Rescue operations lead to increased cardiovascular stress in HEMS Crew Members - A prospective pilot study of a German HEMS cohort

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Abstract

Background

Helicopter emergency medical service (HEMS) is an important part of prehospital emergency medicine. The working conditions lead to high physical stress, especially in rescue operations. To date, little is known about the cardiovascular stress of HEMS crew members in the rescue service. Examinations of professional groups in public security have shown a significant risk in these. The present study aims to determine the cardiovascular stress profile during rescue situations in HEMS crew members.

Methods

A total number of 21 (male n=20) HEMS crew members (11 emergency physicians and 10 paramedics) participated in the prospective study. Heart rate (HR), blood pressure (BP) and long-term ECG measurements were recorded at the whole operation day. The changes of measurements during rescue operation (in total 52 operations) were compared to these of standby time.

Results

Rescue operations lead to increased load on the cardiovascular system. Expression of this is significantly higher BP, HR values and rate of cardiac events compared to standby time. Significantly higher of both, mean and maximal, diastolic and systolic blood pressure were measured on duty. Especially the difference in BP sys mean is 7.4 ± 9.0 mmHg (7.4, CI [5.1; 9.7], $p < 0.001$). HR minimal, mean and maximal were also significantly higher during rescue operations. HR max was 33.7 bpm higher on average than in the standby time (CI [26.2; 40.8], $p < 0.001$). Cardiac events occurred significantly more frequently during the period of rescue operation than in standby time hours (time volume of 1 hour, $p = 0.02$).

Conclusions

The results show a significant load on the cardiovascular system during rescue operations in HEMS crew members. This is expressed in a higher occurrence of extrasystoles, HR and BP values during rescue operation than on standby time. Therefore, it is important to carry out a risk stratification of the personnel deployed in the HEMS crew members to prevent cardiovascular risk and events.

Background

The working conditions in the helicopter emergency medical service (HEMS) are characterized by high physical and psychological stress in rescue situations (1). Previous studies in professional groups of public services - in particular in the fire and police departments - have shown a significant cardiovascular risk in these (2). In firefighters, sudden cardiac death is the leading cause of death on-duty (3). Helicopter emergency medical service is an important pillar of security in the field of rescue services (4). It has become an integral part of increasing importance in prehospital emergency medicine (5). To date, however, there are only a few scientific studies that have ascertained physical stress, in particular cardiovascular stress, on the HEMS crew in action. A study by Petrowski et al. (6) demonstrated a significantly higher cardiovascular burden in the air rescue service than in comparison to clinical activity in the hospital. As one of the first, in 1991 Benzer et al. (7) analyzed the physiological cardiovascular strain at HEMS crew members. For this purpose, cardiovascular load was examined at different times during use (alarm notification, approach, landing, outbound flight to the hospital, hospital handover, return flight) and was able to demonstrate a significantly higher cardiovascular load in use compared to the idle time. Recent studies by Carchietti et al. (8), who examined the change in heart rate (HR) during rescue operations, were able to demonstrate a relevant cardiovascular strain, particularly in complicated and longer-lasting operations. Dispatch and mission-related stress of the autonomic nervous system seem to play a decisive role in this (6).

Overall, the cardiovascular load of HEMS crew members has been insufficiently investigated. Therefore, the aim of this study is to determine the cardiovascular stress profile during rescue operation and to compare these results with the cardiovascular profile during standby time.

Methods

Study Participants

The study participants are active as medical staff at a German rescue helicopter base. A total of 21 (male n = 20) subjects participated in the study (11 emergency physicians and 10 paramedics). The investigation included at least one full day of work and started at 7:00 a.m. until the end of duty at sunset. A total of 52 emergencies were evaluated. Participation in the study was voluntary and all data was saved anonymously. Each study participant was informed in advance in writing and verbally about the examinations, their risks and the course of the examination. All study participants gave their written consent to participate in the study. It was carried out in accordance with the declaration of Helsinki. All participants reported being in good health.

Study design and procedure

This study was conceived as a prospective pilot study to examine the cardiovascular load of HEMS crew members during rescue situations. For this purpose, the blood pressure (BP) and HR profile, as well as cardiac arrhythmia in use, were compared with that of the resting phases between rescue situations (on the same day). The investigations took place from November 2016 to September 2017. For this purpose, a long-term BP and long-term ECG were set up for the emergency physician on duty as well as the paramedics for the entire day at work. Before going on duty, height, weight, Body Mass Index (BMI) and abdominal circumference were recorded. Body height was measured using a commercially available stadiometer. A digital bathroom scale from the manufacturer Smart Weigh, model SBS500, was used to determine body weight. BMI was determined according to the formula: body weight: (height in m)^2. The abdominal circumference was measured in a standing position at the end of expiration, in a horizontal plane, midway between the lower edge of the rib and the upper edge of the iliac crest (9).

Long-term blood pressure and long-term electrocardiography measurements

The Holter ABDM from Custo med GmbH was used for long-term BP and long-term electrocardiography (ECG) measurements. The device saves synchronous recordings of long-term BP and long-term ECG measurements with the Custo screen 400. The ECG signal is accepted via the Custo guard 3 and custo belt 3 by radio. The devices were installed at the start of the service. This included a BP-cuff for non-invasive BP measurement and an elastic 3-channel electrode belt with EKG transmitter (custo belt and custo guard). The custo screen 400 Holter-ABDM recorder was attached to the subject's belt with a designated pocket. The long-term ECG recorded continuously throughout the working day. The device for long-term BP measurement started with a manual measurement at the push of a button. In the beginning, a resting measurement was made after 5 minutes of physical relaxation. The BP measurement intervals were installed at 10-minute intervals, both in the non-operational and during the operation. In the event of incorrect measurements, an immediate automatic re-measurement was programmed to be carried out.

BP and HR were measured continuously throughout the day. This was followed by a division into "standby time" which includes all values between uses. The time from the receipt of the alarm message to the clinical patient transfer was defined as a “rescue operation”. The systolic and diastolic BP was evaluated according to a minimum (BP dia min and BP sys min), maximum (BP dia max and BP sys max) and mean (BP dia mean and BP sys mean) value with standard deviation on standby time and during rescue operation time.

The HR was evaluated simultaneously with the BP according to the minimum (HR min), maximum (HR max) and mean (HR mean) value with standard deviation during standby time and rescue operation time. The number of occurrences of extrasystoles (supraventricular, ventricular) were also recorded. These were compared to their occurrence in rescue operation vs. standby time. The increase in BP, HR and the occurrence of extrasystoles were taken as an expression of cardiovascular stress.

Statistical analysis

A total of 52 operational situations were included in the study. Due to incorrect measurements and artefacts, a certain number of data collected could not be included in the study evaluation. For the BP sys mean and BP dia mean 7 missions, for BP sys min, BP dia min, BP sys max and BP dia min 9 missions, for HR mean 4 and for HR min and HR max 8 missions.

All statistical analysis was performed using Stata / IC 16.1 for Unix (StataCorp LP, College Station, TX) and IBM SPSS Statistics 25. Anthropometric parameters, BP and HR characteristics parameters were described using mean, standard deviations (SD), median and minimum and maximum values. Differences between standby time and during rescue operation were estimated using random-effects linear regression; 95% confidence intervals (CIs) are also reported. Supraventricular and ventricular extrasystole were rated as cardiac events. Cardiac events were reported for total time, standby time and rescue operation time. These are describing as absolute values and 95% confidence intervals (CIs). The event rate per hour was also shown in absolute values. All statistical tests were two-sided with a significance level of 0.05.

Results

The mean age of all participants was 40.6 ± 7.7 years (31 – 59 years). The emergency physicians were 37.0 ± 3.0 years old, the paramedics 44.6 ± 9.35 years. The average height of the paramedics was 1.83 ± 0.07 meters, the body weight 84.2 ± 9.7 kg. The BMI corresponds to 24.9 ± 1.5 kg / m2. The emergency physicians are 1.82 ± 0.09 meters in height, 81.9 ± 10.4 kg in body weight and 24.6 ± 2.6 kg / m2 in BMI. The average operational experience in air rescue in years was 7.0 ± 7.9 (emergency physicians 2.9 ± 2.4, paramedics 11.4 ± 9. years). Table 1 shows the anthropometric characteristics of the study group.

Table 1: Anthropometric characteristics of the study group (All participants/ Emergency physicians/ Paramedics)

	All participants				Emergency physician				Paramedic			
	n	Mean	SD	Median	n	Mean	SD	Median	n	Mean	SD	Median
Age (years)	21	40.6	7.7	38.0	11	37.0	3.0	36.0	10	44.6	9.35	44.0
Height (m)	21	1.83	0.08	1.83	11	1.82	0.09	1.82	10	1.83	0.07	1.83
Weight(kg)	21	83.0	9.9	84.0	11	81.9	10.4	82.5	10	84.2	9.7	84.2
BMI	21	24.8	2.1	25.1	11	24.6	2.6	24.9	10	24.9	1.5	25.2
Waist circumference (cm)	21	89.4	7.1	90.0	11	88.1	8.4	90.0	10	90.9	5.4	90.5
Professional experience (years)	21	7.0	7.9	4.0	11	2.9	2.4	3.0	10	11.4	9.4	8.0

Operating characteristics

HEMS crew member had an average of 2.7 ± 1.3 rescue operations per shift (total 52) with an average duration of 53 ± 34 minutes. Over the day, the mean total operating time totaled 158 ± 96 minutes. The distribution of operational reports was 26 (50%) internal emergencies, 17 (32.7%) traumatological-surgical emergencies, 5 (9.6%) resuscitations and 4 (7.7%) other emergencies.

Blood pressure

Table 2 provides a descriptive overview of selected BP variables on standby time and rescue operation. The BP mean values in standby time were systolic 127.6 ± 11.4 mmHg and 85.3 ± 7.3 mmHg diastolic. During the period of rescue operations, the BP mean values were 135 ± 13.6 mmHg systolic and 88.7 ± 9.1 mmHg diastolic. The difference in the mean BP sys mean is 7.4 ± 9.0 mmHg and is statistically significant (7.4, CI [5.1; 9.7], $p < 0.001$). The verification of the hypothesis that the stress during an operation is higher than during the rest period was carried out with a connected t-test of the BP measurements. The resting BP value was measured while sitting and compared to the BP sys mean during the first rescue operation of the working day. There was a significant difference between the two measured values (p-value < 0.001; CI [4; 20]). The individual values of the subjects on standby are lower than during the period of a rescue operation. During rescue operations, the average systolic BP values were 14.2 ± 11.4 mmHg higher on average than at standby time. The values of the BP dia mean (p < 0.001) and BP syst max (p = 0.019) are significantly higher during rescue operations than in standby time. The changes to BP syst mean, BP dia mean and BP sys max are shown in Fig. 1.

Table 2: Blood pressure values during rescue operations and on standby time

		Description				Linear regression**	
		Mean	Sd	Median	Min-Max	Estimated mean [95%-CI]	p-value
BP sys mean*	standby time	127.6	11.4	126.8	104.5-153.7	128.0 [123.6 ; 132.4]	
n=45	rescue operation	135.0	13.6	136.0	107.0-166.0	135.6 [130.1 ; 141.1]	
	difference	7.4	9.0	7.2	-16.0-31.0	7.4 [5.1 ; 9.7]	<0.001
BP dia mean*	standby time	85.3	7.3	84.0	70.5-102.4	85.2 [82.4 ; 88.0]	
n=45	rescue operation	88.7	9.1	88.0	70.0-108.0	89.1 [85.5 ; 92.9]	
	difference	3.4	6.0	3.5	-12.0-20.0	3.6 [1.8 ; 5.5]	<0.001
BP sys min*	standby time	114.7	12.6	114.0	84.0-143.0	114.6 [109.7 ; 119.4]	
n=41	emergency operation	124.7	13.0	125.0	102.0-152.0	125.2 [119.5 ; 103.8]	
	difference	10.0	8.9	9.0	-8.0-28.0	10.1 [7.0 ; 13.3]	<0.001
BP dia min*	standby time	76.4	8.7	77.0	50.0-94.0	76.4 [73.0 ; 79.8]	
n=41	rescue operation	82.8	9.5	84.0	63.0-104.0	83.1 [78.8 ; 87.5]	
	difference	6.4	7.0	7.0	-7.0-24.0	6.7 [3.8 ; 9.5]	<0.001
BP sys max*	standby time	141.8	15.5	142.0	106.0-185.0	142.4 [136.5 ; 148.4]	
n=41	rescue operation	147.4	17.3	149.0	107.0-182.0	147.7 [141.9 ; 153.5]	
	difference	5.6	16.5	6.0	-42.0-48.0	5.6 [0.9 ; 10.3]	0.019
BP dia min*	standby time	95.7	10.5	94.0	78.0-124.0	95.8 [91.9 ; 99.7]	
n=41	rescue operation	95.6	11.2	95.0	70.0-117.0	96.0 [91.6 ; 100.4]	
	difference	-0.1	11.4	2.0	-45.0-25.0	0.0 [-3.9 ; 3.9]	1.000

* Participants whose measurements were recorded before and during an rescue only ** random-effects linear regression

Holter (24 h)-ECG

The HR at maximum, minimum and average was measured for HEMS crew members during 48 rescue missions in the standby time and during the rescue operations (Table 3). In 4 cases, no data could be evaluated for HR min and HR max. None of the study participants experienced pathological arrhythmias or signs of ischemia during the measurements. Nevertheless, irregularities in cardiac activity were recorded in each subject. Ventricular extrasystoles (VES) occurred most frequently with an average of 163 VES per day of use. Furthermore, 24 supraventricular extrasystoles (SVES), 4 missing QRS complexes and 2 supraventricular tachycardias were recorded on average.

Significant differences between the values of the standby time and during the operating time can be seen for the HR mean, HR max and HR min. The HR mean was 13 bpm higher on average than in the standby time (13.0, CI [10.8; 15.3], $p < 0.001$). The HR max was 33.7 bpm higher on average than in the standby time (33.5, CI [26.2; 40.8], $p < 0.001$) and the HR min 7.2 bpm (7.2, CI [5.1; 9.4], $p < 0.001$).

Table 3: Heart rate (HR max, HR min, HR mean) during rescue operation and on standby time

		Description:				lineare regression**	
		Mean	Sd	Median	Min-Max	Estimated mean [95%-CI]	p-value
HR mean*	standby time	78.1	13.2	78.8	56.4-115.0	76.3 [71.3 ; 81.6]	
n=48	rescue operation	91.1	14.8	92.0	60.0-126.0	89.5 [83.8 ; 95.1]	
	difference	13.0	9.4	12.3	-11.0-37.5	13.0 [10.8 ; 15.3]	<0.001
HR min*	standby time	67.9	12.7	68.0	44.0-100.0	67.3 [61.9 ; 72.6]	
n=44	rescue operation	75.1	14.1	74.0	49.0-111.0	74.6 [69.2 ; 80.0]	
	difference	7.2	9.1	6.0	-9.0-33.0	7.2 [5.1 ; 9.4]	<0.001
HR max*	standby time	90.0	15.4	89.5	56.0-128.0	89.8 [84.5 ; 95.1]	
n=44	rescue operation	123.7	21.0	127.0	83.0-165.0	122.9 [115.1 ; 130.8]	
	difference	33.7	20.5	36.0	-18-70.0	33.5 [26.2 ; 40.8]	<0.001

* Participants whose measurements were recorded before and during an rescue only ** random-effects linear regression

Cardiac event rates

The measurements show a total of 2514 cardiac events during the standby period and 770 cardiac events during the rescue operation period. Measured by a time volume of 1-hour, cardiac events occurred significantly more frequently during the period of rescue operation than in standby time hours ($p = 0.02$). Shown in table 4 outside of the operating time, the event rate per hour was 11 (CI [10.6–11.5]), while on rescue operation period the rate was 16.7 (CI [15.6–18.0]) per hour.

Table 4: Cardiac event rates (Total, Standby time, Rescue operation)

	Time (hours)	Cardiac events	Event rate per hour	95%-CI*	p-value**
Standby time	227.8	2514	11.0	10.6-11.5	
Rescue operation	46.0	770	16.7	15.6-18.0	0.020
Total	273.8	3284	12.0	11.6-12.4	

* Assuming Poisson-distributed number of events

** random-effects poisson regression

Discussion

The present study aimed to determine the stress on the cardiovascular system during rescue operations in helicopter emergency medical service. The cardiovascular load was determined by recording the BP and HR values and the derivation of the long-term ECG in rescue operations. These values were compared to values during standby time.

The working conditions in helicopter emergency medical service cause physical stress that can put the human organism in extreme stress situations (10). HEMS crew members are exposed to the following stressors: shift and night work, unpredictable alarms resulting in abrupt stress on the cardiovascular system, physically and psychologically challenging medical situations during repetitive mission's, as well as flight-related stress situations and unpredictability.

Change in blood pressure

In the examined cohort, none of the participants showed systolic hypertension (BP sys > 140 mmHg), 28.6% showed increased diastolic (BP dia > 90 mmHg) values at rest. The mean resting values of the HEMS crew members were at 123/83 mmHg in the normal range. The study collective showed a significantly lower average resting BP value compared to colleagues working in the ground-based emergency services. These showed systolic hypertension in 17.5% and diastolic hypertension in 40.2% (11). Also, they were below the German national average, in which 31.8% of the German population was found to have high BP (12).

Except for the BP dia min, the examined cohort showed significantly higher BP values in rescue operations than during standby time. In regard to differences between BP values in rescue operations, the examined cohort showed significantly higher mean systolic BP values of 14.2 ± 11.4 mmHg. Overall, there was a significant increase in mean systolic BP of 7.4 ± 9 mmHg and diastolic of 3.4 ± 6 mmHg over the entire working day during rescue operations.

Up to now, there have hardly been any studies on changes in BP during air rescue operations. It is therefore difficult to assess the results we have collected due to the lack of comparable data. Investigations in related occupational groups with a similar occupational load profile are in particular the ground-based emergency services and the fire department. Firefighters have hypertension in > 20% (13). Studies in this occupational group indicate that increased systolic BP is an independent predictor of coronary events on duty (14, 15). Arterial hypertension is considered to be one of several main risk factors that can be influenced by a cardiovascular load in the professional group of emergency services (16, 17). Kales et al. (18) were able to demonstrate that this is insufficiently controlled in the professional group of the rescue workers and therefore significantly increases the risk of cardiovascular events.

In the general population, cardiovascular events occur frequently in the morning (19). This increase in time is justified by the fact that the cortisol level is higher in the morning, catecholamines are released and BP and HR increase. Cardiovascular deaths during firefighters' work hours, on the other hand, do not follow this circadian pattern but occur more frequently between noon and midnight (15). This fact makes it clear that there is a greater influence through individual risk constellations and work-related response situations. It was shown that there was a significantly higher prevalence of cardiovascular risk factors in cardiovascular deaths (15). The research group led by Kales et al. identifies professional and personal risk factors associated with cardiovascular deaths during firefighting duties. These are a deviating circadian rhythm in the context of shift work and the highest risk of death during extremely physically demanding activities. It can be assumed that these factors are relevant for HEMS crew members and contribute to an increased cardiovascular risk.

An Italian study by Carchietti et al. (8) examined the influence of stressors on the HEMS crew members during the operation by determining the BP and HR values before and after the flight. The resting BP values measured were slightly lower compared to our study (Carchietti et al.: systolic 120.2 ± 13.2 mmHg and diastolic 75.4 ± 11.1 mmHg vs. our results: BP sys resting 123 ± 7.8; BP dia resting 83 ± 7 mmHg).

Adams et al. (20) carried out a study with long-term BP measurements and long-term ECG recordings with doctors during 24-hour hospital services and in their leisure time. The data indicate a mean BP increase during the service period, which is significant in the diastolic range. At 125.8 / 82.5 mmHg, these were higher in service than in comparison to 123.8 / 77 mmHg in leisure time.

Heart rate change

The mean resting HR was in the normal range with an average of 73 ± 9.7 bpm. The HR is easy to measure parameter and can be used to document psychological and physical stress (21). In 2007, the European Cardiology Society declared increased resting HR as an independent risk factor for cardiovascular diseases (22). The background was the finding of an increased risk of cardiovascular morbidity and mortality with increased HR. Based on the data from the Framingham study, a long-term increased cardiovascular risk with increased resting HRs was confirmed, whereby no limit value was set (23). Compared to the no-work time, the mean HR in our cohort was significantly higher at 91.1 ± 14.8 bpm than in the non-work time (mean HR: 78.1 ± 13.2 bpm) with an average difference of 13 bpm (CI [10.8; 15.3], $p < 0.001$). The Carchietti et al. (8) also determined significantly increased HRs for HEMS crew members even after the end of the flight with a difference of 3.9 ± 9.5 bpm. The reasons that can cause an increase in frequency in air rescue operations are diverse: vibrations during the flight due to the rotors, and psychological and physical stress from the rescue operation and noise (8, 24).

Cardiac events

All study participants had SVES and or VES during the examination time.

Extrasystoles are widespread among healthy and clinically asymptomatic persons so that SVES occur in approximate 87% in the long-term measurement and VES in approximate 1% in the resting ECG and in

40–75% in the long-term measurement (25, 26). Frequent VES (> 60 / hour or 1 / minute) have an estimated prevalence of 1–4% in apparently healthy people and no worse prognosis compared to the normal population (27–29). Recent clinical studies report that frequent VES cause myocardial dysfunction (30, 31). Using the speckle tracking echocardiography technique, an ultrasound procedure for the objective representation of the myocardial function, Barutcu et al. (32) decreased left ventricular cardiac function after VES (33). In healthy people, 5–9% SVES were described in the exercise test with an age-related increase in prevalence. VES, however, were registered in 21–44% (34–36).

The comparison of the rescue phase time with the standby time in the present study showed a significantly more frequent occurrence of SVES and VES during the rescue operation phase. VES and SVES were 16.7 vs. 11.0 events / h significantly more frequently during the operational phase than during the standby time. This fact can be seen as an expression of increased cardiovascular stress.

Mauerer et al. were unable to establish an association between exercise-induced SVES and cardiovascular mortality or coronary mortality in the follow-up in 1383 asymptomatic volunteers (37). The study by Morshedi-Meibodi et al. (38), as part of the Framingham Heart Study, showed that the occurrence of ventricular extrasystoles in the stress test in asymptomatic people was associated with increased mortality. Age, male gender and hypertension correlated in this cohort of stress-induced ventricular extrasystoles. In the long-term observation, 60–80% of these were associated with an increased risk of mortality according to frequency. Data from the Paris Prospective Study was used to test whether stress-induced VES is a physiological response to training (39). The authors conclude that in middle-aged asymptomatic men, the occurrence of premature ventricular depolarizations during exercise is associated with a long-term increase in the risk of death from cardiovascular causes.

Smith et al. (40) examined a group of firefighters in the United States with no known medical history for ECG changes during a 12-hour post-firefighting and control period. The evaluation was carried out after complex simulation firefighting that lasted about 30 minutes. SVES and VES, as well as ST segment changes, have been described that may indicate myocardial ischemia. Earlier examinations provided indications for ECG changes due to a fire-fighting phase (41, 42). These could explain the high risk of sudden cardiac death in this occupational group (43, 44). A pilot study from New York performed long-term ECG analyzes of firefighters during duty and in the immediate hours for 16 hours afterwards (41). 57% (n = 28) of firefighters had at least one VES. Carey et al. (41) described non-persistent ventricular tachycardias with ≥ 3 consecutive VES in 11% of the test persons, without accumulation during the period of use, but with a significantly higher prevalence compared to the normal population.

Conclusion

Increased resting blood pressure and resting heart rate values compared to the general population were not more frequently found in the HEMS crew members. It can be assumed that the cardiovascular risk corresponds to that of the average population. A lower risk profile would be recommended against the background of the occupational burden. However, the results of this study show that recurring physical stress events occur during the day on duty in the rescue operation, which put a strain on the cardiovascular system. Expression of this could be the significantly higher evidence of the increased occurrence of extrasystoles, significantly higher heart rate and blood pressure values during the rescue operation. It can be assumed that these subsequently have potentially harmful effects on the health of the individual, especially in crew members with pre-existing cardiovascular risk factors, and that they can significantly increase the cardiovascular risk.

It is therefore important to carry out general prevention programs as part of continuous risk stratification of HEMS crew members to prevent cardiovascular events in active HEMS missions. Overall, to date, it has been insufficiently studied the operational cardiovascular burden on air rescue personnel. Using the fire brigade as an example, there are numerous studies worldwide on recording cardiovascular risks in the workplace as well as approaches to targeted preventive measures. Based on these, such approaches should also be implemented by crew members of helicopter emergency service.

Abbreviations

BMI Body Mass Index

ECG Electrocardiography

HEMS Helicopter emergency medical service

HR Heart rate

HR max Maximum heart rate

HR mean Average heart rate

HR min Minimal heart rate

BP Blood pressure

BP dia max Diastolic maximum blood pressure

BP dia mean Diastolic average blood pressure

BP dia min Diastolic minimum blood pressure

BP sys max Systolic maximum blood pressure

BP sys mean Systolic average blood pressure

BP sys min Systolic minimum blood pressure

SVES Supraventricular extrasystoles

VES Ventricular extrasystoles

Declarations

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Availability of data and materials

Please contact author for data requests.

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Contributions

MS, JD, SH, MB and RL conceived the study. MS, JD and SH analysed the data. MS, JD drafted the manuscript. MS, SH and RL undertook the statistical analysis. MS, JD, SH and RL conducted literature searches. MS, SH and JD contributed to the study design and analysis. MS wrote the manuscript. All authors contributed substantially to manuscript revision. All authors read and approved the final manuscript.

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Ethics declarations

Ethics approval and consent to participate

Scientific evaluation of this research received a positive assessment by the Central Ethics Commission of the University of Witten/Herdecke (no. 35/2016). As data were anonymised informed consent was not obtainable and thus waived by the ethics committee.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

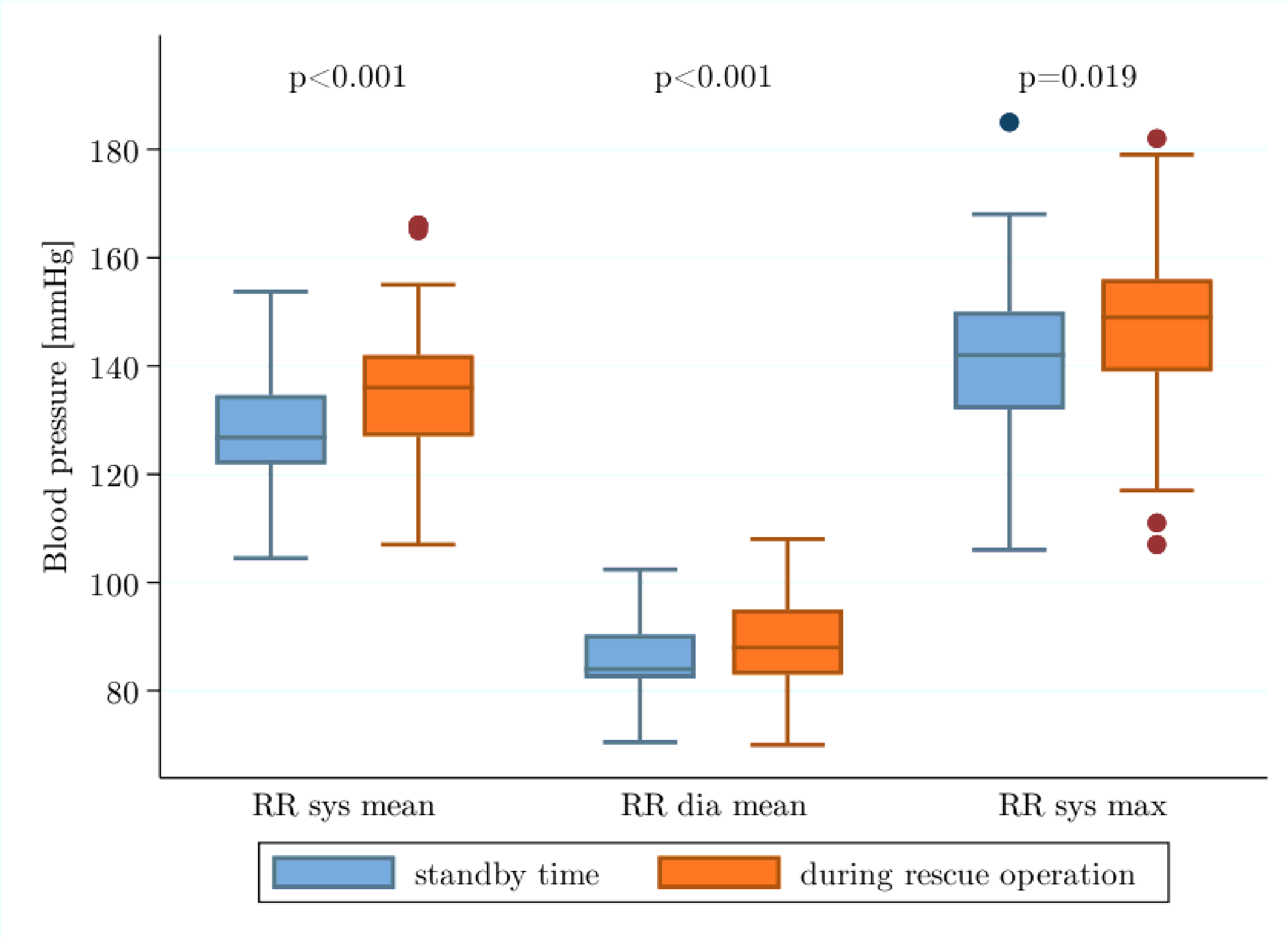

Figure 1

Differences in blood pressure (BP sys mean, BP dia mean, BP sys max) during standby time and during rescue operations

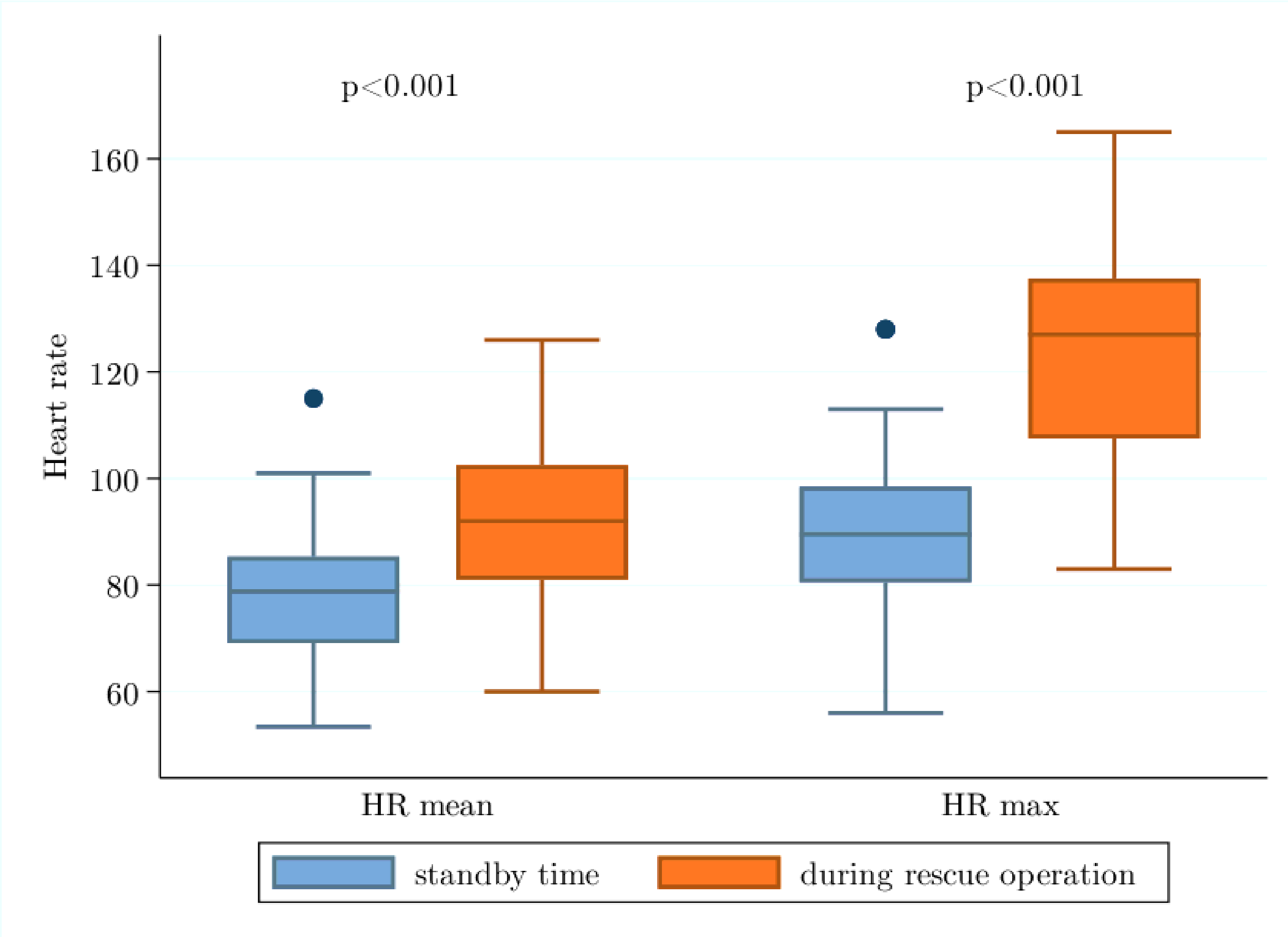

Figure 2

Overview of mean (HR mean) and maximum (HR max) heart rates on standby time and during rescue operations