Relationship Between Velocity Reached at VO$_{2\text{max}}$ and Time-Trial Performances in Elite Australian Rules Footballers

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Purpose: Running velocity reached at maximal oxygen uptake (vVO$_{2\text{max}}$) can be a useful measure to prescribe training intensity for aerobic conditioning. Obtaining it in the laboratory is often not practical, and average velocities from time trials are an attractive alternative. To date, the efficacies of such practices for team sport players are unknown. This study aimed to assess the relationship between vVO$_{2\text{max}}$ obtained in the laboratory against two time-trial estimates (1500 m and 3200 m).

Methods: During the early preseason, elite Australian Rules football players (n = 23, 22.7 ± 3.4 y, 187.7 ± 8.2 cm, 75.5 ± 9.2 kg) participated in a laboratory test on a motorized treadmill and two outdoor time trials.

Results: Based on average velocity the 1500-m time-trial performance (5.01 ± 0.23 m·s$^{-1}$) overestimated (0.36 m·s$^{-1}$, $d = 1.75$), whereas the 3200-m time trial (4.47 ± 0.23 m·s$^{-1}$) underestimated (0.17 m·s$^{-1}$, $d = 0.83$) the laboratory vVO$_{2\text{max}}$ (4.64 ± 0.18 m·s$^{-1}$). Despite these differences, both 1500-m and 3200-m time-trial performances correlated with the laboratory measure ($r = −0.791$; $r = −0.793$ respectively). Both subsequent linear regressions were of good fit and predicted the laboratory measure within ±0.12 m·s$^{-1}$.

Conclusion: Estimates of vVO$_{2\text{max}}$ should not be used interchangeably, nor should they replace the laboratory measure. When laboratory testing is not accessible for team sports players, prescription of training intensity may be more accurately estimated from linear regression based on either 1500-m or 3200-m time-trial performance than from the corresponding average velocity.

Velocity at maximum oxygen uptake (vVO$_{2\text{max}}$) has been used to calibrate and prescribe exercise intensity, and subsequently improve aerobic endurance.1,2 It is the maximum running velocity attained for at least 1 min before completion of the test.3 Obtaining vVO$_{2\text{max}}$ is, however, labor intensive and time consuming. An indirect alternative, supported in the literature,3,4 is mean running velocity based on time-trial performance.5 Time trials are clearly easier, quicker, and more cost effective than laboratory testing. Some Australian Rules football clubs regularly use time trials to prescribe training intensity and assess aerobic fitness of

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their players. To our knowledge, an examination of the relationship between time-trial performance and vVO$_{2\text{max}}$ obtained from the laboratory in elite Australian Rules football (ARF) players has not been assessed. Understanding these relationships may improve the accuracy of intensity prescription based on time-trial performance. Therefore, we aimed to test this relationship between vVO$_{2\text{max}}$ and mean running velocity for 1500-m and 3200-m timetrials in ARF players.

### Method

#### Participants

Participants (n = 23, age = 22.7 ± 3.4 y, stature = 187.7 ± 8.2 cm, mass = 75.5 ± 9.2 kg) were from an Australian Football League club. All were uninjured and on the senior playing list at the time of testing. This investigation was approved by the university’s ethics committee, and all participants volunteered and gave written consent.

#### Procedure

Testing was conducted during preseason in the following order: 1) 3200-m time trial, 2) incremental VO$_{2\text{max}}$ test, and 3) 1500-m time trial. Approximately 1 wk was allowed between testing sessions. Participants completed each time trial together, around an outdoor (gravel) running circuit. The distances were measured with a trundle wheel and cross-referenced with a global positioning system (WiSPl, GPSports, Canberra, Australia). Ambient temperature was 15.7°C and 17.8°C, and relative humidity was 72% and 64% at the time of the 3200-m and 1500-m time trials, respectively.

Warm-up for the vVO$_{2\text{max}}$ test consisted of two 2-min bouts of running on a motorized treadmill (H/P/Cosmos Sports and Medical GmbH, Pulsar 3P 4.0, Amsporplatz, Nussdorf-Traunstein, Germany). The first bout was at 0.56 m·s$^{-1}$ below the starting velocity (estimated as 1.11 m·s$^{-1}$ below average velocity of previous preseason 3200-m time trial) and the second bout was at starting velocity. At a constant gradient of 1%, the test followed incremental increases of 0.14 m·s$^{-1}$ (0.5 km·h$^{-1}$) every minute until volitional exhaustion. Heart rate was recorded (Sunto Oy, t6c, Vantaa, Finland), and breath-by-breath measurements were recorded with a metabolic cart (MOXUS Modular VO$_2$ system, Max II Metabolic System, AEI Technologies, Pittsburgh, PA). To achieve VO$_{2\text{max}}$ three out of four of the following criteria had to be met: 1) age-predicted maximum heart-rate, 2) plateau in VO$_2$ (±2.1 mL·kg$^{-1}$·min$^{-1}$), 3) RER > 1.1, and 4) volitional maximal fatigue.

#### Statistical Analyses

Two participants failed to meet the VO$_{2\text{max}}$ criterion and their data were removed from further analyses. Differences between time-trial estimates and laboratory vVO$_{2\text{max}}$ were analyzed using paired $t$ tests and effect size ($d$). Pearson’s correlation coefficient and linear regression were performed and subsequent equations presented with standard error of estimates (SEE).
Figure 1 — 1500-m (upper panel) and 3200-m (lower panel) time-trial performance against vVO₂max attained from the laboratory.
Results and Discussion

Participants completed the 1500-m time trial in 300 ± 14 s, the 3200-m time trial in 718 ± 40 s, and attained a VO$_2$max of 54.1 ± 3.3 mL·kg$^{-1}$·min$^{-1}$ in the laboratory.

Laboratory vVO$_2$max was 4.64 ± 0.18 m·s$^{-1}$. Based on average velocity of the time trials, estimated vVO$_2$max values were 5.01 ± 0.23 m·s$^{-1}$ (1500 m) and 4.47 ± 0.23 m·s$^{-1}$ (3200 m). When compared, vVO$_2$max was different and dependent upon the method used. The 1500-m time-trial performance overestimated ($P < .001$, $d = 1.75$) vVO$_2$max by 0.36 m·s$^{-1}$ (95% CI, 0.30 to 0.43 m·s$^{-1}$). In contrast, vVO$_2$max was underestimated ($P < .001$, $d = 0.83$) by 0.17 m·s$^{-1}$ (95% CI, 0.11 to 0.24 m·s$^{-1}$) by the 3200-m time-trial performance. These differences can be explained by the dissimilar designs of the protocols. Estimated vVO$_2$max from 1500 m ($r = −0.791$) and 3200 m ($r = −0.793$) time-trial performances both correlated to an acceptable level with the laboratory measure (Figure 1). The subsequent regression equations (Equations 1 and 2) were both of good fit (ANOVA $P < .001$; all coefficients $P < .001$) and time-trial performances explained 63% of variance in vVO$_2$max. The equations may be used to reduce the observed discrepancies in vVO$_2$max between time-trial and laboratory methods.

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vVO_2max = −0.010(1500\text{-m time trial}) + 7.795 ± 0.12 \text{ m·s}^{-1} \quad (1)
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\[
vVO_2max = −0.004(3200\text{-m time trial}) + 7.286 ± 0.12 \text{ m·s}^{-1} \quad (2)
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Conclusion

Estimates of vVO$_2$max should not be used interchangeably or replace the laboratory measure. When laboratory testing is not accessible for team sports players, prescription of training intensity may be more accurately estimated from linear regression based on either 1500-m or 3200-m time-trial performance than from the corresponding average velocity. Future work will aim to cross-validate these regression equations.

References

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