

Fever increases heart rate and respiratory rate; a prospective observational study of acutely admitted medical patients

MM Jensen, JG Kellett, P Hallas & M Brabrand

Abstract

Background: The relationship between increase in body temperature, heart rate, and respiratory rate has only been studied in young, healthy subjects.

Aim: To show the changes in heart and respiratory rate associated with fever in acutely admitted medical patients.

Design: A prospective observational cohort study

Methods: Vital parameters from 4,493 patients were retrospectively extracted. Linear and multiple variable regression analysis was used to calculate the change in heart and temperature rate for every degree rise in temperature (i.e. $\Delta HR/^{\circ}C$ and $\Delta RR/^{\circ}C$) in the entire study group and in those with low ($<36.1^{\circ}C$), normal ($36.1-38^{\circ}C$) and high ($>38^{\circ}C$) body temperatures.

Results: The $\Delta HR/^{\circ}C$ and $\Delta RR/^{\circ}C$ was 7.2 ± 0.4 beats per minute (bpm) and 1.4 ± 0.1 (1.2 to 1.62) breaths per minute (bpm). Adjusting for age, oxygen saturation and mean blood pressure, the results were 6.4 ± 0.4 (5.7 to 7.1) bpm and 1.2 ± 0.1 (1.0 to 1.4) bpm. In low, normal and high body temperature the $\Delta HR/^{\circ}C$ were 2.7 ± 1.9 , 6.9 ± 1.9 and 7.4 ± 0.9 bpm, respectively; for $\Delta RR/^{\circ}C$ the values were -0.5 ± 0.5 , 1.5 ± 0.5 and 2.3 ± 0.3 bpm, respectively.

Conclusions: We only found a modest association between fever and changes in heart rate and respiratory rate.

Keywords

Fever, Heart rate, Respiratory rate, Regression analysis, Tachycardia, Emergency care

Introduction

Heart rates have been reported to increase by 4.4 to 18.0 beats per minute and respiratory rates by 2 to 4 breaths per minute for every degree centigrade rise in body temperature.¹ Although the relationships between temperature increase and respiratory and heart rate have been recently studied in children^{2,3} there are no recent studies on adults. The published studies in adults that are currently available all examined healthy young people who were free from cardiac disease and, therefore, not taking any medication likely to influence heart or breathing rate. It is clearly not appropriate to extrapolate findings in such subjects to acutely ill elderly patients with multiple co-morbid conditions taking multiple medications. In this study we provide practice based evidence of the changes in heart and respiratory rate associated with fever observed in a large cohort of acutely ill medical patients admitted to a Danish hospital.

Methods

Design

This was a prospective observational cohort study performed on acutely admitted medical patients who had routine recording of vital signs at arrival at the admission unit. The cohort has previously been used to validate existing biochemical prediction models.⁴

Registry studies are exempt from the need for approval from research ethics committees in Denmark.

Subjects

Data was registered on 5,894 patients admitted to the medical admission unit at the Hospital of South West Jutland from 2 October 2008 until 19 February 2009 and 23 February 2010 until 26 May 2010. Temperature was measured tympanically. Heart rate was assessed manually, read off the ECG, the pulse oximeter or along with the electronic measurement of blood pressure. Respiratory rate was measured manually over one minute.

Inclusion criteria were: age ≥ 15 years and existing data on body temperature, heart rate and respiratory rate, mean arterial pressure, and oxygen saturation.

Ethics

The registration of data was performed prospectively but had no influence on the treatment of the individual patient or the manner in which the vital parameters were obtained or the number of observations done on each patient.

Statistics

Simple linear regression analysis was used to calculate the increase in heart and respiratory rate per $^{\circ}C$ in those with low, normal and high body temperatures.

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Normal body temperature was arbitrarily defined according to the National Early Warning Score as 36.1–38.0,¹ a low body temperature as <36.1°C and a high body temperature >38.0°C. Simple linear regression was used to calculate the change in heart and respiratory rate per degree centigrade (i.e. $\Delta\text{HR}/^{\circ}\text{C}$ and $\Delta\text{RR}/^{\circ}\text{C}$) for the entire study group. Multivariable linear regression was used to adjust these increases for age, oxygen saturation and systolic arterial pressure for the entire study group for comparison. We also stratified our analyses on whether the patient survived to discharge. Stata version 14.2 (State Corp., College Station, TX USA) was used for analysis.

Results

Out of 5894 subjects enrolled, 151 (3%) had missing temperature, 54 (1%) pulse and 1,265 (21%) respiratory rate. A total of 4,598 (80%) patients had a normal temperature, 583 (10%) hypothermia and 562 (10%) fever and the entire temperature range was 33.1 to 40.8 °C. The characteristics of the final study population are shown in Table 1.

Overall the $\Delta\text{HR}/^{\circ}\text{C}$ was 7.0 (95% CI 6.4–7.7) beats per minute (Figure 1) and the $\Delta\text{RR}/^{\circ}\text{C}$ 1.4 (95% CI 1.2–1.6) breaths per minute (Figure 2). Adjusting for age, systolic arterial pressure and oxygen saturation, the $\Delta\text{HR}/^{\circ}\text{C}$ fell to 6.3 (95% CI 5.7–7.0) and the $\Delta\text{RR}/^{\circ}\text{C}$ to 1.2 (95% CI 1.0–1.3).

The $\Delta\text{HR}/^{\circ}\text{C}$ was highest in the groups with normal body temperature: 8.6 (95% CI 7.3–9.9) and 5.4 (95% CI 2.4–8.4) with fever, but with no significant association with hypothermia. The association between respiratory rate and temperature was not significant when stratifying by temperature.

Patients who survived to discharge had a $\Delta\text{HR}/^{\circ}\text{C}$ of 7.2 (95% CI 6.5–7.8) while patients who died had $\Delta\text{HR}/^{\circ}\text{C}$ of 5.2 (95% CI 2.2–8.2). $\Delta\text{RR}/^{\circ}\text{C}$ for survivors was 1.5 (95% CI 1.3–1.7), while it was not significant for patients who died.

Table 1. Background data for the study population. Data presented as median (Interquartile range) or number (%).	
Total	5,894 (100%)
Female	2,950 (50%)
Age(years)	65 (49-77)
Heart rate (bpm)	85 (72-100)
Systolic blood pressure (mmHg)	135 (119-151)
Diastolic blood pressure (mmHg)	77 (68-87)
Respiratory rate	16 (14-20)
Temperature (°C)	36.9 (36.5-37.3)
Oxygen saturation (%)	96 (94-98)
Charlson score	1 (0-3)
Survived to discharge (%)	5,689 (97%)

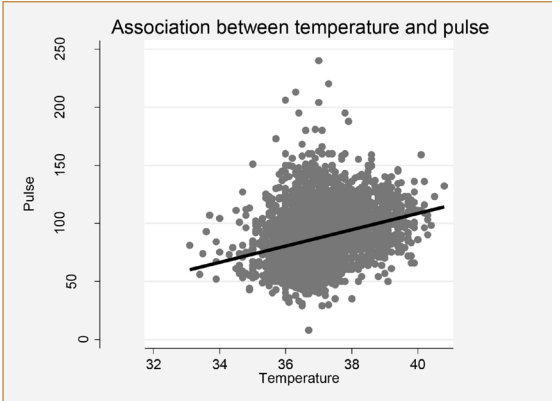


Figure 1. The association between temperature and pulse

If stratifying on patients admitted due to suspected infection (admission diagnosis beginning with A or B), we found no significant difference in $\Delta\text{HR}/^{\circ}\text{C}$ or $\Delta\text{RR}/^{\circ}\text{C}$ (data not shown).

Discussion

This study provides practice based evidence of the relationship between temperature and heart and breathing rate likely to be seen in acutely ill medical patients currently being admitted to Danish hospitals. In our very heterogeneous study group, the $\Delta\text{HR}/^{\circ}\text{C}$ was generally lower than reported in the literature in albeit younger patients with no medical history. The highest $\Delta\text{HR}/^{\circ}\text{C}$ was in those patients with a normal temperature and the response in heart rate becomes inconsistent when the body temperature drops below normal. Other factors, such as age, oxygen saturation, and systolic arterial pressure also slightly reduce the heart rate response to a rise in temperature.

Compared to the literature we found a more modest increase in respiratory rate associated with temperature: 1.4 bpm for the whole study population and 1.2 bpm when adjusting for age, oxygen saturation and systolic arterial pressure. As with heart rate the highest $\Delta\text{RR}/^{\circ}\text{C}$ was seen in patients with a high temperature.

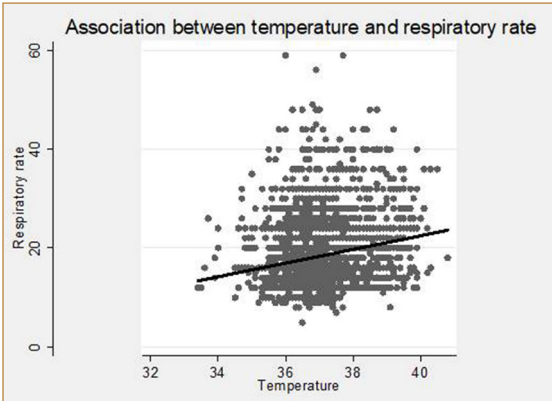


Figure 2. The association between temperature and respiratory rate

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The strengths of our study were the large number of unselected acutely ill study subjects in which the systematic collection of data eliminated measurement bias. A weakness of the study was the number of patients who had missing data and hence could not participate in the study. We do not know whether this group differed from the study group. Another weakness might be the fact that we had only one set of measurements from each subject while some of the studies we compare with make serial measurements in study subjects during hyperthermia.^{5,6,7} Last, we did not have access to previous medications used by the patients.

Conclusion

The changes in heart and respiratory rate associated with a rise in temperature reported in the current

medical literature are based on studies performed in young healthy volunteers. The response actually observed in acutely ill patients are more modest.

Conflict of interest

The authors declare that there are no conflicts of interest.

Data availability statement

Due to Danish and EU law, data cannot be shared in an open register. However, data can be obtained by contacting the corresponding author directly.

Funding statement

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References

1. Smith GB, Prytherch DR, Meredith P, Schmidt PE, Featherstone PI. The ability of the National Early Warning Score (NEWS) to discriminate patients at risk of early cardiac arrest, unanticipated intensive care unit admission, and death. *Resuscitation*. 2013;**84**(4):465-70.
 2. Davies P, Maconochie I. The relationship between body temperature, heart rate and respiratory rate in children. *Emergency medicine journal : EMJ*. 2009;**26**(9):641-3.
 3. Spruijt B, Vergouwe Y, Nijman RG, Thompson M, Oostenbrink R. Vital signs should be maintained as continuous variables when predicting bacterial infections in febrile children. *Journal of clinical epidemiology*. 2013;**66**(4):453-7.
 4. Brabrand M, Knudsen T, Hallas J. Identifying admitted patients at risk of dying: a prospective observational validation of four biochemical scoring systems. *BMJ open*. 2013;**3**(6).
 5. Weinberg JR, Innes JA, Thomas K, Tooke JE, Guz A. Studies on the circulation in normotensive febrile patients. *Quarterly journal of experimental physiology* (Cambridge, England). 1989;**74**(3):301-10.
 6. Lyon D. The relation of pulse-rate to temperature in febrile conditions. *Q J Med*. 1927;**20**:205-18.
 7. Karjalainen J, Viitasalo M. Fever and cardiac rhythm. *Archives of internal medicine*. 1986;**146**(6):1169-71.
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