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THE EFFECT OF BLOOD DONATION ON TALK TEST RESPONSES IN
RECREATIONALLY ACTIVE MEN

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ABSTRACT

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The Talk Test (TT) is a valid method of evaluating exercise intensity as well as exercise prescription. It has been widely studied as surrogate to the ventilatory threshold (VT). Blood donation highly effects exercise intensity due to a significant drop in hemoglobin (Hgb). Purpose: To investigate TT responses 3 days and 21 days post a blood donation (475ml). Methods: Recreationally fit college-aged males (N=13) performed a baseline TT and then were instructed to donate blood at local blood donation center. They performed the same TT 3 days and 21 days post blood donation. Results: There was no significant change in TT responses 3 days and 21 days post blood donation. Hemoglobin significantly dropped 3 days post blood donation but returned to baseline levels 21 days later. Conclusion: A standard unit of blood donation does not affect TT responses. In order to see significant change a larger blood loss is required.

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INTRODUCTION

The frequency, intensity, time, type, volume, progression (FITT-VP) principle is widely used as a guide to create exercise programs. Intensity is the most challenging program variable to prescribe. In order to prescribe exercise intensity graded exercise tests (GXT) have been used. These tests find maximal values for heart rate and VO_2 , which are the basis for exercise prescription (Riebe, 2018). From the absolute values derived from a GXT we can prescribe exercise based on heart rate max (HRmax), heart rate reserve (HRR), maximal oxygen consumption (VO_{2max}) or maximal oxygen consumption reserve (VO_{2R}). These parameters are used to prescribe intensity primarily based on a relative percent of values acquired from the GXT. However, there have been suggestions for over 40 years that the relative percent concept does not always correlate well with endurance and cardiovascular improvements during training (Katch, Weltman, Sady & Freedson, 1978; Sharhag-Rosenberg et al., 2010). This limitation to the relative percent model of exercise prescription has led to exercise intensity prescription based on threshold concepts (Mezzani, et al., 2012). Generally, to test for threshold a GXT (often maximal) is also required. However, due to the limited availability, potential risks, and cost of tests, the use of a GXT has declined (Thompson, Arena, Riebe, & Pescatello, 2013).

Methods that are easier to understand and implement are needed. A widely used method to generate a target HR is the age-predicted maximal heart rate. However, there is

evidence suggesting that age predicted maximal heart HR is an inadequate method of guiding individual exercise prescription due to substantial individual variation of maximal HR with a standard deviation of ± 10 -12 bpm (Tanaka, Monahan, & Seals 2001, Robergs & Landwehr, 2002).

A subjective method of intensity prescription that has supporting evidence is the Rating of Perceived Exertion (RPE) (Borg, 1998; Eston, 2012). The RPE scale has been a useful surrogate of exercise intensity as a momentary rating (Pollock, Foster, Rod & Wible, 1982) or as a measure for an entire exercise bout (Foster et al., 2001). Additionally, when comparing the RPE scale to an objective measure such as VO_2R , it has been found that mean exercise intensity does not differ between the two methods. Also, after a 6-week training period where one group utilized RPE and the other group used VO_2R the 12-minute run distance improved similarly (Johnson, 2017). Parfitt, Evans & Eston (2012) tested the RPE Borg scale that ranges from 6 to 20. After an 8-week training period where sedentary subjects trained at an RPE of 13 for 3 times a week there was significant improvements in VO_{2max} and $VO_2 @ VT$. The RPE scale does have limitation. The scale is based on perceived effort but that measure alone may be insufficient to capture the whole range of perceptual sensation that people experience when exercising or being physically active (Hutchinson & Tenenbaum, 2006).

Another subjective method of guiding exercise intensity is the Talk Test (TT), which has gained wide interest over the last 20 years (Foster et al., 2018). The TT is simple to administer in any setting without the need to ground the individual to an RPE scale. The participant performs an incrementally increasing GXT. At each interval, they are asked to recite a standard passage of 90-100 words and state if they are able to “speak

comfortably”. An answer of “Yes” is a positive response, an answer of “Yes, but...” is considered an equivocal response, and an answer of “No” is a negative response. The participant continues the test until they provide a negative response or reach volitional fatigue. The equivocal response during the TT has been well correlated with the VT (Dehart-Beverley, Foster, Porcari, Fater, & Mikat, 2000; Alaimi et al., 2020). The VT describes the point where pulmonary ventilation increases disproportionately relative to increases in VO_2 . The VT has also been found to be well-correlated to the first lactate threshold which is also a submaximal exercise intensity. The negative response during the TT has been well correlated with the respiratory compensation threshold (RCT) (Recalde et al., 2002; Rodriguez-Morroyo et al.,). The RCT is defined as a further increase in ventilation, disproportionate to CO_2 production, to counter the decrease in plasma pH during intense physical activity. Graphical illustration is shown in figure 1.

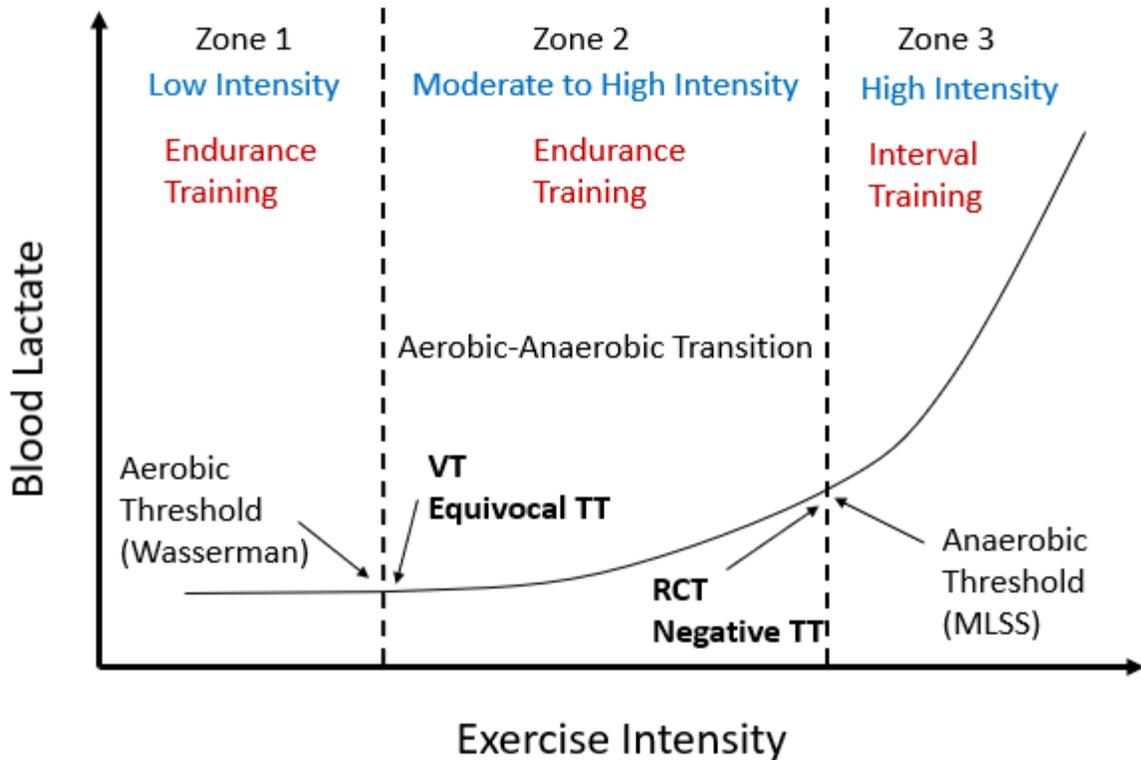


Figure 1. Graphical illustration of where VT and RCT occur during exercise.

Creemers, Foster, Porcari, Cress & de Koning (2017) demonstrated that the requirement for suppressing respiratory rate to allow for speech leads to a reduction in VCO_2 , which is very important because VCO_2 increases when VT is achieved. When VCO_2 is reduced, end-tidal carbon dioxide ($P_{et}CO_2$), a surrogate of partial pressure of carbon dioxide in arterial blood (P_aCO_2), increases augmenting the sensation of increased respiration making speech uncomfortable.

The TT relationship with the VT and RCT has been replicated in multiple populations. This includes, athletes (Jeans, Foster, Porcari, Gibson, & Doberstein, 2011, Rodriguez-Morroyo, 2013), patients with cardiovascular disease (Voelker et al., 2002, Cannon et al., 2004, Brawner, et al., 2006, Zanettini et al., 2012), patients with spinal

cord injuries (Cowan, Ginnity, Kressler, & Nash, 2012) and in untrained populations (Foster, 2019). When compared to an objective measure such as HRR the TT has demonstrated the ability to guide training to achieve similar improvements in aerobic capacity (Porcari, 2018). This demonstrates that the TT can guide exercise prescription.

When evaluating the TT, the Fick equation must be considered. The basic equation is $VO_2 = HR \times SV$. Any alteration to the Fick equation changes an individual's response to exercise. With the TT being comparable to objective measures such as HRR and having the TT responses being measures of internal training load any alteration to the Fick equation theoretically will create augment TT responses. A common and sensitive alteration is blood loss. A common way blood loss is experienced is through a standard blood donation of about 450-500mL. Blood donation has been found to reduce VO_2 by 9% (Balke, Grillo, and Konecni, 1954). This decrease in VO_2 is due to a decrease in blood volume and hemoglobin (Hb). Blood donation severely lowers Hb which is associated with oxygen transport at a cellular level. Recovery of Hb has been found to have a wide recovery time of 9-95 days depending on a subjects' pre donation iron level (Fowler, 1942). More recent research has shown recovery periods of 20-59 days (Pottgiesser, 2008).

Limiting oxygen transport by reducing Hb concentration has been found to decrease VO_{2peak} (Burnley, 2006). However, submaximal exercise shows no change in VO_2 at 2 and 7 after blood donation despite significant reductions in Hb (Panebianco, Stachenfeld, Coplan, & Gleim, 1995). Compensatory adjustments such as an increase in HR to increase cardiac output may offset the lower Hb and enable muscle oxygen delivery to be maintained during low-intensity exercise after blood donation (Gordon,

Marshall, Connell, & Barnes, 2010), When assessing exercise performance, it has been found it can take 2 weeks (Ziegler et al. 2014) to 3 weeks (Bennet & McKay, 2012; Judd, Ornish, Barss, Oroz, & Chilibeck, 2011) for peak aerobic power to return to baseline levels. Interventions that have enhanced Hb concentration showed an increase in VO_2 peak during maximal exercise 24 hours after (Thomsen, 2007) and 4 weeks after recombinant human erythropoietin treatment (Wilkerson, 2005).

Foster et al. 2008 compared TT responses after a standard blood donation by evaluating baseline TT and VO_2 results, having subjects donate blood, and retesting them 3 days after the blood donation. They found a standard blood donation resulted in a 9% decrease in hematocrit (Hct), 9.5% decrease in VO_2 peak and an 8% decrease in VO_2 at VT. They also found a 15% drop in VO_2 at the last positive talk test (LPTT) which occurs a stage before the equivocal response of the TT which is a surrogate of VT. The conclusion from Foster et al. 2008 is the TT can accurately track changes in exercise intensity after blood donation. But there were three critical flaws: a short speech passage for the TT, a measurement of Hct instead of Hb, and a protracted recovery period to assess the rebound of exercise performance. To measure TT responses the “Pledge of Allegiance”, which is a 31-word passage was used. It has been shown that a longer passage, of 90-100 words, estimates TT responses more accurately than a shorter passage because the shorter word count was not a long enough stimulus to retain CO_2 leading to an overestimation of TT responses (Schroeder, Foster, Porcari, & Mikat, 2017). Hct can be an inaccurate variable due to Hct being strongly influenced by environmental factors such as hydration, posture, exercise, and circadian rhythm (Pottgiesser, 2008). Only

looking at variables 3 days post blood donation does not encapsulate the recovery window of hemoglobin or exercise performance.

There is no current literature on the results of how blood donation affects a subjective measure such as the TT over a 3-week period. The hypothesis is after an initial 3 day decrease in VO_2max , VT, Hb, the LPTT, equivocal, and negative stages of the TT following a 500mL blood donation testing the same variables 3 weeks later will result in significantly similar TT results as baseline. This study is designed to replicate the previous study performed by Foster et al. (2018) by incorporating a TT of adequate length, utilizing Hb as the measurement of internal change, and measuring beyond the 3-day window for recovery post blood donation.

METHODS

Subjects

The subjects for this study were 13 healthy recreationally active young adult males aged 18-35 years old. Participants were eligible to participate in the study if they were healthy, exercised a minimum of 150 minutes per week and had a normal hemoglobin concentration (13.5 to 17.5g/dL). Descriptive characteristics of the subjects are presented in Table 1. The study was approved by the University of Wisconsin-La Crosse Institutional Board for the Protection of Human Subjects and all subjects provided written informed consent.

Table 1. Descriptive Physical Characteristics of the Subjects at baseline

Variable	Male (n=13)
Age (years)	23.4 ± 3.44
Height (m)	1.78 ± 0.07
Weight (kg)	87.1 ± 9.62
VO ₂ max (ml/kg/min)	44.7 ± 4.93
HR peak (bpm)	183 ± 11.6

Mean ± Standard Deviation

Screening

Potential participants came to the Human Performance Lab to complete the screening procedures. Prior to screening, the details of the study were explained to the participants and they provided written informed consent. Screening consisted of the PAR-Q Physical readiness form and a capillary blood draw to determine resting hemoglobin levels. Eligible participants were enrolled in the study and their data was privately secured. They were then familiarized with the exercise equipment used during the GXT. The study protocol was approved by the Institutional Review Board for the Protection of Human Subjects at the University of Wisconsin-La Crosse.

Protocol

The GXT was performed on an electrically braked cycle ergometer (Lode Excalibur, Groningen, The Netherlands). During the GXT, subjects wore a facemask (Hans Rudolph, Shawnee, KS) to facilitate the collection of expired using open circuit spirometry (AEI Moxus) was used. The test started at a workload of 25W and was increased by 25W every 2 minutes until failure. Failure was defined as an inability to maintain RPMs above 50 on the bike or the subject reaching failure. Subjects then completed a 5-minute active recovery period on the cycle ergometer using a load of 25w at 60 rpm before completing a verification phase to confirm achievement of a true VO_2max during the GXT. Subjects were instructed to cycle at one exercise stage above their workload achieved in the first test. The subject continued to cycle until failure was achieved.

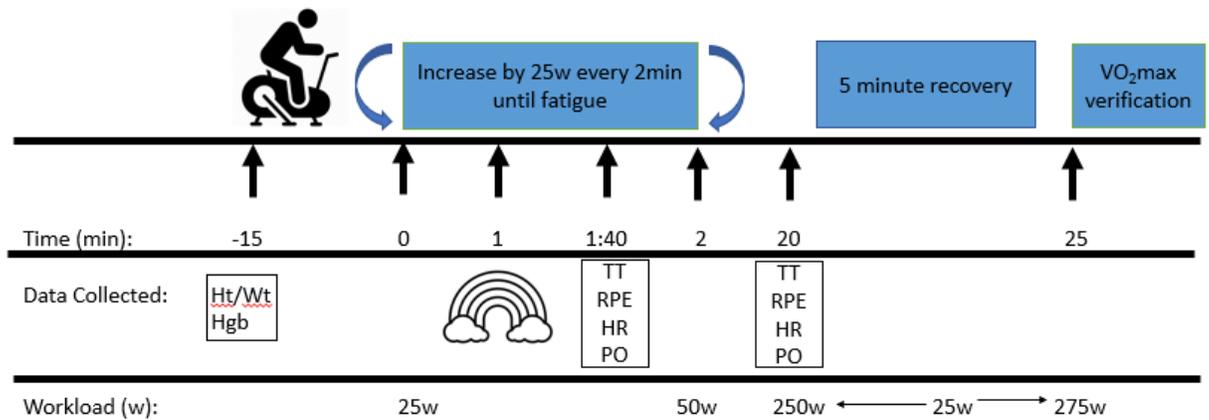
At the end of the 1st minute of each stage of the primary test the subject performed the TT which consisted of the recitation of the “Rainbow Passage” (101 words). After completion of the passage, the subjects were asked if they were “able to speak comfortably”. An answer of ‘Yes’ indicated a positive response, an answer of ‘Yes, but...’ indicated an equivocal response and an answer of ‘No’ indicated a negative response. The test was completed within 12-36 minutes. The VT was be determined using V-Slope and ventilatory equivalent methods (Foster & Cotter, 2005). VO_2max was

accepted as the highest value observed during either the primary or the verification test.

Graphical illustration of the testing is day is on figure 2.

To eliminate error, from utilizing a facemask, prior to beginning the test the facemask was checked for any air leaks.

GXT Testing Day Sample



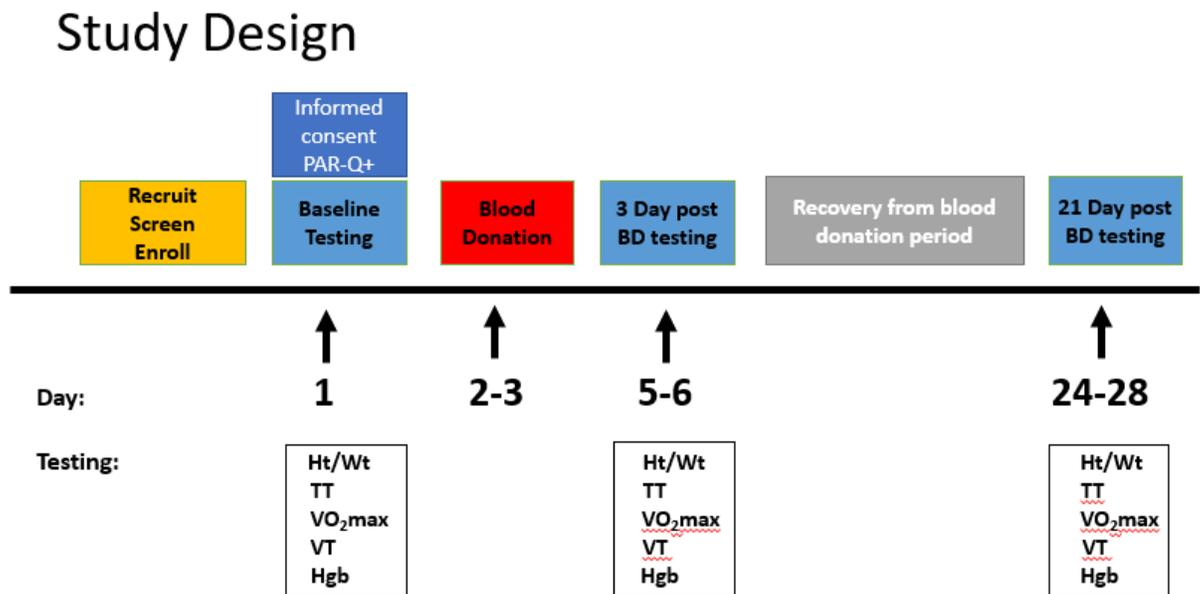
Note: ***TT discontinues when subject states they cannot speak comfortably (Negative Response).***
 = TT (rainbow passage)

Figure 2. Illustration of the testing protocol

Blood Donation and Follow-Up Testing

At the completion of baseline tests, the subjects were instructed to schedule a blood donation at the local Red Cross Blood Donation center and provided the research team with a receipt confirming the date of completion of their blood donation. Subjects then completed the GXT testing procedure on 3 days and 21 days after donation.

Graphical illustration is shown on figure 3.



Ht = Height, Wt = Weight, TT = Talk Test, VO₂max = VO₂max test, Hgb = Hemoglobin analysis

Figure 3. Graphical illustration of the study design.

Data Collection, Storage and Statistical Analysis

Data collected included VO_2max , VT, the power output (PO) when they reached the LPTT, the PO at EQTT, the PO at the NEG-TT and resting Hb during all 3 series of tests. Statistical analysis (SPSS, Version 26; SPSS., Chicago, IL.) were performed using a repeated measures ANOVA. Post hoc tests, when justified, were performed using the Tukeys' test.

RESULTS

Hemoglobin

There was a significant reduction in hemoglobin (Hgb) ($p < .05$) from baseline to 3 days post-blood donation 15.2 ± 0.66 g/dl to 13.9 ± 0.98 g/dl (Figure 3). There was no significant difference in Hgb levels from baseline to 21 days post blood donation 15.2 ± 0.66 g/dl to 14.2 ± 1.20 g/dl.

VO₂max

3 days after blood donation VO₂max was significantly reduced from a baseline level of 45.6 ± 4.66 ml/kg/min to 42.6 ± 5.36 ml/kg/min (Figure 2). There was no significant difference in VO₂max from baseline to 21 days post blood donation (45.6 ± 4.66 to 43.1 ± 4.72) and no significant difference 3 days post blood donation compared to 21 days post blood donation (42.6 ± 5.36 to 43.1 ± 4.72).

Talk Test Metrics

After blood donation heart rate at ventilatory threshold (HRVT) did not significantly change from a baseline level of 129 ± 11.8 bpm to 137 ± 16.3 bpm three days post blood donation (Figure 4). There was a significant increase in PO@LPTT from baseline to 21 days post blood donation 100 ± 27.0 W to 119 ± 25.3 W and there was no significant change from baseline to 3 days post blood donation 100 ± 27.0 W to 111 ± 26.3 W (Figure 5). There was no significant change from 3 days to 21 days post blood donation. There was a significant change in PO@EQTT from baseline to 21 days post blood donation 125 ± 27.0 W to 137 ± 26.3 W and no significant change from baseline to

3 days post blood donation 125 ± 27.0 W to 137 ± 26.3 (Figure 6). There was no significant change 3 days post blood donation to 21 days post blood donation. There was no significant change in PO@NEGTT from baseline to 3 days post blood donation 190 ± 33.1 W to 188 ± 24.2 W and no significant differences between baseline and 21 days post blood donation (Figure 7). Differences are illustrated in Table 2.

Table 2. Summary of variables at baseline, 3 days post blood donation, and 21 days post blood donation.

Variable	Baseline	Day 3	Day 21
Hgb g/dL	15.2 ± 0.66	$13.9 \pm 0.98^*$	14.2 ± 1.20
PO @ LPTT (W)	100 ± 27.0	111 ± 26.3	$119 \pm 25.3^*$
PO @ EQTT (W)	125 ± 27.0	137 ± 26.3	$146 \pm 26.7^*$
PO @ NEGTT (W)	190 ± 33.1	188 ± 24.2	202 ± 21.6
VO ₂ (ml/kg/min)	45.6 ± 4.66	$42.6 \pm 5.36^*$	43.1 ± 4.72
VO ₂ (L/min)	3.90 ± 0.39	$3.64 \pm 0.42^*$	3.70 ± 0.36
HRmax (bpm)	185 ± 9.71	185 ± 11.0	182.9 ± 13.5
RPEmax	8.35 ± 1.57	8.23 ± 1.24	8.15 ± 1.52
RPE @ VT	3.77 ± 0.93	4.08 ± 0.86	3.85 ± 1.21
PO @ VT (W)	146 ± 22.5	146 ± 17.2	140 ± 21.7
VO ₂ @ VT	24.8 ± 4.52	25.8 ± 4.18	25.0 ± 3.59
VE @ VT	52.9 ± 13.3	55.3 ± 13.3	55.8 ± 13.3
HR @ VT	129 ± 11.8	137 ± 16.3	132 ± 15.4
PO @ Max (W)	249 ± 20.8	246 ± 20.6	245 ± 20.5

* Significantly different from baseline

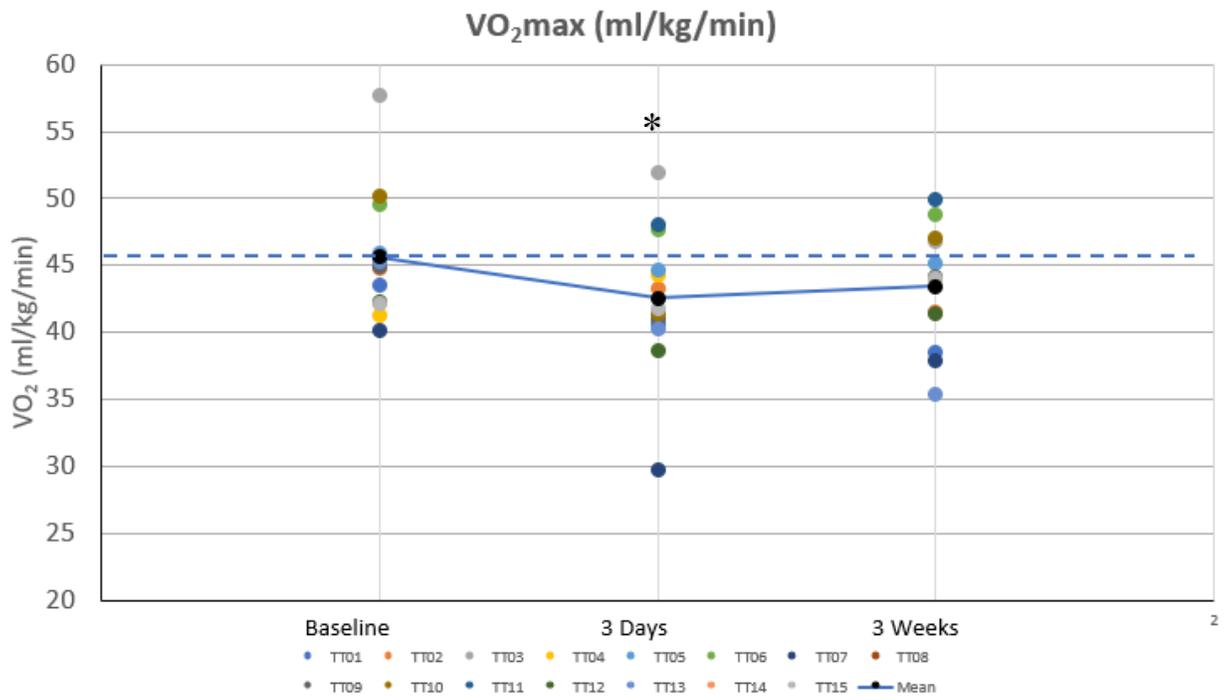


Figure 1. Changes in VO₂ (ml/kg/min) 3 days and 21 days post blood donation

* Significantly different from baseline

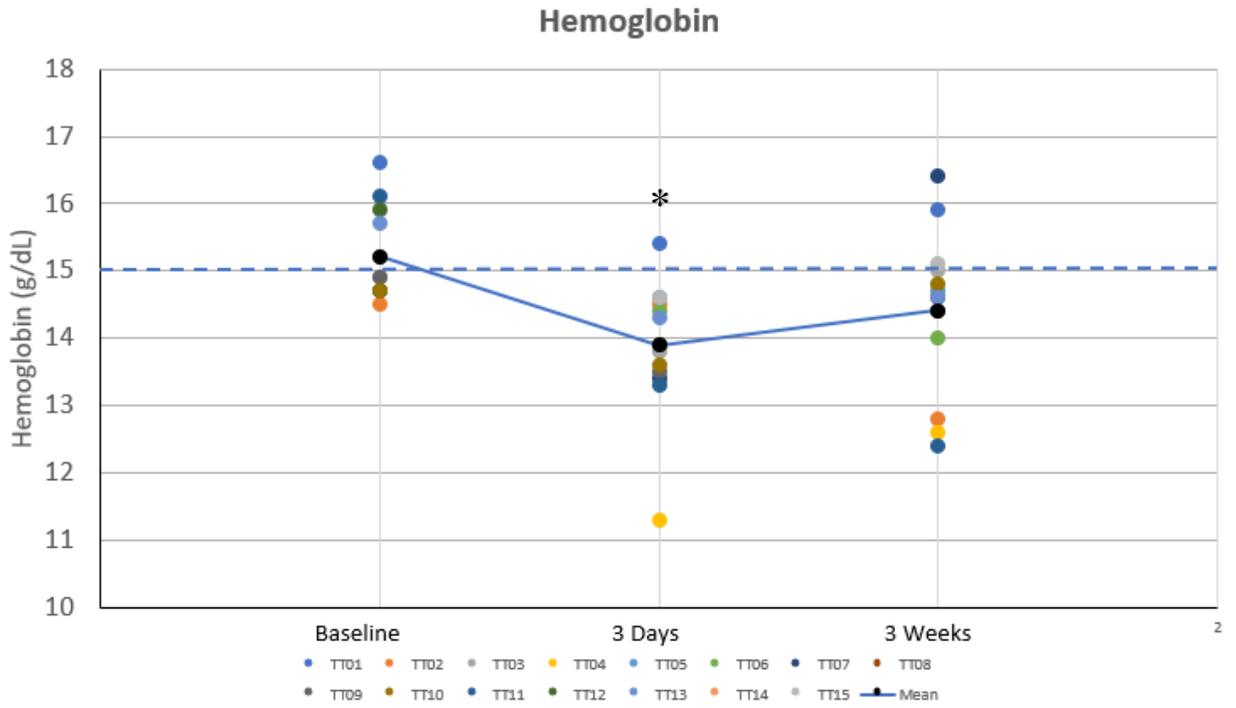


Figure 2. Changes in Hemoglobin (g/dL) 3 days and 21 days post blood donation

* Significantly different from baseline

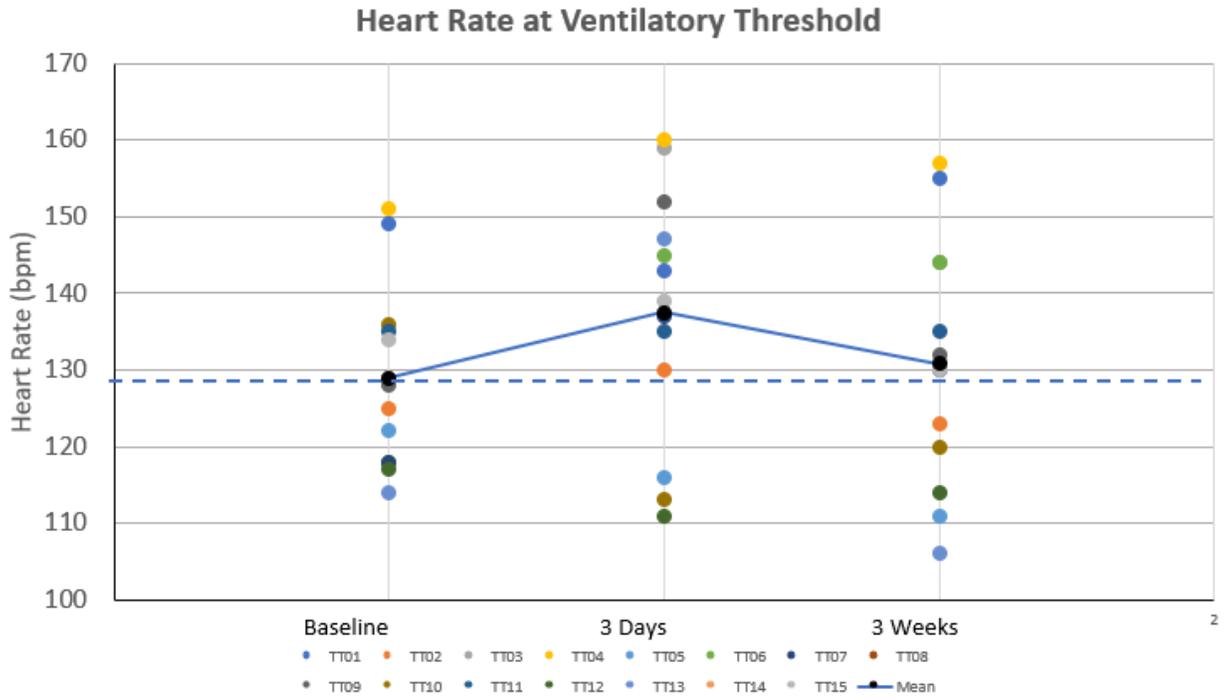


Figure 3. Changes in heart rate and ventilatory threshold (bpm) at 3 days and 21 days post blood donation.

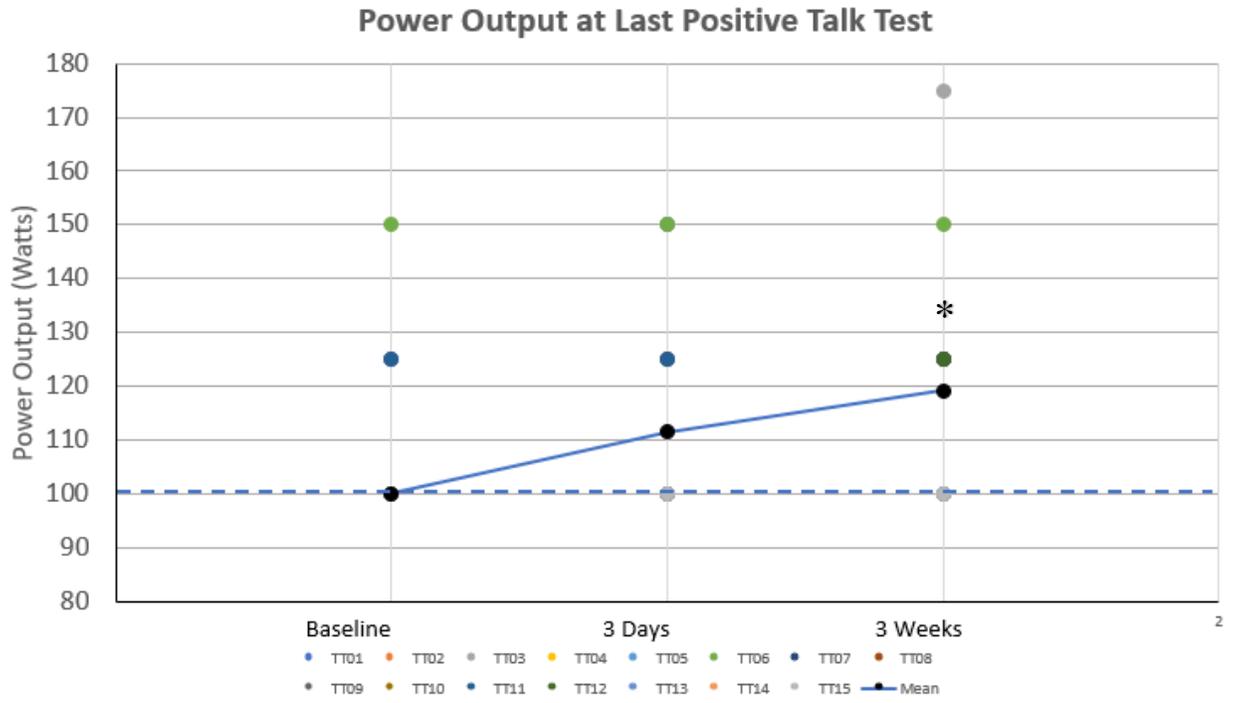


Figure 4. Changes in power output at last positive Talk Test (LPTT) at 3 days and 21 days post blood donation.

* Significantly different from baseline

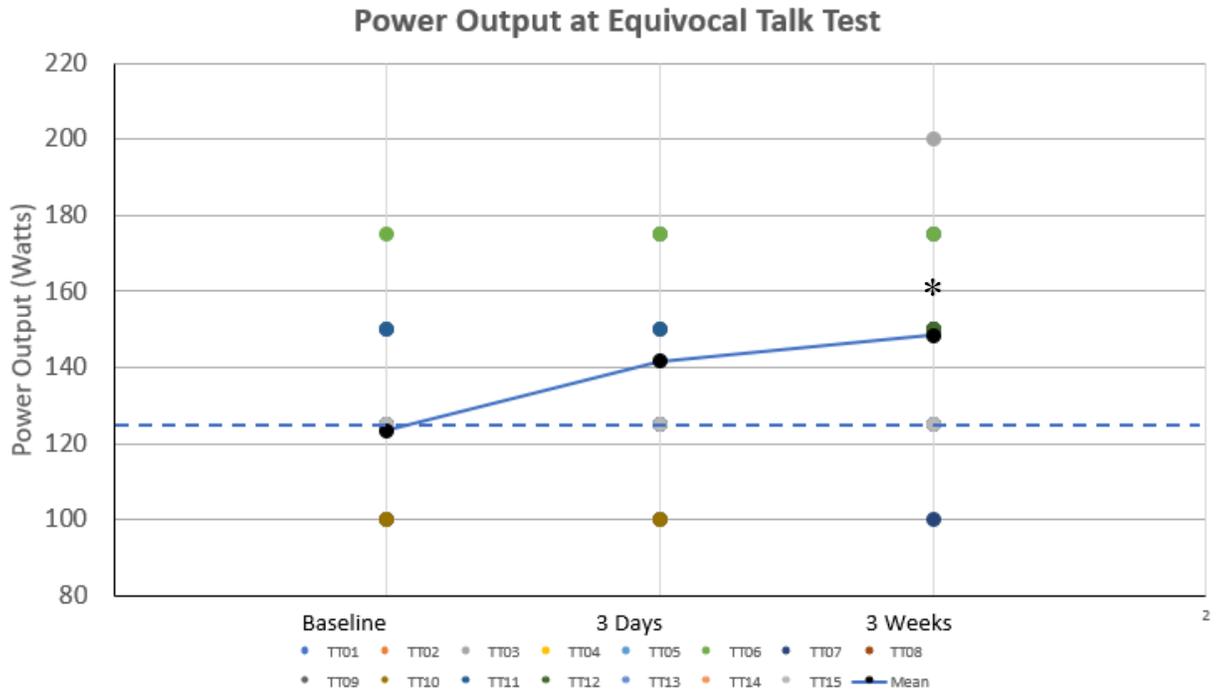


Figure 5. Changes in power output at equivocal Talk Test (EQTT) at 3 days and 21 days post blood donation.

* Significantly different from baseline

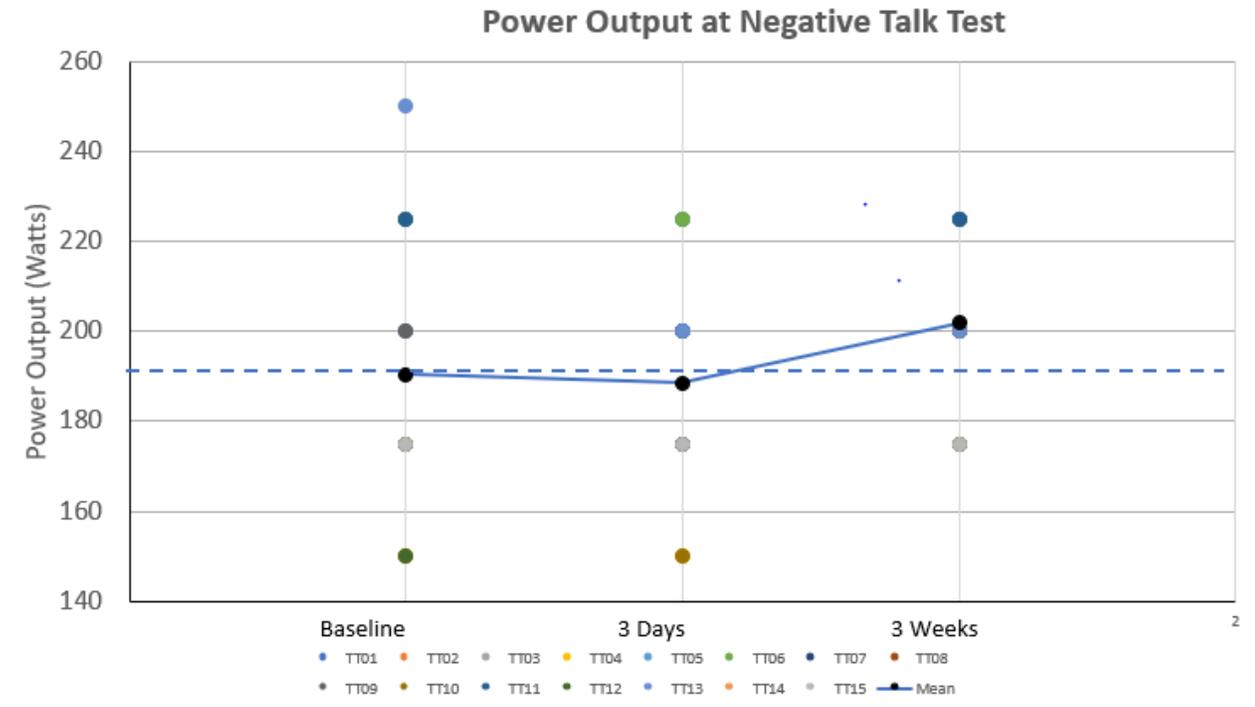


Figure 6. Changes in power output at negative Talk Test (NEGTT) at 3 days and 21 days post blood donation.

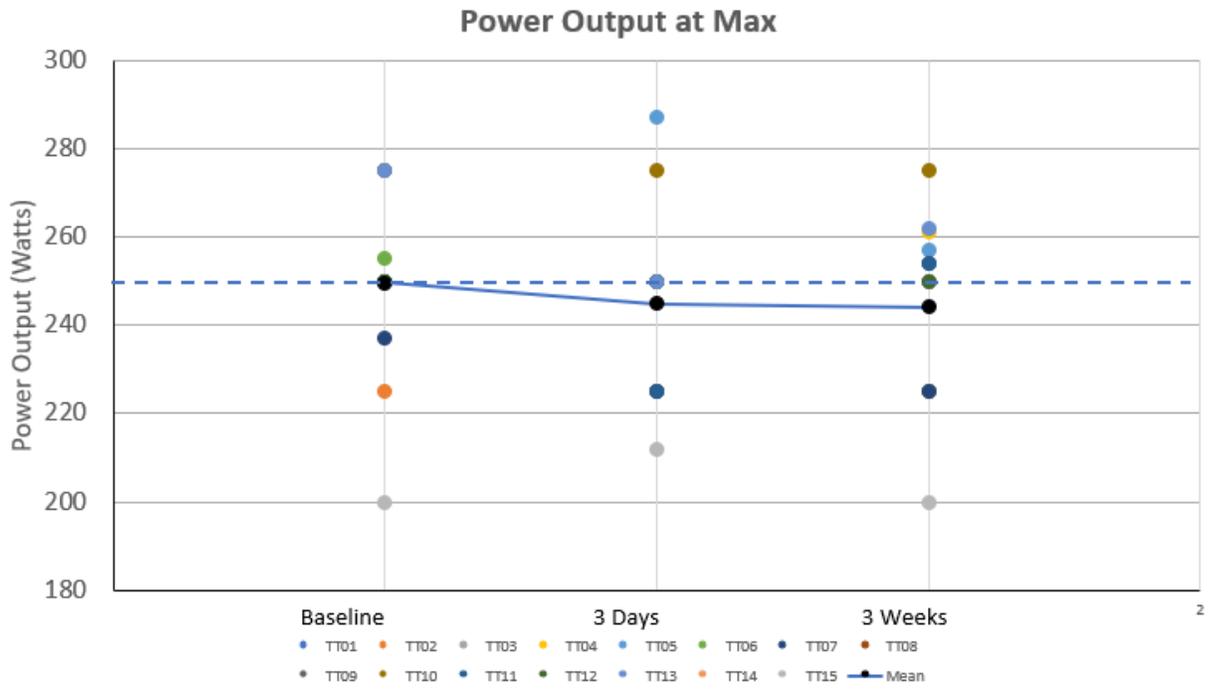


Figure 7. Changes in peak power output at 3 days and 21 days post blood donation

DISCUSSION

The main conclusion of this study is that blood donation does not affect TT responses at the LPTT or EQTT stages. These results differed from Foster et al., 2008 even at 3 days post blood donation. Additionally, the results support previous research on blood donation effects. These include a significantly decreased VO_2 3 days post blood donation and a recovery of Hb in 21 days. Lastly, the result of support the previous literature that the TT is a surrogate of VT.

It was hypothesized that the LPTT and EQTT would occur at a lower PO 3 days after blood donation and return to (or at least toward) baseline levels after 21 days. Paradoxically, compared to baseline, PO at LPTT and EQTT increased significantly post-blood donation. There was no change in LPTT or EQTT when comparing 3 days post blood donation and 21 days post blood donation. Peak power output, in watts, was not significantly changed across all 3 conditions. Additionally, no change was seen in RPE responses, and no significant change was seen for the PO at the VT or VO_2 at the VT. However, the PO at LPTT and PO at EQTT is equivalent to the PO at VT.

Foster et al. 2008 concluded blood loss resulted in a decrease in VO_2 at VT and a comparable drop in the VO_2 at the LPTT. But, according to Panebianco et al. 1995 they should not have seen a difference in results because blood donation does not affect submaximal exercise intensities and the VT and LPTT are both submaximal exercise intensities. The only study to observe changes in submaximal exercise intensity is

Ekblom, Goldbarg, & Gullbring. But in order to see a change subjects lost 1200mL of blood which correlates to a 15% drop in hemoglobin. The current study found an 8.3% drop in hemoglobin while other comparable studies found a 9.5% drop (Burnley et al., 2006), 8.8 (Pottgeisser, 2008), 7.9% (Ziegler et al., 2014). Foster et al., say a 9% drop in Hct.

In this study two subjects were excluded from the data due to low levels of hemoglobin at baseline testing. For Future studies designed to evaluate a difference in submaximal values may need to create a larger blood loss in order to see changes. Additionally, two baseline TT should be performed due to subjects being unaccustomed to performing the procedure as it will minimize the learning effect during the test.

CONCLUSION

The present study found that a standard unit of blood donation of 475ml does not affect talk test results at submaximal or maximal intensities. After acquiring baseline measurements and re-testing 3 days later there was a significant drop in Hgb and VO_2 with a significant increase in LPTT, and EQTT. The increase in LPTT and EQTT is likely due to learning effect of the test. When comparing baseline levels to 21 days post blood donation no significant change occurred. When comparing 3 days post blood donation to 21 days post blood donation the main differences is a recovery of VO_{2max} and Hgb to baseline levels. Future studies may want to create a larger blood loss, measure levels 1-day post blood donation, and have two baseline tests.

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APPENDIX A

PHYSICAL ACTIVE READINESS QUESTIONNAIRE for Everyone – 2019 PAR-Q+

2019 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1) Has your doctor ever said that you have a heart condition <input type="checkbox"/> OR high blood pressure <input type="checkbox"/> ?	<input type="checkbox"/>	<input type="checkbox"/>
2) Do you feel pain in your chest at rest, during your daily activities of living, OR when you do physical activity?	<input type="checkbox"/>	<input type="checkbox"/>
3) Do you lose balance because of dizziness OR have you lost consciousness in the last 12 months? Please answer NO if your dizziness was associated with over-breathing (including during vigorous exercise).	<input type="checkbox"/>	<input type="checkbox"/>
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? PLEASE LIST CONDITION(S) HERE: _____	<input type="checkbox"/>	<input type="checkbox"/>
5) Are you currently taking prescribed medications for a chronic medical condition? PLEASE LIST CONDITION(S) AND MEDICATIONS HERE: _____	<input type="checkbox"/>	<input type="checkbox"/>
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer NO if you had a problem in the past, but it does not limit your current ability to be physically active. PLEASE LIST CONDITION(S) HERE: _____	<input type="checkbox"/>	<input type="checkbox"/>
7) Has your doctor ever said that you should only do medically supervised physical activity?	<input type="checkbox"/>	<input type="checkbox"/>



If you answered NO to all of the questions above, you are cleared for physical activity. Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

- ▶ Start becoming much more physically active – start slowly and build up gradually.
- ▶ Follow International Physical Activity Guidelines for your age (www.who.int/dietphysicalactivity/en/).
- ▶ You may take part in a health and fitness appraisal.
- ▶ If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
- ▶ If you have any further questions, contact a qualified exercise professional.

PARTICIPANT DECLARATION

If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for its records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME _____ DATE _____

SIGNATURE _____ WITNESS _____

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER _____



If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

⚠ Delay becoming more active if:

- ✔ You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- ✔ You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.com before becoming more physically active.
- ✔ Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

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FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. Do you have Arthritis, Osteoporosis, or Back Problems?

If the above condition(s) is/are present, answer questions 1a-1c

If **NO** go to question 2

- 1a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES NO
-
- 1b. Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)? YES NO
-
- 1c. Have you had steroid injections or taken steroid tablets regularly for more than 3 months? YES NO

2. Do you currently have Cancer of any kind?

If the above condition(s) is/are present, answer questions 2a-2b

If **NO** go to question 3

- 2a. Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and/or neck? YES NO
-
- 2b. Are you currently receiving cancer therapy (such as chemotherapy or radiotherapy)? YES NO

3. Do you have a Heart or Cardiovascular Condition? This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm

If the above condition(s) is/are present, answer questions 3a-3d

If **NO** go to question 4

- 3a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES NO
-
- 3b. Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction) YES NO
-
- 3c. Do you have chronic heart failure? YES NO
-
- 3d. Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months? YES NO

4. Do you have High Blood Pressure?

If the above condition(s) is/are present, answer questions 4a-4b

If **NO** go to question 5

- 4a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES NO
-
- 4b. Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (Answer **YES** if you do not know your resting blood pressure) YES NO

5. Do you have any Metabolic Conditions? This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes

If the above condition(s) is/are present, answer questions 5a-5e

If **NO** go to question 6

- 5a. Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician-prescribed therapies? YES NO
-
- 5b. Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness. YES NO
-
- 5c. Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, **OR** the sensation in your toes and feet? YES NO
-
- 5d. Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)? YES NO
-
- 5e. Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future? YES NO

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- 6. Do you have any Mental Health Problems or Learning Difficulties?** This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome
If the above condition(s) is/are present, answer questions 6a-6b If **NO** go to question 7
- 6a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES NO
- 6b. Do you have Down Syndrome **AND** back problems affecting nerves or muscles? YES NO
-
- 7. Do you have a Respiratory Disease?** This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure
If the above condition(s) is/are present, answer questions 7a-7d If **NO** go to question 8
- 7a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES NO
- 7b. Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy? YES NO
- 7c. If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week? YES NO
- 7d. Has your doctor ever said you have high blood pressure in the blood vessels of your lungs? YES NO
-
- 8. Do you have a Spinal Cord Injury?** This includes Tetraplegia and Paraplegia
If the above condition(s) is/are present, answer questions 8a-8c If **NO** go to question 9
- 8a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES NO
- 8b. Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting? YES NO
- 8c. Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)? YES NO
-
- 9. Have you had a Stroke?** This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event
If the above condition(s) is/are present, answer questions 9a-9c If **NO** go to question 10
- 9a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES NO
- 9b. Do you have any impairment in walking or mobility? YES NO
- 9c. Have you experienced a stroke or impairment in nerves or muscles in the past 6 months? YES NO
-
- 10. Do you have any other medical condition not listed above or do you have two or more medical conditions?**
If you have other medical conditions, answer questions 10a-10c If **NO** read the Page 4 recommendations
- 10a. Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months **OR** have you had a diagnosed concussion within the last 12 months? YES NO
- 10b. Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)? YES NO
- 10c. Do you currently live with two or more medical conditions? YES NO

PLEASE LIST YOUR MEDICAL CONDITION(S)
AND ANY RELATED MEDICATIONS HERE: _____

GO to Page 4 for recommendations about your current medical condition(s) and sign the PARTICIPANT DECLARATION.

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 **If you answered NO to all of the FOLLOW-UP questions (pgs. 2-3) about your medical condition, you are ready to become more physically active - sign the PARTICIPANT DECLARATION below:**

-  It is advised that you consult a qualified exercise professional to help you develop a safe and effective physical activity plan to meet your health needs.
-  You are encouraged to start slowly and build up gradually - 20 to 60 minutes of low to moderate intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises.
-  As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week.
-  If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

 **If you answered YES to one or more of the follow-up questions about your medical condition:**
You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the **ePARmed-X+** at www.eparmedx.com and/or visit a qualified exercise professional to work through the ePARmed-X+ and for further information.

 **Delay becoming more active if:**

-  You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
-  You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.com before becoming more physically active.
-  Your health changes - talk to your doctor or qualified exercise professional before continuing with any physical activity program.

- You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted.
- The authors, the PAR-Q+ Collaboration, partner organizations, and their agents assume no liability for persons who undertake physical activity and/or make use of the PAR-Q+ or ePARmed-X+. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

PARTICIPANT DECLARATION

- All persons who have completed the PAR-Q+ please read and sign the declaration below.
- If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME _____ DATE _____
SIGNATURE _____ WITNESS _____
SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER _____

For more information, please contact
www.eparmedx.com
Email: eparmedx@gmail.com

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Key References

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APPENDIX B

RAINBOW PASSAGE

THE RAINBOW PASSAGE

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend a boiling pot of gold at one end. People look but no one every finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow.

APPENDIX C
INFORMED CONSENT

Informed Consent

Project: Talk Test Response to Blood Donation after Six Weeks

Principal Investigator: Kirill Shumilov
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Faculty Advisor: Carl Foster, Ph. D.
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University of Wisconsin – La Crosse
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Purpose and Procedures

- The purpose of this study is to see if the Talk Test can track changes in response to blood donation over a 6 week trial period
- My participation will include three laboratory visits that will all be very fatiguing. These visits involve a VO₂max test, a Talk Test, and a finger prick to obtain hemoglobin content. Additionally, one blood donation will occur a few days after the initial laboratory visit
- The total time required is 4 hours over a 6-week period.
- Testing will take place in room 225 Mitchell Hall, UW-L.
- During one of the tests I will wear a snorkel-like device to analyze my breathing and a heart rate monitor, strapped around my chest, to monitor my heart rate.
- Blood will be taken from my fingertip before each trial. This will occur three times.

Potential Risks

- I may experience finger and muscle soreness and substantial fatigue.
- Individuals trained in CPR, Advanced Cardiac Life Support and First Aid will be in the laboratory, and the test will be terminated if complications occur
- The risk of serious or life-threatening complications, for healthy individuals, like myself, is near zero.

Rights & Confidentiality

- My participation is voluntary. I can withdraw or refuse to answer any questions without consequences at any time.
- I can withdraw from the study at any time for any reason without penalty.

- The results of this study may be published in scientific literature or presented at professional meetings using grouped data only
- All information will be kept confidential through the use of number codes. My data will not be linked with personally identifiable information.

Possible benefits (for use if there are any direct benefits to the participant)

- I and other participants may benefit by understanding how blood donation effects their body in regards to exercise.

Questions regarding study procedures may be directed to Kirill Shumilov (shumilov2115@uwlax.edu; 612-321-6968), the principal investigator, or the study advisor Dr. Carl Foster, Department of Exercise and Sport Science, UW-L (608-785-8687). Questions regarding the protection of human subjects may be addressed to the UW-La Crosse Institutional Review Board for the Protection of Human Subjects, (608-785-8044 or irb@uwlax.edu).

Participant _____
Date _____

Researcher _____
Date _____

APPENDIX D
REVIEW OF THE LITERATURE

REVIEW OF LITERATURE

The purpose of this review is to document the literature that relates to how exercise prescription improve fitness. Additionally, we will review how the talk test results respond to blood donation. Assessing individual fitness changes before and after blood donation via the talk test is important because it allows us to manipulate physiology and test the validity of the Talk Test (TT). The goal is to further support the TT as a method of exercise prescription.

The FITT-VP principle (frequency, intensity, time, type, volume, and progression) is used for exercise prescription as stated in the *ACSM Guidelines for Exercise Testing and Prescription*. However, this principle is challenged by difficulty in prescribing or determining intensity. Various methods of calculating relative intensity have been used, including: percentage of maximal oxygen uptake ($\%VO_{2max}$), percentage of maximal heart rate ($\%HR_{max}$), percentage of oxygen uptake reserve ($\%VO_2R$) and percentage of heart rate reserve ($\%HRR$). These objective methods can be inaccurate (Katch et al.,1979), use arbitrary intensity guidelines, can be lengthy, and require specialized equipment. The Talk Test (TT) is a subjective method that has recently been used to prescribe exercise intensity (Foster et al., 2018) The TT is a practical concept to monitor exercise intensity. It was first suggested in 1937 by professor Grayson. His famous quote to British mountaineers to “climb no faster than you can speak” framed the conceptual basis for the TT. The TT is used to determine intensity by asking how comfortable someone feels during speaking at different exercise intensities. In the most widely used version, the subject recites a standard paragraph of 30-100 words, and

responds to the question of whether they can speak comfortably? An answer of 'Yes' indicates a positive response, an answer of 'Yes, but...' indicates an equivocal response, and an answer of 'No' indicates a negative response. The TT appears to identify values associated with the ventilatory threshold (VT), the respiratory compensation threshold (RCT), and brackets people in the appropriate %HRR intensities when prescribing exercise. As long as they are able to speak comfortably, they are thought to be within the recommended range (Porcari et al., 2018; Foster et al., 2018) If they cannot speak comfortably, they are approximately at VT, which is often used as an objective marker of intensity (Mezzani et al., 2012). The VT is defined as the point at which lactate accumulation begins in the body and the breathing becomes labored to the point that an individual cannot speak comfortably during exercise. This has been shown in various populations and using various modes of exercise (Foster et al., 2018). There have been numerous studies conducted on the Talk Test to show its correlation to the objective measures described above and its use as an exercise prescription tool. Foster et al. 2018 completed a study on TT fitness results after a blood donation to show that the TT is a surrogate of the ventilatory threshold. This is the only study to date that included longer period to assess TT and VT after a blood donation and to see if the correlation still exists that the measures of surrogates of one another.

In Creemers, Foster, Porcari, Cress and De Koning (2017) The purpose of the study was to evaluate the mechanisms behind the TT. Twenty healthy college-aged subjects performed a maximal and two sub-maximal cycle ergometer tests. One of the sub-maximal exercises was done using the TT and the other was done without speaking. VO_2 , VCO_2 , V_E , breathing frequency, end-tidal CO_2 pressure (P_{ETCO_2}), and TT times

were recorded. They found that during speech $P_{ET}CO_2$ was significantly higher than before speaking suggesting that CO_2 is retained during speech and supports the hypothesis that talking causes CO_2 retention which causes the ventilatory drive to increase and makes speech uncomfortable. Above the VT, the ventilatory drive is already high and the increase in $P_{ET}CO_2$ causes speech to become uncomfortable. This increase in CO_2 appears to be the reason for the mechanism behind the Talk Test.

To understand how the Talk Test works, its relationship with ventilatory threshold is paramount. This way an objective and subjective measure can be tested to identify their relationship. In Dehart- Beverly et al. (2000) Twenty-eight healthy volunteers completed two maximal tests. One test was a graded exercise test to measure VT and the second test was a Talk Test. The subjects read a standard paragraph (the rainbow passage) during each stage and reported if they could talk comfortably. They found that when subjects could either talk comfortably or were equivocal, they were at or below their VT. Subjects who could not talk comfortably were beyond their VT. This study showed the Talk Test can be a surrogate of the VT.

In the TT the subjects recite a passage of about 30-100 words about every 2 minutes to understand their level of intensity at that moment. There can be a lot of variability in a passage. Including how the subject understands the passage, if they can pronounce the words, and the length of the passage. Current research has utilized many methods for provoking speech. These include “hearing your breath” (Goode et al., 1998), reciting a standard speech passage such as the Pledge of Allegiance or The Rainbow Passage. Schroeder, Foster, Porcari and Mikat (2017) compared the length of the speech-provoking stimulus on power output (PO) at standard TT speech comfort markers. These

markers include: last positive (LP), equivocal (EQ), negative (NEG), in relation to objective markers of exercise intensity, the VT and respiratory compensation threshold (RCT). Healthy subjects performed incremental exercise of 25 watts every 2 minutes with standard gas exchange to measure VT and RCT. They also performed an incremental exercise without gas exchange while repeating standard speech passage of 31, 62, and 93 words to identify the TT speech comfort markers. The main result of this study is that the EQ and NEG stages of the TT can be used to predict the PO at VT and RCT most accurately when using longer speech passage durations around 90 words. The shorter passages tend to overestimate the PO at both the VT and the RCT.

Shafer, Foster, Porcari, and Fater (2000) studied the relationship between VT and TT in healthy sedentary adults. Subjects Completed three exercise tests using a modified Balke treadmill protocol. One test measured VO_2 and HR and the other two measured HR during TT. They found that participants reached their VT before they were unable to speak comfortably. These results reinforced the concept that an individual who is able to speak comfortably is probably at or below VT.

Quinn and Coons (2011) studied the talk test and its relationship with the ventilatory and lactate thresholds (LT). Participants underwent a treadmill lactate threshold test followed by a VO_2 max test in which the VT was determined. On a different day, the Talk Test was administered. The results show that when participants could speak comfortably during exercise, they were below their LT with the equivocal and negative stages the participants were above their LT. They also found that the Talk Test data was more strongly related to physiological and perceptual variables corresponding to the LT than to VT.

There have been many other studies done on the Talk Test on different populations and modalities. Each study showed the Talk Test was a strong predictor of exercise intensity.

Voelker et al. (2002) conducted a study on a correlation of the TT with VT in patients with stable coronary artery disease. They used 10 patients with stable ischemic heart disease who were exercising regularly. They performed two maximal treadmill tests. One to determine VT and the other to determine TT. After comparison the subjects reached VT at the same intensity as when speech became equivocal.

Recalde et al. (2002) wanted to see what the relationship between VT and the TT was in well-trained individuals. The subjects were given three exercise sessions. The first test measured VO_2 and determined VT and RCT. The second test was the TT and the third session was for habituation. They found the LP and EQ stages of the TT there were not different compared to VT. They concluded the TT can be used to represent exercise intensities near VT and RCT. This same conclusion is found to be true in normally active university students, sedentary adults, and patients with stable cardiovascular disease (CVD) (Foster et al. 2018).

In one of the first tests of TT Brawner, Kateyian, and Czaplicki (1995) studied healthy, sedentary adults. They completed a symptom limited graded exercise test measuring VO_2 and heart rate (HR). Subjects were then asked to walk or jog at the fastest pace that still allowed them to comfortably respond to taped questions. Heart rate was measured and compared to the corresponding VO_2 taken from the first incremental test. Subjects achieved an increase in VO_2 and some subjects exceeded the 85% upper limit set

by the American College of Sports Medicine (ACSM). Brawner (1995) concluded that the TT generally reaches intensities that fall within ACSM guidelines.

Foster et al. (2008) had healthy young adults participate in four independent series of experiments designed to decrease VT through blood donation or to increase VT through training. These interventions were matched to the responses of the TT. In the first series, changes in VT and the TT were evaluated before and 48 hours after blood loss via donation of 500 mL of whole blood. In the second series, changes in VT and the TT were evaluated before and after a 6-week exercise training program. The third series, observations of the ability to speak comfortably, or “pass” the TT, were made during a 30-minute training bout where the exercise intensity was systematically varied above and below VT. In the fourth series, the time required for speech to become uncomfortable after the exercise intensity was increased from below to above the VT was evaluated. In the final results the changes in the exercise intensity at VT and at the end of the last positive (LP) stage of the TT matched each other following both blood donation and training. When exercise intensity was varied above and below VT, the predicted ability to speak was well matched to the observations of the TT. The results confirm the robust relationship between VT and the TT during various interventions and suggests that the TT is suitable for exercise prescription.

Jeans, Foster, Porcari, Gibson, and Doberstein (2011) sought to determine how much of a reduction in absolute exercise intensity from those observed during incremental exercise testing was necessary to allow for comfortable speed during exercise training. Well-trained (5-7h/wk) individuals performed incremental exercise tests and three steady-state training bouts. The LP-1 (before the last positive) and the LP

(last positive) runs resulted in the %HRmax and Rating of Perceived Exertion (RPE) values within the recommended range for exercise training, The EQ run elicited an unacceptably high %HRmax and RPE. Most subjects could still speak comfortably during the LP-1 and LP stages and no subject could speak comfortably during the EQ stage. The results of this study suggest that the absolute exercise intensity during the LP-1 and LP stages of incremental exercise tests of the TT may produce steady-state exercise responses appropriate for training in well trained and athletic individuals and that the reproducibility of the TT is satisfactory.

Porcari et al. (2018) studied prescribing exercise intensity solely using the TT to provoke training that are established to known guidelines (ACSM, 2018). They compared the responses to training using either the TT or %HRR. Subjects completed an incremental maximal cycle ergometer test and were stratified based on gender and VO₂max. One training group was guided by %HRR and the other was guided by the TT. They assessed VO₂max, peak power output, VO₂ at VT, peak power output (PPO) at VT and compared the groups using two-way ANOVA with repeated measures after 10 weeks of training. In both groups, there was a significant increase in VO₂max, PPO, VO₂ at VT, and PO at VT. The study concluded that guiding exercise prescription using the TT is a simple and effective method for prescribing exercise intensity and demonstrates that improvements in exercise performance that are comparable to the traditional %HRR guidelines in the ACSM.

Blood donation is a common act performed in the United States for altruistic and health reasons. An estimated 6.8 million people in the United States donate blood each year. Balke, Grillo and Konecci (1954) studied the effect of blood donation on work

capacity on the treadmill immediately after blood donation and for up to 10 days after. Subjects completed five tests over 4 weeks. Two control tests were done, one week later the third test was given one hour after blood donation. The fourth test took place two to three days after and the fifth test was 8 to 10 days after blood donation. In each test, HR, blood pressure (BP), VO₂, oxygen pulse, pulmonary ventilation, and hemoglobin (Hgb) concentrations were measured and recorded. They found that within one hour following blood loss work capacity significantly decreased. Two to three days after blood donation, results were not significantly different from normal, and eight to ten days after blood donation showed an improvement in work capacity.

Eklom, Goldbarg, and Gullbring (1972) completed a study on the body's response to exercise after blood loss and reinfusion. Subjects performed submaximal tests (30% and 60% VO₂ max) on a mechanically braked Monarch bicycle ergometer and maximal exercise tests were on a treadmill. HR, VO₂, blood lactate, Hgb, hematocrit (Hct), red cell volume, and RPE data were collected each time. Hemoglobin decreased by 13-18%, VO₂max decreased by 13-18%, and the performance capacity decreased by about 30%. These results indicate that blood donation has a large effect on work capacity.

Bennet and McKay (2012) did a double blind; randomized controlled trial examined the effect of a 450ml blood donation on exercise performance and when performance returned to pre-donation levels. They had 13 young males complete a 20m multilevel shuttle test twice before and three times after blood was donated. They found that blood donation significantly affected maximal exercise performance up to eight days after donation but returns to normal by 22 days.

Judd, Cornsuh, Barss, Oroz, and Chilibeck (2011) studied moderately active individuals based on their VO_2 peak results. They wanted to find when peak power returned to normal levels. They measured VO_2 peak and exercise time to fatigue before and weekly for 4 weeks after the blood donation to determine time course of recovery. Time to fatigue and peak heart rate were not significantly affected by blood donation. They concluded that blood donation causes a significant decrease in VO_2 peak until the third week where it recovered to normal levels.

Ziegler et al. (2014) measured VO_2 peak, a 3km time trial, Hgb, and Hct before and 3,7,14, and 28 days post blood donation. The authors found that performance recovered 14 days after blood donation despite Hgb concentrations remaining lower than baseline during the same time period. Hemoglobin recovery has proven to depend on the individuals' prior iron levels, with recovery of Hgb and Hct levels ranging from 10-59 days (Pottgiesser et al., 2008). Fowler and Barer (1942) found that recovery can take anywhere from 23 to 98 days for Hgb and Hct levels to return to baseline.

The TT is a proven tool in multiple different studies for its practical use in numerous populations. It is correlated strongly with all the objective markers we use currently to prescribe exercise: VT , VO_2 , RCT, %HRR, % HR_{max} . Additionally, it is correlated with different methods of RPE. The populations we've seen correlations with include: trained individuals, sedentary adults, patients with ischemia, and in apparent healthy individuals. When performing the Talk Test, it can generally be assumed if you can speak comfortably, you are within guidelines of exercise intensity. It is apparent from the literature that blood loss decreases overall hemoglobin content of blood, lowers VO_2 max and lowers VT . These lower levels are significant for up to 3 weeks depending

on the individual. Although the TT is clearly a simple and cost effective method for prescribing exercise intensity, it would be of interest to know if the TT can track changes in exercise capacity in response to blood donation and during the recovery from blood donation.

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