{2max}$ and verification protocols.



PARTICIPANTS

- Fourteen healthy individuals
  - 11 males, 3 females
  - Age: 24 ± 6 y
  - Body mass: 73.2 ± 15.7 kg
  - Height: 171 ± 8 cm
- Engaged in aerobic and resistance exercise ≥ 30 minutes on at least 2 days per week
- Free of contraindicated medical conditions, illnesses, and injuries
- Provided written informed consent

PROCEDURES

- Oxygen uptake ($mL \cdot kg^{-1} \cdot min^{-1}$) was measured via indirect calorimetry.
- Heart rate was monitored throughout each test via Polar H1 heart rate monitor.

STATISTICAL ANALYSIS

- Data were averaged over 30 second epochs, and the highest value was considered $\dot{V}O_{2max}$.
- Statistical equivalence was assessed by evaluating whether the 90% confidence interval (CI) around the mean difference was within equivalence limits of ± 2.1 $mL \cdot kg^{-1} \cdot min^{-1}$.
- Test-retest reliability of the incremental and verification tests were quantified using intraclass correlation coefficients (ICC).

RESULTS

Figure 2. Bland-Altman plots of agreement between speed-based incremental and verification tests within and between two test visits (V1 and V2). Grey shading, equivalence limits (± 2.1 $mL \cdot kg^{-1} \cdot min^{-1}$); solid black line, mean difference; dashed black lines, 90% confidence intervals.

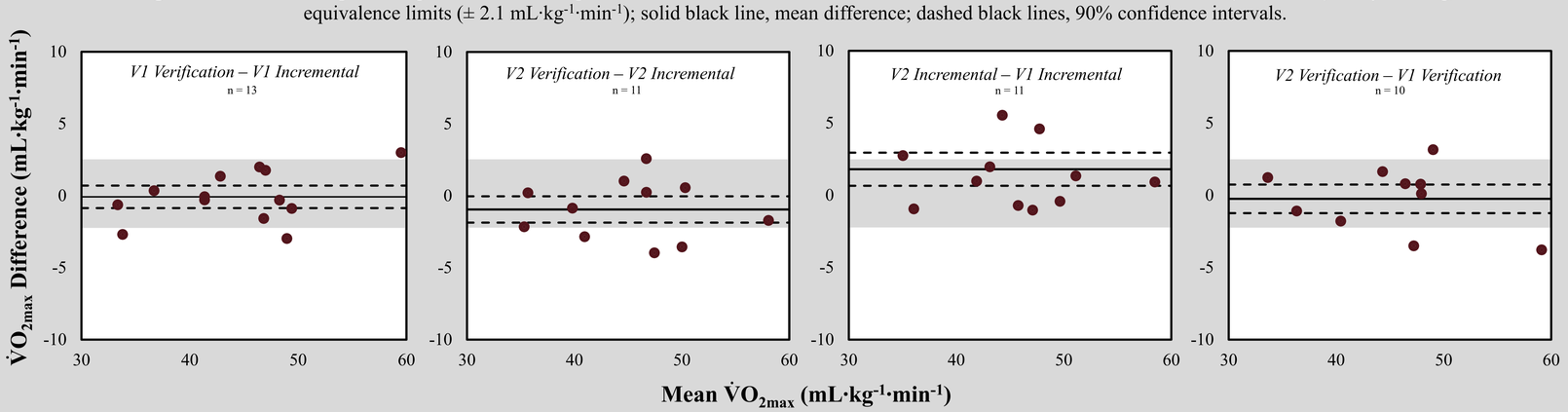
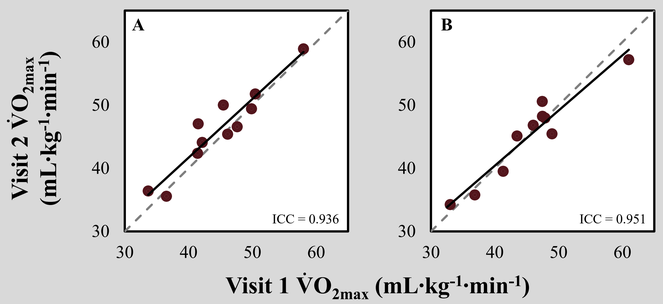


Figure 3. Test-retest reliability of the speed-based incremental protocol (A) and verification trial (B) across two test visits. Grey dashed line, identity; solid black line, linear fit.



- $\dot{V}O_{2max}$ was statistically equivalent between incremental and verification trials for both visit 1 (mean difference, -0.08 $mL \cdot kg^{-1} \cdot min^{-1}$; 90% CI, [-0.86, 0.70]) and visit 2 (-0.95 $mL \cdot kg^{-1} \cdot min^{-1}$; 90% CI, [-1.87, -0.04]).
- $\dot{V}O_{2max}$ obtained during the incremental test was not statistically equivalent between visits (1.35 $mL \cdot kg^{-1} \cdot min^{-1}$; 90% CI, [0.38, 2.33]).
- $\dot{V}O_{2max}$ measured during the verification trials were statistically equivalent between visits (-0.25 $mL \cdot kg^{-1} \cdot min^{-1}$; 90% CI, [-1.24, 0.74]).
- Excellent test-retest reliability was observed across visits for both the incremental (ICC=0.936; 95% CI, [0.786, 0.979]) and verification tests (ICC=0.951; 95% CI, [0.836, 0.985]).

PRACTICAL APPLICATIONS

- Practitioners can confidently employ the speed-based $\dot{V}O_{2max}$ protocol for measuring cardiorespiratory fitness in tactical and recreational athletes.
- A supramaximal verification trial can be used to validate the $\dot{V}O_{2max}$ obtained during a speed-based incremental protocol.

CONCLUSIONS

- The $\dot{V}O_{2max}$ obtained during the speed-based incremental and verification protocols were statistically equivalent.
- Statistical inequivalence between $\dot{V}O_{2max}$ from Visit 1 and Visit 2 incremental tests may be explained by familiarization with testing procedures during the second visit.
- Excellent test-retest reliability was observed for both protocols.

REFERENCES

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