Immediate effects of blood donation on physical and cognitive performance—A randomized controlled double-blinded trial

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BACKGROUND: The success of implementing damage control resuscitation principles pre-hospital has been at the expense of several logistic burdens including the requirements for resupply, and the question of donor safety during the development of whole blood programs. Previous studies have reported effects on physical performance after blood donation; however, none have investigated the effects of blood donation on cognitive performance.

METHOD: We describe a prospective double-blinded, randomized, controlled study comprised of a battery of tests: three cognitive tests, and VO_{2max} testing on a cycle ergometer. Testing was performed 7 days before blinded donation (baseline day), immediately after donation (Day 0), and 7 days (Day 7) after donation. The inclusion criteria included being active blood donors at the Haukeland University Hospital blood bank, where eligibility requirements were met on the testing days, and providing informed consent. Participants were randomized to either the experimental (n = 26) or control group (n = 31). Control group participants underwent a "mock donation" in which a phlebotomy needle was placed but blood was not withdrawn.

RESULTS: In the experimental group, mean ± SEM VO_{2max} declined 6% from 41.35 ± 1.7 mLO_2/(min·kg) at baseline to 39.0 ± 1.6 mLO_2/(min·kg) on Day 0 and increased to 40.51 ± 1.5 mLO_2/(min·kg) on Day 7. Comparable values in the control group were 42.1 ± 1.8 mLO_2/(min·kg) at baseline, 41.6 ± 1.8 mLO_2/(min·kg)) on Day 1 (1% decline from baseline), and 41.8 ± 1.8 mLO_2/(min·kg) on Day 7.Comparing scores of all three cognitive tests on Day 0 and Day 7 showed no significant differences ($p > 0.05$).

CONCLUSION: Our main findings are that executive cognitive and physical performances were well maintained after whole blood donation in healthy blood donors. The findings inform postdonation guidance on when donors may be required to return to duty. (*J Trauma Acute Care Surg.* 2018;84: S125–S131.

LEVEL OF EVIDENCE: Randomized, controlled, double-blinded prospective trial study, level 1.

KEY WORDS: Blood donation; physical performance; cognitive performance; walking blood bank; remote damage control.

For the last two decades, there has been a major shift in transfusion practices for patients experiencing traumatic hemorrhagic shock. The introduction of damage control resuscitation (DCR) has increasingly gained global acceptance.[1] Damage control resuscitation principles advocate for the early use of whole blood or blood components containing a balanced ratio of red blood cell concentrates, plasma, and platelets (reconstituted whole blood) together with the judicious use of clear fluids. The success of DCR has been at the expense of the logistic burden including the requirements for resupply.[2] The Norwegian Naval Special Operation Command initiated the Blood Far Forward research program in 2010. The aims of the program include improvement of battlefield survival through the development[3] and implementation of a whole blood program.[3,4] Clinical studies to research the effects of blood donation on performance are important to reach the goals of the program.

The DCR principles have been successfully exported to a wide range of communities, where emergency access to blood may be required, but logistical support is limited.[5] Examples include military special operations, humanitarian missions, remote industry, the cruise industry, scientific exploration, and hospitals or clinics located far from a blood bank with vulnerable logistical lines. Blood donors in this context may need to return to physically and mentally demanding duties soon after donation. Physical performance after blood donation has been previously investigated,[6–21] but none have used a randomized controlled design and most are small trials with a young and well-trained population. To further inform postdonation policy of returning to duty, trials with heterogeneous populations of well-motivated nonmilitary volunteer donors is needed.

While it is well known that VO_{2max} is correlated with executive functions,[22] we were unable to find any literature on cognitive performance immediately following blood donation.

Here, we describe a prospective double-blinded randomized controlled study comprising a battery of tests: three cognitive

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tests and VO_{2max} testing on a cycle ergometer. Our primary outcomes are cognitive test scores and maximum oxygen consumption. We hypothesized that donating one unit of blood would reduce VO_{2max} and that cognitive performance would be unaffected by the donation.

METHODS

Study Design

This study was performed at The University College in Bergen, Norway and led by a research group from Haukeland University Hospital, Bergen, Norway. The study was conducted in three parts, each a block of three weeks, between September 2016 and June 2017. Invitations to participate (approximately 1,500) were mailed and e-mailed to donors due for donation in the appropriate timeframe. In total, 68 responded and were available for testing. Of the eligible volunteers, 36 were randomly assigned to the control group and 32 to the test group.

The inclusion criteria included being active blood donors at the Haukeland University Hospital blood bank, complying with eligibility requirements on test days, and providing informed consent. Exclusion criteria were donor ineligibility, test failure, or unacceptable donation volume (<425 mL).

The trial was approved by the local ethics committee (Ref: 2014/1927/REK Vest).

Procedure

The participants were randomized to test or control group by coin flip. Both the participants and physical test operators were blinded to the randomization. Testing was performed 7 days before donation (baseline), immediately after donation (Day 0), and 7 days (Day 7) after donation. Upon arrival for physical testing, the participants were encouraged to eat a snack and to drink 0.5 L of soda or mineral water before exercise.

Donation Procedure

Donors were prescreened and required to drink 0.5 L of water before donation. All donors underwent venipuncture but were blinded to their procedure by placing their donor arm through a curtain to remove visual cues. Auditory clues were attenuated using a headset with music and the familiar noise of the agitator in the donation room. The personnel performing sham donation simulated a real donation by approximating time, checking the needle position, and encouraging instruction to squeeze a ball in their hand. In total, two 4-mL blood samples were drawn into Vacutainer EDTA Hemogard 4.5 mL (Becton Dickinson, Switzerland) on each day, totaling 24 mL of extra blood loss. Hemoglobin concentrations were measured by CELL-DYN 4000 (Abbott Laboratories, Abbott Park, IL, USA).

Donors then proceeded to cognitive and physical testing. Cognitive testing lasted for approximately 10 minutes, and the physical testing took approximately 25 minutes. Weight was obtained on Inbody 720 (BioSpace, Cerritos, CA, USA) immediately before physical testing. Upon completion of the physical testing, all candidates rested for 10 minutes while recording capillary lactate values. Then, the cognitive performance assessment on delayed memory was performed, and a final blood sample was collected.

Cognitive Testing

Trail Making Test

The test investigates cognitive processing speed and executive functioning,[23] and has two parts, A and B. The candidate is timed while drawing a line between numbers only (part A) and numbers and letters (part B). Time is measured and mistakes are corrected during the test, i.e., adding extra time.

Hopkins Verbal Learning Test (HVLT)

The Hopkins Verbal Learning Test (HVLT) examines both short-term memory (Part 1) and delayed memory (Part 2).[24] In Part 1, done before physical testing, the test operator reads a list of 12 words three times, and after each time, the candidate repeats as many words as he/she can remember. Delayed memory testing was done after physical testing. First, the candidate is asked to repeat as many of the words as he/she can remember from Part 1. Then the operator reads 24 words and the candidate is asked to discriminate between words from Part 1 and new words.

Stroop Test

This test measures the selective attention capacity and skills of an individual as well as their processing speed ability.[25] This test consists of three parts. First, the candidate verbalizes randomly ordered colored boxes in red, blue, and green. Second, the candidate reads a list of the words "red", "blue" and "green", shown in black font and random order. Finally, the candidate is timed while verbalizing the font color instead of reading the word when the font color and word do not match.

Physical Testing

Maximal oxygen consumption (VO_{2max}) was tested on a Lode Excalibur Sport ergometer (Groningen, The Netherlands) and measured using an Oxycon Pro apparatus (Jaeger GmbH, Hoechberg, Germany) with a mixing chamber. Heart rate (HR) was recorded using a Polar MH450 computer (Polar Electro OY, Kempele, Finland). The test began with a 10-minute warm up at 10 W then increased with 20 W for females and 30 W for males every minute until volitional fatigue. Maximal oxygen consumption was defined as the highest 1-minute average during the test. Baseline lactate and HR were measured during warm up. Lactate was also measured immediately after exercise, 5 minutes after exercise, and 10 minutes after exercise (Biosen C-Line, EKF Diagnostics system, Cardiff, UK). At the point of exhaustion, the candidates were instructed to sit still until the last lactate was measured. The VO_{2max} test was considered valid if two of the following three criteria were fulfilled: respiratory exchange rate greater than 1.1, capillary lactate greater than 8 mmol/L, or drop in VO_{2max}.[26]

Statistical Analyses

Suitable data to perform accurate power calculations were not available, as our test group was heterogeneous compared to inclusion criteria in previously published studies.[6–21] Statistical analyses were performed using the IBM SPSS Statistics Package Version 25.0 (IBM, Armonk, New York, USA). A Student t-test was used to compare differences between the groups. A paired t-test was used to analyze differences within groups, and the general linear model was used to analyze repeated measures. The

level of significance was set at $p < 0.05$. Results are reported as mean ± SEM unless otherwise mentioned.

RESULTS

Subjects

Baseline characteristics were similar between the control and test groups as shown in Table 1. In the control group (n = 31), one subject did not complete testing, three subjects dropped out for undisclosed reasons, and one subject reported an illness on a test day. In the intervention group (n = 26), three subjects dropped out for undisclosed reasons, two did not meet VO_{2max} test criteria, and one reported an illness on a test day. One adverse event was observed during donation and needle procedure, and one donor fainted after physical testing. The latter participant was excluded from further participation and analysis due to failure of reaching VO_{2max} test criteria.

Physical Testing

Maximal Oxygen Consumption

In the test group, mean VO_{2max} declined 6% from 41.35 ± 1.7 mLO_2/(min·kg) at baseline to 39.0 ± 1.6 mLO_2/(min·kg)$_)$ on Day 0, and increased to 40.51 ± 1.5 mLO_2/(min·kg) on Day 7. For the control group, the comparable values were 42.1 ± 1.8 mLO_2/(min·kg) at baseline, 41.6 ± 1.8 mLO_2/(min·kg) on Day 1 (1% decline from baseline), and 41.8 ± 1.8 mLO_2/(min·kg) on Day 7. There was no significant difference of mean relative maximal oxygen consumption comparing the two groups at any time point ($p > 0.05$). When performing within group analysis, the decrease from baseline to Day 0 within the test group was significant ($p < 0.001$) as was the increase from Day 0 to Day 7 ($p = 0.008$). No significant difference was observed between baseline and Day 7 ($p = 0.167$). The equivalent analysis in the control group did not show any significant difference. Results are shown in Figure 1.

TABLE 1. Baseline Characteristics and Performance and Comparison of Means Between the Two Groups

	Test Group		Control Group		
N, Total	**26 (100%)**		**31 (100%)**		
n, Females (% of group)	**9 (34.6%)**		**11 (35.5%)**		**Students t-test**
n, Males (% of group)	**17 (65.4%)**		**20 (64.5%)**		
	Mean	**SEM**	**Mean**	**SEM**	***p***
Age, y	41.1	1.6	42.4	1.55	0.589
Level of education (1–4)	2.85	0.19	3.29	0.16	0.052
Level of physical training (1–4)	2.15	0.14	2.23	0.15	0.727
BMI (weight/height^2)	27.2	0.92	27.1	0.56	0.958
Baseline [Hb], g/dL	15.1	0.26	15,0	0.17	0.692
Baseline $VO_{2\ max}$, mLO_2/(min·kg)	41.4	1.66	42.1	1.80	0.778
Baseline SCWI, score	54.4	2.19	48.5	1.65	0.033
Baseline TmB, score	65.7	7.61	55.6	3.13	0.195
Baseline H_{tot}, score	26.5	0.71	26.8	0.69	0.814
Baseline D_{mem}, score	9.7	0.29	9.5	0.34	0.641
Time from donation to VO_{2max}, minutes	33.1	2.08	29.5	1.45	0.156

$p < 0.05$ indicates significant difference between the two groups on baseline day. Hemoglobin concentration (Hb), Maximal Oxygen Consumption (VO_{2max}), Total score on HVLT (H_{tot}), score on delayed memory part of Hopkins Verbal Learning Test (D_{mem}), score on Trail-making part B (TmB), score on Stroop color-word interference (SCWI), and body mass index (BMI).

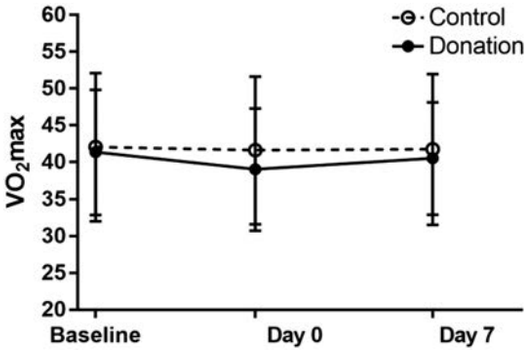

Figure 1. VO_{2max} is measured by mLO_2/(min·kg). The difference in VO_{2max} between control group and test group was not significant by Student *t*-test. Within-group comparisons in the test group showed a significant reduction from baseline to Day 0 ($p < 0.001$), and then a significant increase from Day 0 to Day 7 ($p = 0.008$). These variations were not seen in the control group.

Heart Rate

When comparing submaximal HR (on Levels 0–10) between the two groups by the general linear model, we observed a significant increase in HR on Day 0 ($f = 4.458$, $p = 0.04$); however, this difference was not present at baseline ($f = 0.504$, $p = 0.481$) or Day 7 ($f = 3.799$, $p = 0.058$) (Fig. 2).

The maximal HRs in the test group at baseline, Day 0, and Day 7 were 176 ± 2.0 beats per minute (bpm), 179.3 ± 2.5 bpm, and 177.7 ± 2.3 bpm, respectively. No significant difference was observed in maximal HR between the two groups on any test day ($p > 0.05$).

In addition, no significant differences were observed in the maximal HR within the test group across the test days ($p > 0.05$). In the control group, the comparable values at baseline, Day 0, and Day 7 were 179.3 ± 2.4 bpm, 177.2 ± 2.2 bpm, and 178.3 ± 2.5 bpm, respectively. No significant differences

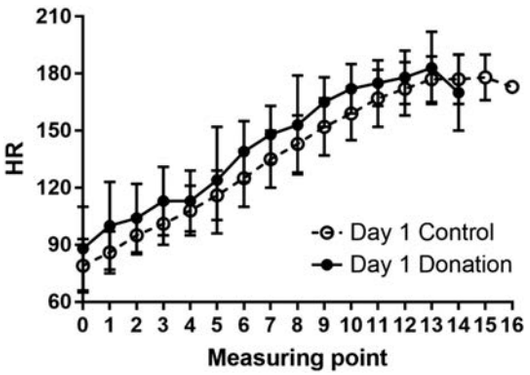

Figure 2. Heart rate (beats per minute) during stages 1 to 16 for the two groups on donation day. General linear model showed a significant difference between the two groups from levels 0 to 10 ($f = 4.458$, $p = 0.04$). Data are reported as mean HR with SEM from levels 0 to 16 on Day 1.

were observed in the maximal HR measurements of the control group.

Hemoglobin

After testing at baseline and Day 0, the hemoglobin concentration (g/dL) in test group was reduced from 15.8 ± 0.3 g/dL to 15.1 ± 0.3 g/dL, with a further decrease by Day 7 (14.6 ± 0.3 g/dL). In the control group, the equivalent measurements were 15.4 ± 0.2 g/dL at baseline, 15.2 ± 0.2 g/dL on Day 0, and 15.2 ± 0.2 g/dL on Day 7. There were no significant differences between the two groups on any test day with regard to posttest hemoglobin concentrations ($p > 0.05$). Within-group analyses of the test group demonstrate a significant decrease in serum hemoglobin from baseline to Day 0, with a further reduction on Day 7 ($p < 0.001$). As shown in Figure 3, analyses of the control group showed a significant decrease from baseline to Day 0 and baseline to Day 7, but no difference from Day 0 to Day 7.

Lactate

No significant differences were observed when lactate concentrations were compared between the test group and the control group at any of the three data collection points ($p > 0.05$).

However, lactate levels significantly increased in the test group on Day 7 compared to baseline after 0 minute (11.9 ± 0.5 mmol/L vs 10.9 ± 0.4 mmol/L, $p = 0.015$) and 10 minutes (11.6 ± 0.7 mmol/L vs 10.7 ± 0.5 mmol/L, $p = 0.04$). This change was not observed in the control group (data not shown).

Hopkins Verbal Learning Test

In the HVLT test, the total score (H_{tot}) and the delayed memory score (D_{mem}) are the most sensitive scores for disclosing reduced cognitive performance.[24] Comparing mean test results on each test day between the two groups did not show any significant differences ($p > 0.05$). The H_{tot} was reduced in the test group from baseline (26.5 ± 0.7) to Day 0 (26.3 ± 0.8), and improved on Day 7 (26.6 ± 0.8); however, these differences were not significant ($p > 0.05$). The D_{mem} in the test group was reduced from baseline (9.7 ± 0.3) to Day 0 (9.1 ± 0.4) and further reduced on Day 7 (9.0 ± 0.5) and were also not significant ($p > 0.05$). In the control group, H_{tot} decreased slightly over time (baseline, 26.77 ± 0.7; Day 0, 26.71 ± 0.6; Day 7, 26.2 ± 0.9), but these differences were not significant ($p > 0.05$). The D_{mem} in the control group increased from baseline to Day 0 (9.5 ± 0.3 to 9.7 +/0.3) and then decreased to Day 7 (9.1 ± 0.4). The increased score from baseline to Day 0 was not significant ($p > 0.05$), whereas the decreased score on Day 7 was significant compared to Day 0 ($p = 0.04$) but not to baseline ($p > 0.05$).

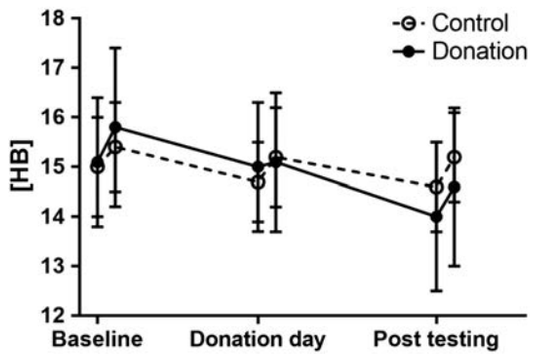

Figure 3. Mean hemoglobin concentration in gram per deciliter [Hb] with SEM before testing and after testing on each test day. A significant decrease is shown for [Hb] for the test group from baseline to Day 0 ($p < 0.001$) and from Day 0 to Day 7 ($p < 0.001$).

Trail Making

In the test group, time in seconds (s) on the trail-making test part B (TmB) significantly improved from baseline to Day 0 (65.7 ± 7.6 s to 52.3 ± 5.1 s, $p = 0.003$) and further improved on Day 7 (51.3 ± 4.3 s). While the latter improvement was not significant compared to Day 0 ($p > 0.05$), it was significant compared to baseline ($p = 0.006$). In the control group, we observed similar results with an improved time from baseline (55.6 ± 3.1 s) to Day 0 (50.9 ± 2.6 s) and to Day 7 (43.9 ± 1.8 s). While the improvement from baseline to Day 0 was not significant ($p > 0.05$), the improvement at Day 7 was significant compared to Day 0 ($p = 0.01$) and baseline ($p < 0.01$). No significant differences were observed between the test and control groups on each test day ($p > 0.05$).

Stroop

Color and word discrimination is the most sensitive portion of this test.[25] Time usage (in seconds (s)) on the color-word interference part of the Stroop test significantly improved in the test group from baseline (54.4 ± 2.2 s) to Day 0 (48.3 ± 1.9 s) ($p < 0.001$) and further improved on Day 7 (44.2 ± 1.8 s), $p = 0.001$. In the control group, we observed a trend toward improvement from baseline (48.5 ± 1.7) to Day 0 (46.4 ± 2.0) ($p = 0.066$) and further to Day 7 (41.7 ± 1.6) ($p < 0.001$).

Compared to baseline, the two groups performed significantly different on Day 0 ($p = 0.033$); however, on Day 7, there was no significant difference between the two groups ($p > 0.05$).

Results from cognitive tests are shown in Figure 4.

DISCUSSION

We found a 6% reduction of VO_{2max} from 41.35 ± 1.7 mLO_2/(min·kg) to 39.0 ± 1.6 mLO_2/(min·kg) immediately after blood collection, and this corroborates the results of others.[6–8,12–15] For example, in 1942, Karpovich and Millman[13] reported that aerobic endurance was more affected than anaerobic endurance after blood donation. In a recent study on female Danish blood donors, VO_{2max} was reduced by 7.3% and the trail performance was reduced by 5.2%.[12] Judd et al.[14] reported that 12 moderately active individuals (2 women and 10 men) demonstrated a significant reduction in VO_{2max} on Day 1 and Day 7 after donation. Similar, but more pronounced changes, were published from a study with a donation volume of 1 L.[6] We recently published the effects of blood donation on Norwegian Naval Special Operation Command soldiers after a 7-day course of strenuous exercise. We observed a significant reduction in maximal oxygen consumption in the test group.[15] With the exception of our

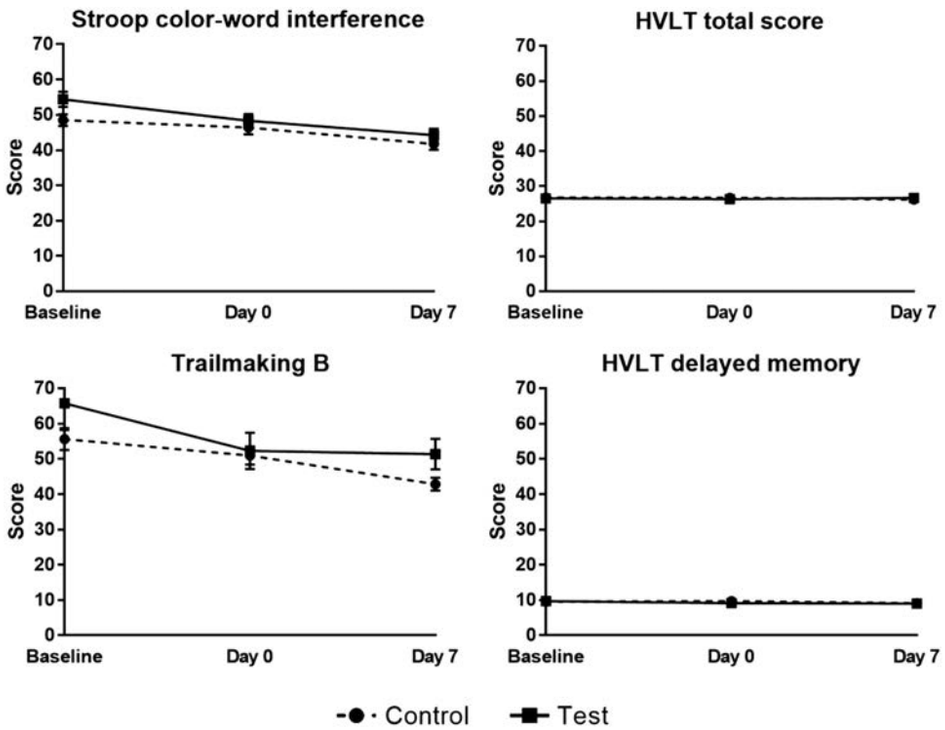

Figure 4. Mean scores on cognitive tests with SEM on each test day. No significant differences between groups on any test or test day, except for the Stroop test (color-word interference part) on Day 0 compared to baseline in test group.

previously published study, the current study is the only reported blinded study with a control group.

It is worth mentioning that reduced VO_{2max} after blood donation is not a universal phenomenon. We previously reported a study of elite soldiers and found no decrease in VO_{2max} immediately after donation of one unit of blood.[16] This could be explained by motivational aspects among the subjects and by their physical fitness. In 1963, Howell and Coupe performed a blinded study of physical performance within 30 minutes of a 500-mL blood donation. Using exercise tolerance time as the unit of measure, they found decreased performance in both groups. Their design was to mock blood draw from the control group; thus, all subjects believed that they were donating blood, and Howell and Coupe suggest that motivational aspects seemed to influence the results.[10]

Noakes[27,28] is currently advocating for a different way of understanding the limitations on physical performance in a central governor model, which implies that the brain limits VO_{2max} and ends exercise before there is catastrophic biological failure. Our previous findings, in conjunction with that of Howell and Coupe, are in support of Noakes's theory, but the leading model for understanding VO_{2max} is still based on cardiorespiratory limitations, where cardiac output is the relevant determinant for oxygen uptake. We base our discussion of physical performance results on cardiovascular physiology, i.e., the classic understanding of limitations of VO_{2max}.[29] The Fick Principle explains the cardiovascular compensatory mechanism and limiting factors of cardiac output to be determined by recruitment of blood volume from capacitance vessels combined with increased inotrope and chronotrope activity of the heart.[30] Due to the short timeframe of testing, other determinants of VO_{2max}, such as metabolic adaptations and mitochondrial enzyme activities, were less relevant than the cardiovascular mechanisms.[31]

Heart Rate

Oxygen demand from tissues should theoretically be similar at corresponding levels of the ergometer test on any given test day. According to the Fick Principle, increased HR is a compensatory mechanism for reduced blood volume to obtain a satisfactory cardiac output. In the current study, we report an increased HR on submaximal performance levels after blood donation (Day 0), which corresponds with the Fick Principle and other publications.[6,8]

Similar to previously published results,[14] we did not find any differences in maximal HR within or between the two groups before and after blood donation. This could be explained by physiological limits of the compensatory mechanisms toward the end of the test; maximal volume is recruited from the capacitance vessels and maximal inotrope/chronotrope effects of the heart is applied; thus, we see a reduced capacity of delivering blood to the tissues, i.e., reduced VO_{2max}, rather than a further increased HR.

Hemoglobin Concentration

It is well documented that blood volume recovers faster than serum hemoglobin levels.[11,17–20] Hemoglobin concentration did not change on Day 0 but significantly decreased on Day 7. This corresponds with previous findings that hemoglobin concentrations are not reduced at 2 hours after donation but reduce significantly 2 days after donation.[7] This is also in alignment with findings by Christensen and Christensen[6] and Stangerup et al.[12]

We collected postdonation blood samples after VO_{2max} testing, with a mean time from donation to blood sampling of 53 ± 7 minutes in control group and 52 ± 9 minutes in the test group, which was not significantly different. This short timeframe and the test itself, which is strenuous and acts as a hemoconcentrator, counteracts the ongoing hemodilution process after donation[32] and could reasonably explain the lack of hemoglobin reduction in the test group on Day 0. The significant difference in hemoglobin between Day 0 and Day 7 is in line with previously published data, and could have resulted as a consequence of restored blood volume.

Lactate

In the test group, we observed an increased lactate concentration 0 and 10 minutes, but not 5 minutes after testing on Day 7. We did not find any differences after testing on Day 0. A previous comparison on effects of plasma versus whole blood donations found decreased anaerobic capacity and capillary lactate concentrations 2 hours after testing in plasma group versus no change in the whole blood group. Seven days after donation, they found no difference in lactate or anaerobic capacity in either group. The authors suggest that decreased anaerobic capacity 2 hours after donation could be explained by a decreased buffer capacity in the blood due to the loss of bicarbonate in plasma donations.[7] Our observations of increased lactate on Day 7 but not on Day 0 contradict the observations of Hill et al. We suggest that our findings can be explained by a reduced buffering capacity of the blood due to the reduced hemoglobin concentration present on Day 7. The lack of increased lactate 5 minutes after donation on Day 7 remains unexplained.

Cognitive Performance

We did not identify any reports documenting adverse cognitive effects of blood donation. The best evidence for blood donation safety is from the recent INTERVAL study of more than 45,000 donors, demonstrating that self-reported outcomes, including cognitive function, were unaffected by donation.[33] However, the INTERVAL study investigated long-term effects of blood donation as opposed to our investigation of acute effects, reducing the transferability to our trial. Our testing schedule used a battery of directly observed tests designed to identify deficits in cognitive function (e.g., after minor cerebral injuries). These techniques have been validated in a variety of clinical settings, for example, the Stroop test has been used to detect changes in patients with HIV,[34] Huntington disease,[35] and effects obtained by placebo.[36] Furthermore, cardiorespiratory fitness is positively correlated with improved executive functioning.[22] It is unclear whether a sudden decrease of VO_{2max} will affect executive functioning. Our results demonstrate a reduction in VO_{2max} but not a reduced level of cognitive functioning.

In the HVLT test, there were no differences between or within test groups on any test day. This result, in combination with a self-assessment score on alertness on each testing day, suggests that a standard blood donation does not affect test results on the HVLT immediately or 1 week after donation.

In the Stroop test, we found a significant difference between the two groups at baseline that was not present on Day 0 or Day 7. Both groups subsequently performed better on each test, indicating a learning effect rather than an effect of the donation.

Similarly, the Trail Making test showed an improvement each day, which could potentially be explained by a learning effect.

LIMITATIONS

This was a small study of well-motivated regular volunteer blood donors, and the results cannot be extrapolated to the general population. However, the controlled and sophisticated design of the experiments makes the results relevant to future blood donor studies. Male and female donors were able to complete the physical tests. The subjects were not allowed to familiarize themselves with the physical testing, as earlier studies on treadmills have shown that this could result in a positive effect on performance.[37]

The subject group is highly heterogeneous, which allows for several confounders, particularly the broad range of age and fitness level. The two groups were compared after randomizing for the following confounders: age, time since last meal, strenuous physical activity the day before each test day, tobacco use, level of education, physical training habits, and a subjective grading (0–10) of alertness on each test day. We were not able to measure cerebral blood flow in our design. The recruitment strategy implies a possibility for self-selection bias, and we did not compare results with a group of athletes. Power analysis was not performed due to lack of available data, which is an important limitation with regard to cognitive performance testing. We report one adverse event during donation and one during venipuncture. One donor fainted immediately after physical testing. We were unable to determine whether this was related to exertion or donation.[38] Postdonation complications can include both immediate and delayed fainting. All efforts should be made to mitigate postdonation fainting, and postdonation restrictions may be advisable in certain occupational groups.

CONCLUSION

Our main findings indicate that executive cognitive and physical performances are maintained after whole blood donation in healthy blood donors. The findings inform postdonation guidance where donors may be required to return to physical or cognitive demanding tasks.

AUTHORSHIP

All authors participated in data interpretation and article preparation. HSE, TH, VVI, MK, AG, TF, CKB, HD, and GS conceived the study design. HSE, TH, AG, and HD performed the literature search. Data collection was performed by HSE, JSB, JS, VVI, and MK collected the data. HSE, JSB, JS, VVI, MK, AG, and TA analyzed the data.

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DISCLOSURE

The authors declare no conflicts of interest.

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