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SUPPLEMENT ARTICLE

TRANSFUSION

Minimal tactical impact and maximal donor safety after a buddy transfusion: A study on elite soldier performances in both laboratory and field environments

Julie Degueldre[1,2,3] | **Emilie Dessy**[3] | **France T'Sas**[1] | **Véronique Deneys**[2] | **Nathalie Pattyn**[3,4]

[1]HRMA, Military Medical Laboratory Capacity, Brussels, Belgium

[2]UCL, Cliniques Universitaires Saint Luc, Université Catholique de Louvain, Brussels, Belgium

[3]VIPER Research Unit, Royal Military Academy, Brussels, Belgium

[4]Human Physiology Department, Vrije Universiteit Brussel, Brussels, Belgium

Correspondence
Julie Degueldre, HRMA—Military Medical Laboratory Capacity, Rue Bruyn 1, 1000 Brussels, Belgium.
Email: julie.degueldre@mil.be

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Abstract

Background: The major causes of death of combat casualties in austere environments are related to hemorrhage and occur early after injury. The implementation of a walking blood bank may overcome the logistical issues raised using blood component therapy. Nonetheless, it is important to ensure that this buddy transfusion is not going to compromise the mission success by altering the donor's performance. The results available so far cannot rule out this issue with certainty. Therefore, this study aimed at investigating the immediate effect of a 450-ml blood donation on the performances of elite soldiers in laboratory and field environments.

Study design and methods: This double-blind, randomized controlled study included two experiments. For both experiments, subjects were randomly assigned either to a control group ($n_1 = n_2 = 7$) or to a 450-ml-blood-bag donation group ($n_1 = 7$ and $n_2 = 8$). All participants underwent before and after a potential blood donation a multifactorial assessment including adapted physical tasks, hematological variables, vigilance parameters, and subjective assessments.

Results: No significant results were evidenced in this study. There was no impact of blood donation on the participants' performances in both the hospital and the combat-like environments.

Conclusion: From a donor's point of view, a 450-ml blood donation has no impact on the required abilities of our elite soldiers to fulfill a demanding tactical mission. Thus, the results of this study support the fact that buddy transfusions could be part of the operational clinical armamentarium in austere environments for elite soldiers when no blood components are available.

KEYWORDS

buddy transfusion, donor safety, performance, walking blood bank, whole blood

Abbreviations: ANOVA, Analysis Of Variance; d', Cohen's d; η^2, Partial eta-squared; PVT, Psychomotor Vigilance Task; RT, Reaction Time; SF, Special Forces; SFGP, Special Forces Group; SPSS, Statistical Package for the Social Sciences; UZ-Brussel, Universiteit Brussel; VAS, Visual Analog Scale; VO_2Max, Maximal oxygen uptake/consumption; VUB, Vrije Universiteit Brussel; WB, Whole Blood; WBB, Walking Blood Bank.

1 | INTRODUCTION

Hemorrhage is the leading "preventable" cause of death from combat injuries.[1,2] Survival rates in the hemorrhaging patient depend on rapid and adequate management of the patients[3] as well as early initiation of balanced resuscitation.[4] Unfortunately, most of them die before reaching a Military Treatment Facility.[5] Therefore, the immediate availability of blood in prehospital conditions can save life and improve prognosis. However, blood supply and storage in austere environments remains an important logistical challenge. To compensate the unavailability of blood components in exceptional operational circumstances, on-site collection of whole blood (WB) from a "buddy" deployed on the same site[6] is successfully used in operational settings.[7] This method is known as a walking blood bank (WBB).

Because of the well-known biological advantages of WB and the logistical issues raised using components, most of the North Atlantic Treaty Organization countries are developing their own WBB procedures in accordance with their national requirements. This is also the case in Belgium; we are currently developing WBB guidelines to aid our medical staff deciding when to trigger a buddy transfusion while having minimal tactical impact and ensuring maximal donor safety. Therefore, we study the Belgian Special Forces (SF) operators, our most exposed and at-risk population, to evaluate the effect of a blood donation on their vigilance and physical performances. This study aims at guaranteeing that our SF operators will still be able to fulfill their mission and return to a safe place.

To fulfill this objective, we focus on the immediate effect of a 450-ml blood donation (i.e., a standard blood donation) on physical performance, vigilance, hematological parameters, and psychological aspects (e.g., stress, fatigue, well-being) of SF operators. Over the past few decades, a few studies have arisen in the literature investigating some of these parameters among a military population.[8–10] With regard to vigilance, no effects of the blood donation were reported.[11] Yet, several studies reported a detrimental effect of standard blood donation on physical performance in a laboratory environment.[9,11–13] These studies reported that standard blood donation reduced hemoglobin level, maximal oxygen uptake (VO_2max), and maximal exercise capacity in a laboratory environment.[9,11,12] Unfortunately, only a few studies investigated the effect of a standard blood donation on performance in field scenarios.[8,9] These studies showed that the combat abilities of the participants are preserved immediately after a 450-ml blood donation.[10] However, a recent meta-analysis highlighted important limitations in these studies, precluding the possibility of establishing a clear effect of blood donation on performance.[12] Indeed, all these studies used different populations, procedures, designs, or/and variables.[12] Thus, the results were not readily transposable to the operational world for such a specific population. Indeed, the increased circulating blood volume of our highly trained SF operators[14] could decrease the visible impact of the donation on performance.[9]

We aim to evaluate precisely the potential immediate impact of the donation on the SF operators' performances in two different setups. First, we conduct a study in a laboratory and secure environment in order to verify the results of the literature. Then, we study our target population in an ecologically valid environment (i.e., a field exercise in a desert environment) to ensure the transferability of our results to real-life operational settings. In each setting, we evaluate in a double-blind randomized controlled experiment, the effect of a single 450-ml blood donation through a multifactorial assessment including hematological parameters, vigilance, and physical performance measures. Moreover, even if psychological parameters such as the expected effect of the blood donation were ignored in previous research studies, we consider these factors in both setups as they could significantly impact the participant's performance[15] through placebo effects.

2 | MATERIALS AND METHODS

This double-blind, randomized controlled study consisted of two distinct experiments, first in a laboratory setting and then in the field. The study was approved by the Medical Ethics Committee of the University Hospital (UZ-Brussel) and the Vrije Universiteit Brussel (VUB) (B.U.N.: 143201835663). All participants provided written informed consent. The article was written and edited according to the Consolidated Standards of Reporting Trials statement. The study was made in accordance with the guidelines for good clinical practice and the Declaration of Helsinki. No changes to trial design and methods were made following trial commencement.

2.1 | Study design

There were 14 Belgian male SF operators included in the laboratory experiment and 15 in the field experiment. Participants received an oral and written explanation concerning the study and, if they expressed a wish to participate in the study, they signed an informed consent. Inclusion and exclusion criteria as well as criteria for discontinuation of the study are provided in Table 1.

TABLE 1 Inclusion, exclusion, and discontinuation criteria

Inclusion criteria	Physically active operator of the Belgian Special Forces who volunteer to participate in the study. Military operational (i.e., Med Ops cat A) according to their yearly medical examination at the military hospital. Medically fit to donate blood (based on their medical questionnaire and measurement of vital signs). Right after a strenuous training period for both experiments.
Exclusion criteria	Does not meet blood donation criteria (according to Belgian law for blood donation). Donated blood within the last 3 months. Takes antihypertensive therapy. Suffers any physical injuries before the start of the study.
Discontinuation criteria	Any medical condition or physiological reaction that arises during testing deemed unfit by the supervising medical doctor. Decision of the participant to interrupt his participation.

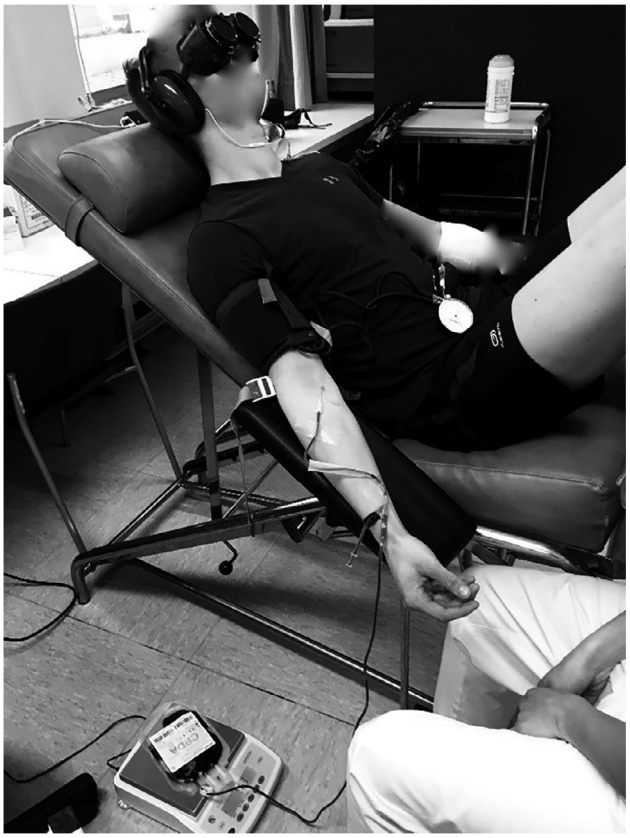

FIGURE 1 During the blood donation, the participant was lying down with his legs raised and his arms alongside the body. He wore blacked-out goggles and noise-canceling headphones while listening to his favorite playlist for approximatively 10 min. This specific setup ensured that he remained blind about his group attribution. The most suitable arm was chosen to setup the sterile single collection bag and start the blood donation. Control group participants donated a small blood sample (5–10 ml) while donation group participants gave a 450-ml blood bag. The collection bag was placed on a scale to guarantee that the same amount of blood was collected from each participant (approximately 475 g)

For both experiments, subjects were randomly assigned either to a control group or to a donation group under the supervision of the study coordinator. To avoid compensatory mechanisms and the potential effect of blood loss awareness, participants wore blacked-out goggles and earmuffs during the blood donation (see Figure 1). Moreover, the field researchers who collected the data were not aware of the group distribution, as the donation procedure was conducted by a different team. All the materials and procedures were identical among both groups to guarantee a double-blind design. Moreover, all the instruments were calibrated, controlled, and used according to the manufacturers' requirements.

The laboratory experiment took place in the military hospital Queen Astrid, Neder-Over-Heembeek, Belgium. The field experiments took place during an exercise abroad under similar conditions to those experienced in operations (e.g., gear, climate). All participants underwent a multifactorial assessment including measures of hematological parameters, vigilance, and physical performances as well as subjective assessments. Only physical performance measurements differed between both experimentations. During the laboratory experiment, the potential effect of blood donation on performance was determined by comparing the results of the baseline with the results of the postdonation measures (see Figure 2). During the field experiment, the population performed one strenuous ecologically valid physical task (i.e., the warrior competition) after the blood donation (see Figure 3).

2.2 | Outcomes

As the main study objective was to assess the impact of a 450-ml blood donation on tactical capacity, and thus

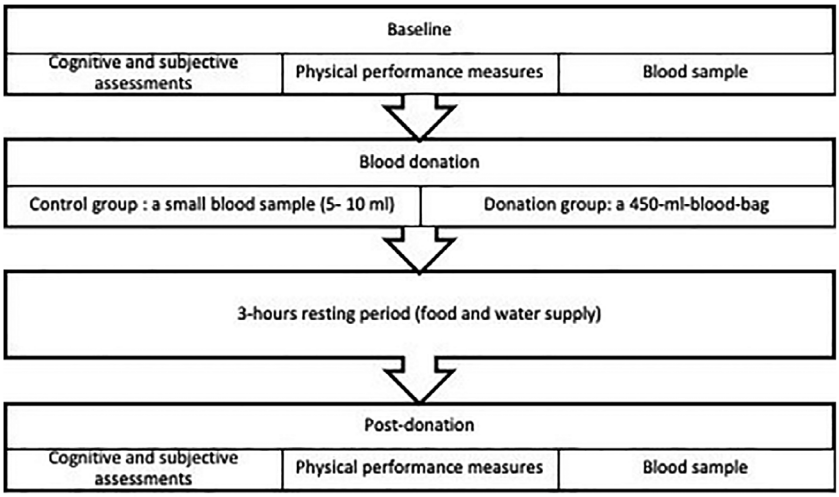

FIGURE 2 Summary of the testing sequence followed by each participant of the laboratory experiment in the Military Hospital. At their arrival, participant received detailed information about the experimental setup and the planning of the day, and they filled in the first subjective questionnaire. Then, they were interviewed by the doctor responsible for the blood collection to attest that they were fit to be a blood donor. Once the medical interview was finished, blood samples were collected. Then, participants performed the baseline psychomotor vigilance task (PVT) as well as the first incremental graded exercise tests until exhaustion. At the end of the first exercise test and before the blood donation, participants filled in a second subjective questionnaire and performed a second PVT. For the blood donation, control group participants donated a small blood sample (5–10 ml) while donation group participants gave a 450-ml blood bag (see Figure 1). A 3-h resting period followed the blood donation. During this period, participants must drink at least 500 ml water and performed a standardized intellectual assessment with a trained psychologist in the framework of a unit's internal project, completely independent from our study. After the resting period, they performed their second exercise test followed by the last PVT. They finished the assessment by filling in a third subjective questionnaire and a last blood sample was drawn

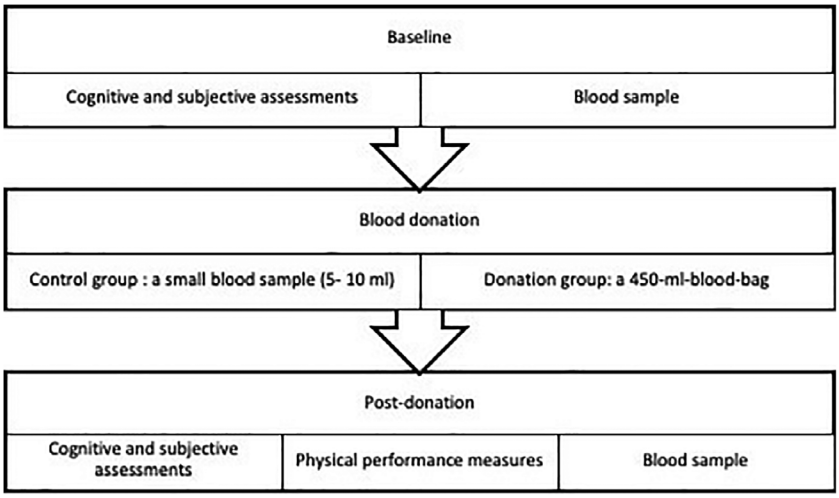

FIGURE 3 Summary of the testing sequence followed by each participant of the battlefield experiment. Upon their arrival, participant received detailed briefing about the study and explanation about the tasks of the day. Then, they were interviewed by the doctor responsible for the blood collection to attest that they were fit to be a blood donor. Once the medical interview was finished, blood samples were collected, and participants filled in their first subjective questionnaire. Before starting the blood donation, participants performed the baseline psychomotor vigilance task (PVT). For the blood donation, control group participants donated a small blood sample (5–10 ml) while donation group participants gave a 450-ml blood bag in a double-blind setup (see Figure 1). Then, participants started directly after blood donation the strenuous military circuit (i.e., the warrior competition), which was followed by the second PVT as well as a subjective questionnaire. Finally, a last blood sample was drawn

vigilance and physical performance right after a strenuous training period, these criteria were defined as the primary outcomes while subjective assessments and hematological variables were considered secondary outcomes.

2.2.1 | Blood parameters

The 5-ml venocapured blood samples were collected at the start and at the end of the testing day in both experiments. Unfortunately, due to logistical problem, these samples were not analyzed for the laboratory experiment. For the field experiment, blood parameters were immediately measured on an i-STAT handle analyzer with the chemistry (Chem8+) and the blood gas (CG4+) cartridges (ABBOTT, Chicago, IL).

Blood donation

Blood donation procedures were the same in both experiments. Upon arrival, the doctor responsible for the blood collection evaluated all the participants. He performed a medical interview through a standardized blood donor questionnaire to verify the participant's eligibility to be a donor as required by Belgian law. Moreover, the doctor also assessed their vital parameters (including body mass and height) to attest that they were fit to donate blood and could be included in the study. Then, participants were randomly assigned to either a control group or a donation group. Control group participants donated a small blood sample (5–10 ml) while the others gave a 450-ml blood bag. Every participant was connected to a sterile single collection bag with anticoagulant solution adequate for whole blood (i.e., citrate phosphate dextrose-adenine) (TERUMO BCT Inc.).

2.2.2 | Vigilance and subjective assessments

The 10 min-computerized Psychomotor Vigilance Test (PVT) recorded reaction times (RT) to visual stimuli that occurred at random inter-stimulus intervals.[16] Participants were instructed to monitor a screen and click as fast as possible once a millisecond counter appeared in the box and starts incrementing (from 0 to 1000 ms). Reaction speed, lapses (reaction time over 500 ms), and misses (missed stimuli) were recorded. This vigilance test was performed three times, before and after each physical task.

At the beginning of each experiment, participant rated their subjective levels of stress, mood, alertness, mental, and physical fatigue, as well as the quality of the previous night on a 10-cm visual analogue scale (VAS). After each physical evaluation, participants rated again on a VAS their subjective levels of physical and mental well-being, muscle pain, training intensity, stress, mood, alertness, mental, and physical fatigue. Scores ranged from 0 to 100, as physically measured on the VAS. A higher score indicated a greater intensity of the subjective feeling being measured.[17–19] At the end of both experiments, participants were asked about the eventual impact of the blood donation on their vigilance and physical performances, the perceived side-effects as well as if their evaluation regarding whether they were in the donation or the control group.

2.2.3 | Physical assessment

Laboratory experiment

Two incremental graded exercise tests until exhaustion[20] were performed, with 3 h of rest in between, in the Sports lab of the Military Hospital under medical supervision. One hour before each test, the participants received a standardized meal. The exercise test was performed on a treadmill associated with an exercise testing system (Ergocard Clinical, Medisoft, Belgium) according to a protocol specially designed and currently used at the exercise lab for the SF population. The protocol started at 5.4 km/h and consisted of 3-min stages at increasing running speeds, with an increase of 1.8 km/h and with a total maximum speed of 23 km/h. Treadmill inclination was kept constant at 0% for all the candidates. At the completion of each stages, blood was drawn from the right fingertip to evaluate blood lactate concentration; moreover, the maximal heart rate (HR) was determined using a HR monitor linked to the computer (Polar Sporttester, Kempele, Finland). The exercise was stopped when participants reached complete exhaustion. Gas exchange data with the candidate's oxygen intake and carbon dioxide output were measured using an automated breath-by-breath system (Ergocard Clinical, Software Medisoft, Belgium). After the test, the relative maximal oxygen consumption (VO_2max) was transcribed from the report of the device.[20]

Field experiment

Physical performance was evaluated, after the blood donation, by a strenuous military circuit (i.e., the warrior competition) while carrying approximately 27 kg of personal equipment and weaponry. Participants were involved in a competition throughout all the circuit. They had to perform as fast and as accurately as possible all the following tasks: a basic obstacle run, a 25 m-shooting range, a 100 m-shooting range, an 8-storey climb of a commando tower, a rappelling descent, and a close quarters battle house run, as well as an urban climbing parkour. In our study, we considered the score computed by the instructors based on the individual results on each task, the time to perform the obstacle run, and the score obtained for each shooting task. Moreover, the HR was determined at rest and within a

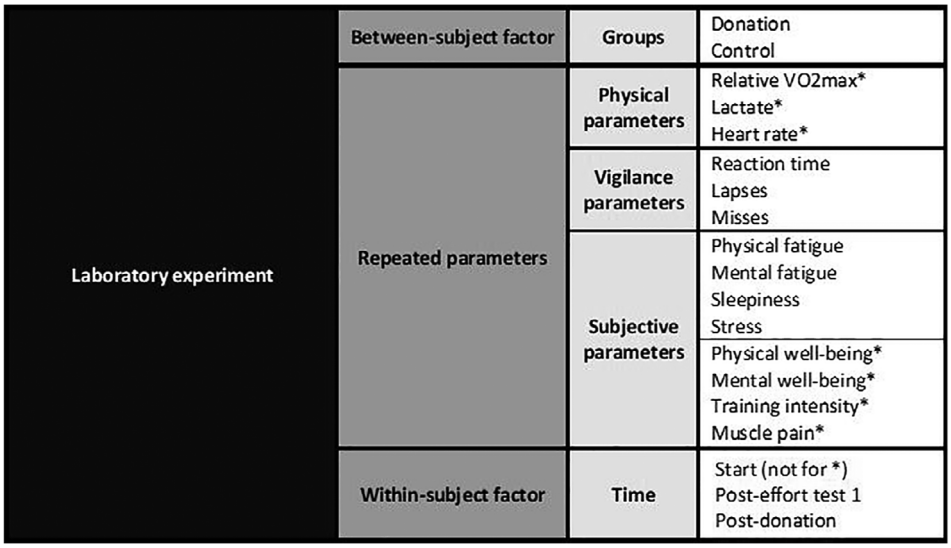

FIGURE 4 Overview of all laboratory experiment variables included within the statistical analyses and the results section

3-min interval after finishing the circuit using a fingertip pulse oximeter (Onyx II, Nonin, Minneapolis, MN).

2.3 | Statistical analysis

All statistical analyses were performed using IBMS Statistical Package for the Social Sciences (SPSS, Chicago, IL) version 25.0 for Windows. For all statistical tests, statistical significance was accepted at the $p \leq .05$ level. Partial eta-squared (η^2) and Cohen's d (d') were used to measure the effect size.

Regarding the laboratory experiment, a 3 (Time [start, post-effort test 1 and post-donation]) × 2 (Group [control and donation]) mixed ANOVA, with Time as within-subjects factor and Group as between-subjects factor, was used to test the results of the repeated parameters (see Figure 4). To investigate the difference between the measures of the other repeated subjective parameters of the two groups (i.e., non-donor vs. donor), a 2 (Time [post-effort test 1 and post-donation]) × 2 (Group [control and donation]) mixed ANOVA with time as within-subjects factor and Group as between-subjects factor when the assumptions of normality and homogeneity were met (see Figure 4). Greenhouse–Geisser epsilon corrections were used when sphericity was violated. The assumptions of normality (Kolmogorov–Smirnov with a Lilliefors significance correction) and homogeneity (Levene's test) were tested before performing these statistical analyses.

With regard to the field experiment, a parametric independent-samples t-test (two-tailed) was used to investigate the difference between the measures of the physical parameters as well as the nonrepeated subjective parameters of the two groups (see Figure 5). Moreover, the repeated parameters were tested using a 2 (Time [pre, post]) × 2 (Group [control and donation]) mixed ANOVA (see Figure 5). Time was used as within-subjects factor and Group as between-subjects factor. Greenhouse–Geisser epsilon corrections were used when sphericity was violated. These statistical analyses were performed as the assumptions of normality and homogeneity were met. When the assumptions of normality and homogeneity were not met, scores on pre- and post-test were compared for each group separately using a nonparametric Wilcoxon signed-rank test.

3 | RESULTS

3.1 | Laboratory experiment

One participant of the donor group was injured and was not able to perform the physical and vigilance assessments; therefore, he was excluded from all the analysis. The ANOVA analysis of physical parameters during the laboratory experiment revealed only a significant decrease over time for the variable relative $V0_2max$ [F (1, 12) = 7.455, p = .018, η^2 = 0.383]. No significant interaction effect between time and group was evidenced for any of the physical parameters (see Table 2).

Regarding the vigilance assessment, data recording on the PVT was problematic for two participants, they were excluded from the analysis ($n_{\text{non-donor}} = 6$ and $n_{\text{donor}} = 6$). The ANOVA analysis of vigilance during the laboratory experiment revealed only a significant main effect of time for the variable reaction time [F (2, 20) = 4.101, p = .0327, η^2 = 0.291] (see Table 2). However, no other significant effects were evidenced.

The analysis of the four subjective measures (i.e., physical fatigue, mental fatigue, sleepiness, and stress) with independent samples t-tests showed no significant differences between both groups at the start of the experiment. The ANOVA analysis of these four repeated

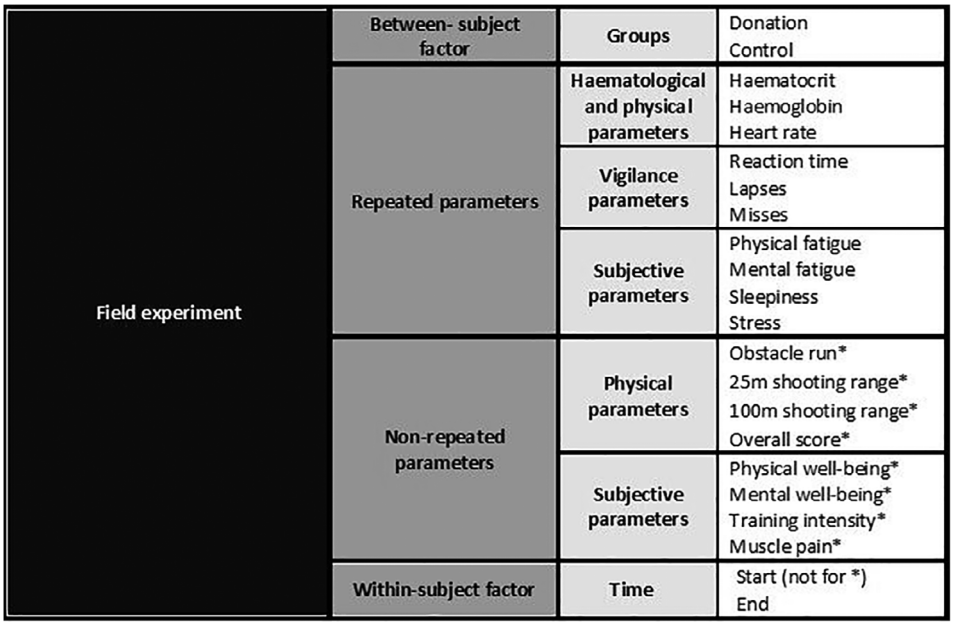

FIGURE 5 Overview of all field experiment variables included within the statistical analyses and the results section

TABLE 2 Means and SDs for the physical, vigilance, and subjective parameters during the laboratory experiment

		Start		Posteffort test 1		Postdonation	
Parameters	**Measures**	**Control ($n = 7$)**	**Donation ($n = 7$)**	**Control ($n = 7$)**	**Donation ($n = 7$)**	**Control ($n = 7$)**	**Donation ($n = 7$)**
Physical parameters	Relative VO_2-max (ml/kg/min)	—	—	54.38 (4.79)	53.96 (7.66)	53.30 (3.79)	49.81 (6.63)*
	Maximal heart rate (beats/min)	—	—	196.86 (3.29)	198.14 (13.21)	197.43 (4.83)	197 (11.27)
	Lactate (mmol/L)	—	—	9.52 (1.89)	9.13 (3.14)	9.41 (1.16)	7.63 (1.92)
Subjective parameters	Physical fatigue	40.31 (24.83)	55.82 (19.69)	35.74 (19.15)	52.65 (20.08)	57.74 (13.02)	49.20 (22.42)
	Mental fatigue	36.90 (24.95)	27.59 (20.45)	23.24 (21.19)	35.76 (19.84)	33.25 (25.13)	38.58 (27.50)
	Sleepiness	35.40 (10.57)	33.77 (20.94)	32.14 (26.7)	39.15 (22.89)	37.40 (24.33)	32.06 (28.40)
	Stress	13.37 (12.34)	15.63 (8.94)	12.43 (17.79)	19.61 (5.82)	11.28 (14.34)	14.02 (10.47)
	Physical well-being	—	—	65.86 (17.01)	63.93 (18.07)	67.13 (18.44)	68.91 (27.89)
	Mental well-being	—	—	84.99 (16.51)	81.52 (7.99)	85.43 (14.74)	80.02 (8.76)
	Training intensity	—	—	75.98 (10.36)	61.10 (21.29)	69.46 (12.92)	63.74 (20.08)
	Muscle Pain	—	—	29.75 (25.86)	3.99 (25.21)	27.81 (27.81)	46.18 (27.89)
Cognitive parameters	Reaction time (ms)	298.95 (18.51)	298.06 (18.01)	296.43 (21.77)	297.60 (24.65)	304.23 (23.81)	311.88 (34.07) *
	Lapses	1.50 (1.52)	0.33 (0.52)	2.17 (1.94)	0.67 (0.82)	1.33 (1.97)	1 (1.09)
	Misses	0.33 (0.52)	0 (0)	0.17 (0.41)	0 (0)	0 (0)	0 (0)

Note: Values are mean (SD).
The symbol * indicates that there was a significant difference in the statistical analysis.

subjective parameters during the laboratory experiment revealed no significant main effect of time or interaction effect between time and group. The analysis of the four subjective measures at the end of each effort test (i.e., physical well-being, mental well-being, training intensity, and muscle pain) showed no significant main effect of time or interaction effect between time and group (see Table 2). Moreover, only two out of the seven donors correctly indicated being part of the donor group (see Table 3). These two candidates were the only one to report a minor effect (average of 12,44%) of the blood donation on their physical performance.

TABLE 3 Crosstab representing the real group distributions versus the participant's expectations in laboratory experiment

		Participant expectations		
		Control	Donation	
Real group distributions	Control	4	3	7
	Donation	5	3	8
		9	6	

Note: Values are number of subjects (n).

3.2 | Field experiment

Four independent-samples t-test were conducted to evaluate the impact of the 450 ml blood donation on the physical performance during the field experiment. No significant differences were evidenced between the nondonor and the donor groups. However, the nondonors obtained a better performance than the donors in both the obstacle run and the 25-m shooting range while the donors performed better than the nondonors for both the overall score and the 100-m shooting range (see Table 4).

The ANOVA analysis of vigilance parameters during the field experiment revealed no main effect of time and no significant interaction effect between time and group.

Hematological parameters were not normally distributed; therefore, two nonparametric Wilcoxon sign-rank tests were performed. These tests indicated that post-test ranks for the donor group were significantly lower than the pretest ranks for hematocrit ($Z = -2456$, $p = .014$) and for hemoglobin ($Z = -2388$, $p = .017$) while no differences were evidenced for the nondonor group.

The analysis of the four subjective measures at the start of the experiment with independent-samples t-tests showed significant differences between both groups for the mental fatigue level (t (13)$= -3.286$, $p = .006$, $d' = 1.701$), the physical fatigue level (t (13)$= -2.875$, $p = .013$, $d' = 1.488$), and the stress level (t (12) $= -2.875$, $p = .014$, $d' = 1.528$). The donors reported to be significantly more stressed and mentally and physically tired than the nondonor group at the start of the experiment (see Table 5). The ANOVA analysis of the four repeated subjective parameters during the field experiment revealed only a significant main effect of time for the physical fatigue [F (1, 12) $= 8.016$, $p = .01$, $\eta^2 = 0.40$] and the sleepiness [F (1, 12) $= 7.454$, $p = .018$, $\eta^2 = 0.383$]. However, no significant interaction effect between time and group has been evidenced. The analysis of the four subjective measures at the end of the testing day showed no significant differences between both groups. Moreover, only three out of the eight donors correctly indicated to be part of the donor group (see Table 6). These three candidates were the only one to report a minor effect (average of 19.33%) of the blood donation on their physical performance.

4 | DISCUSSION

Our double-blind randomized controlled study examined the immediate impact of a 450-ml blood donation on SF donor performances in two distinct experiments: a laboratory experiment and a field experiment. In each trial, participants were randomly assigned to either a control group or a donation group. Then, they were submitted to a multifactorial assessment including hematological measures, vigilance, and physical performance measures as well as subjective assessments. This study aimed at evaluating precisely the potential immediate impact of the donation on the SF operators' performances. First, we analyzed the results of the laboratory experiment to confirm the assumptions of the literature and to guarantee the safety of the participants for a blood donation in an operational-like environment. Indeed, to the best of our knowledge, no double-blinded randomized controlled study so far has examined the effects of a blood donation after a strenuous battle-like task in this context. This is why we adapted the settings for the field experiment.

Regarding the hemoglobin and hematocrit, even if technical reasons prevented us from analyzing the blood samples in the laboratory setting, the analysis of the field data evidenced only significant immediate effect of the 450 ml donation in the donor group. Our results were consistent with the literature[13,21] even if other studies focused only on the effect 24 h after donation.[13,21]

With regard to the impact of blood donation on performance, we did not find any significant effect of the blood donation on the physical performance in both setups, which corroborates the results obtained by Nadler and colleagues.[8] Moreover, our results evidenced no significant effect of the blood donation on the vigilance level, which is consistent with the litterature.[11,22]

This absence of significant differences in performance between both groups at the end of the testing days was evidenced regardless of individual differences (e.g., level of fatigue, stress, or expected effect of blood donation). Indeed, we could have expected an impact on performances due to the significant higher fatigue and stress levels of the donors in the beginning of the field experiment. Furthermore, their expectations regarding their group distribution could have impact their physical

	Control ($n = 7$)	Donation ($n = 8$)	p. *t*-test	Effect size
Obstacle run (s)	158 (18.01)	175 (19.05)	0.100	0.915
Shooting range—25 m	101.43 (13.96)	96.00 (11.02)	0.415	0.436
Shooting range—100 m	74.29 (7.34)	78.50 (11.73)	0.428	0.423
Overall score	49.43 (14.89)	63.88 (16.29)	0.098	0.923

Note: Values are mean (SD).

TABLE 4 Physical performance assessment during the field experiment

TABLE 5 Means and SDs for the hematological, vigilance, and subjective parameters during the field experiment

		Start		End	
Parameters	**Measures**	**Control ($n = 7$)**	**Donation ($n = 8$)**	**Control ($n = 7$)**	**Donation ($n = 8$)**
Hematological and physical parameters	Hematocrit (%PCV)	41.14 (2.19)	42.63 (2.77)	42.00 (2.00)	40.50 (2.726)
	Hemoglobin (g/dl)	13.99 (0.75)	14.49 (0.92)	14.27 (0.69)	13.77 (0.93)
	Heart rate (beats/min)	68.86 (12.24)	68.63 (10.51)	146.43 (31.59)	160 (13.51)
Subjective parameters	Physical fatigue	18.57 (15.80)	46.25 (20.71)*	43.00 (21.82)	54.75 (21.87)*
	Mental fatigue	19.00 (14.34)	43.88 (14.86)*	24.57 (16.79)	39.63 (18.98)
	Sleepiness	14.71 (14.20)	31.00 (18.45)	11.86 (13.73)	16.38 (11.38)*
	Stress	11.29 (12.16)	32.29 (15.16)*	8.71 (8.54)	28.25 (26.75)
	Physical well-being	—	—	84.14 (15.04)	66.00 (17.65)
	Mental well-being	—	—	90.57 (11.46)	78.13 (9.75)
	Training intensity	—	—	66.57 (26.18)	73.75 (15.39)
	Muscle pain	—	—	19.43 (14.57)	41.25 (28.09)
Vigilance parameters	Reaction time (ms)	303.62 (13.95)	314.27 (19.59)	298.68 (20.29)	304.38 (21.49)
	Lapses	0.43 (0.53)	1.87 (1.64)	1.57 (2.07)	1.75 (1.49)
	Misses	0.14 (0.38)	0.12 (0.35)	0 (0)	0 (0)

Note: Values are mean (SD). The symbol * indicates that there was a significant difference in the statistical analysis.

		Participant expectations		
		Nondonor	**Donor**	
Real group distributions	Nondonor	5	2	7
	Donor	5	3	8
		10	5	

Note: Values are number of subjects (n).

TABLE 6 Crosstab representing the real group distributions versus the participants' expectations in the field experiment

performance (i.e., "placebo" effect) or at least the SF operators could have allowed themselves to have a diminished physical performance (i.e., motivational effect).

Despite our attempts to counteract the limitations reported in the literature, certain limitations are inherent to our target population and must be accepted. The major weakness of our study is obviously the rather small sample size, which may lead to the impression of an underpowered study. Nevertheless, even if our sample size seems to be limited, it is still representative of our target population. Indeed, our research focused on an elite military unit composed only by a really restricted number of highly trained male individuals. Therefore, by agreeing to compromise on the sample size rather than on the ecological validity of our field setting, we ensure that the guidelines are tailored to the specificities of our target population. Moreover, it also offered the actual future "client" to this exceptional procedure, the opportunity to safely experience the potential effect of a blood donation on their performances.

5 | CONCLUSIONS

A 450-ml blood donation has no significant impact on the SF operator performances even for a strenuous exercise in an ecologically valid field environment. Thus, a 450-ml blood donation has no immediate effect on their capacities to fulfill their demanding mission in tactical circumstances. Therefore, from a donor point of view, we are in favor of allowing under strict medical supervision the use of a buddy transfusion in exceptional operation life-threatening situations when no blood components are available.

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CONFLICT OF INTEREST

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ORCID

Julie Degueldre https://orcid.org/0000-0003-1704-263X
Emilie Dessy https://orcid.org/0000-0003-1891-9632
Nathalie Pattyn https://orcid.org/0000-0002-2690-5479

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