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A longitudinal study of resting heart rate and violent criminality in more than 700 000 men

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Abstract

Importance: Low resting heart rate is a well-replicated physiological correlate of aggressive and antisocial behavior in children and adolescents, but whether low resting heart rate increases the risk of violence and other antisocial and risk-taking behaviors in adulthood has not been studied in representative samples. **Objective:** To study the predictive association of resting heart rate with violent and non-violent criminality, and with fatal and non-fatal injuries due to assaults and accidents in the population. **Design:** Register-based follow-up study with a follow-up time of up to 35.7 years. **Setting:** General population. **Participants:** 710,264 Swedish men born 1958–1991. **Main Outcomes and Measures:** Violent and non-violent criminal convictions, and medical treatments or deaths due to assaults and accidents. Resting heart rate was measured at mandatory military conscription testing at mean (SD) age of 18.2 (.46) years together with blood pressure. **Results:** Compared to men in the highest quintile of the resting heart rate distribution (heart rate ≥ 83 beats per minute), those in the lowest quintile (heart rate ≤ 60 beats per minute) had 39% (95% CI: 35-44%) higher hazard of violent crimes and 25% (95% CI: 23–28%) higher hazard for non-violent crimes in models adjusted for physical, cardiovascular, psychiatric, cognitive, and socioeconomic covariates. The corresponding hazard was 39% higher for assault injuries (95% CI: 1.33–1.46) and for accident injuries (95% CI: 1.38–1.41). Further adjustment for cardiorespiratory fitness in a subset of 572,610 men with data from an exercise test did not reduce the associations. Similar results were found for violent and non-violent criminality and for assault injuries when systolic blood pressure was studied instead of resting heart rate in more than 1 million men. **Conclusions and Relevance:** Among men, low resting heart rate in late adolescence was associated with an increased risk for violent criminality, non-violent criminality, being a victim of an assault, and being involved in accidents in adulthood. Most results were replicated with systolic blood pressure. Resting heart rate and other autonomic measures merit further study in the development and prevention of violence and antisocial behavior.

Introduction

An estimated 1.2 million violent crimes occurred in 2013 in the U.S. alone, corresponding to a rate of 368 crimes per 100,000 inhabitants.[1] Despite the high cost of violence,[2] its prevention has been unsuccessful compared to other health risks.[3] A better understanding of individual-level biological risk factors in the etiology of violence could help prevention and intervention efforts by allowing early identification of people with an elevated risk for violent behaviors.

Low resting heart rate (RHR) is the best-replicated physiological correlate of antisocial behavior in children and adolescents.[4,5] Meta-analyses have confirmed that antisocial or aggressive children and adolescents have lower RHR than do their peers without antisocial tendencies.[6,7] Low RHR has been viewed either as an indicator of a chronically low level of physiological arousal which may lead individuals to seek stimulating experiences to increase their arousal, or as a marker of attenuated responding to aversive and stressful stimuli, leading to fearless behavior and risk taking.[5,8,9]

Not much is known about RHR as a predictor of severe violence in adulthood. In the meta-analysis, Lorber identified six studies of adult aggressive behavior and found an association with low RHR.[6] The studies were based on small and selected samples, with an average of 43 participants per study. A handful of longitudinal studies have found a predictive association between low RHR and criminality later in adulthood but they too have been based on selected samples, whereas no representative, population-based studies exist.[10–13]

The association between RHR and risk of violence in the general adult population is thus uncertain. It is also unclear whether non-violent antisocial behaviors and other behavioral outcomes of fearlessness or stimulating seeking tendencies are predicted by low RHR. Previous evidence on the association between RHR and different types of criminality in adulthood is scarce[12], and, to our knowledge, no research on the association between RHR and real-life outcomes of risk-taking behaviors such as accident injuries has been conducted despite the well-known association between sensation seeking tendencies and risky behavior.[14]

We conducted a large-scale epidemiological study on the predictive association between RHR assessed in late adolescence and violent criminality later in life using population-based data of men with a follow-up time of up to 35 years. We also tested whether RHR predicted non-violent crimes and injuries whose risk could be elevated due to risk taking as a result of fearlessness or stimulation seeking.

Methods

Study population

We linked several Swedish national registers, maintained by governmental agencies, with longitudinal data available until December 31, 2009. A unique personal identification number, given to all citizens at birth, was used as key in the register linkages. RHR was measured during a 2-day conscription assessment for the Swedish Armed Forces, mandatory until 2009 for all Swedish men at age 18. Only men with severe diseases, handicaps or mental retardation were exempt, and more than 95% of men generally attended the conscription assessment.[15] Combining information from the Total Population Register and the Conscription Register, we identified all men who were born in Sweden between 1958 and 1991 and conscripted by end of 2009 (N = 1,488,886). The Multi-Generation Register[16] was used to identify biological parents of each individual. Those who had missing information on father's or mother's identity were excluded from the study (N = 16,413). We also excluded men who, on the basis of the Migration Register, had emigrated from Sweden before the conscription (N = 15,231). The sample thus included 1,457,242 men. The study was approved by the institutional review board of the Karolinska Institutet.

RHR and outcome measures

RHR was measured as beats per minute (bpm) in the conscription examination together with blood pressure. A standardized procedure was used to measure blood pressure in the supine position with an appropriate cuff at heart level after 5–10 minutes of rest.[17] RHR values below 35 and above 145 were excluded as outliers or possible data errors (N = 138; these cut-offs excluded the bottom and top 0.01% of the RHR distribution). Possibly due to changes in the registering procedures, RHR values were nearly completely missing from the Conscription Register for years 1984–1993, and data coverage varied also during other periods. As a result, a valid RHR value was available for 710,264 men (48.7% of the full cohort). Sensitivity analyses were conducted to assess the effect of missing RHR data (see below).

Information about violent and non-violent criminal convictions was obtained from the Crime Register, which contains all convictions in lower courts for individuals aged 15 (age of criminal responsibility) and older from 1973 onwards. Violent crimes included convictions of murder, manslaughter, assault, kidnapping, illegal restraint, illegal coercion or threats, robbery, threats or violence against an officer, arson, gross violation of a person's integrity, and harassment, as well as any sexual crimes. Non-violent crimes included drug-related crimes, property crimes, and traffic crimes (excluding speeding and parking fines issued by a police officer).

As secondary outcomes we studied injuries whose risk we hypothesized to be elevated as a result of fearless or stimulation seeking behaviors. The injury outcomes were inpatient or outpatient treatments and deaths due to assaults (ICD-8: E960–E968, ICD-9: E960–E968, ICD-10: X85–Y09) and accidents (ICD-8: E800–E929, ICD-9: E800–E869 and E880–E928, ICD-10: V01–X59). Assaults include for example being a victim of homicide, and assaults by firearms, motor vehicles, or other objects. Accident injuries include transport accidents and other external causes of accidental injury, such as falls, accidental poisonings, and exposure to inanimate or animate mechanical forces. The injury data were available from the Patient Register, which contains details of all individual episodes of hospitalization in Sweden since 1973 and outpatient treatment since 2001, and from the Cause of Death Register.

Covariates

As covariates we included factors which could confound the association between RHR and the studied outcomes. Height, weight, and body mass index (BMI, kg/m^2) were included as they could influence both cardiovascular functioning and the risk for criminality.[18] Diastolic blood pressure (mmHg) was included as an indicator of cardiovascular health. We also included information on the history of inpatient or outpatient treatment due to psychiatric disorders (ICD8: 290–315, ICD9: 290–319, and ICD10: F00–F99), available from the Patient Register, and general cognitive ability (IQ), available from the conscription testing as assessed with the Swedish Enlistment Battery (SEB).[15] Family socioeconomic status (SES) before age 10 years was available from National Censuses in 1960, 1970, 1980, 1985 and 1990. The SES variable was derived from the occupation of the head of the household (usually the father) and coded into three classes: low (skilled and unskilled workers across all fields), medium (low- and intermediate-position white collar workers) and high (high-position white collar workers and self-employed professionals and entrepreneurs). Because RHR correlates with cardiorespiratory fitness, which could potentially influence the risk of criminal convictions and injuries, we also adjusted for maximal workload (W_{max}, expressed in Watt) achieved in an exercise test with a cycle ergometer during the conscription testing.[19] W_{max} was available for 572,610 men with a non-missing RHR value. The W_{max} value was divided by weight to take into account the effect of body size. Birth and conscription years were included to adjust for potential cohort and period effects.

Statistical methods

We conducted Cox proportional hazard models to estimate the relative hazard of violent crime and other outcomes across the studied age period starting from the month of conscription. The crime and injury outcomes were analyzed separately, and only outcomes occurring after the conscription were included in the primary analyses. The participants were followed until the first occurrence of the respective outcome. Those for whom the studied outcome did not occur within the study period contributed person-time at risk until the end of follow-up (December 31, 2009), emigration, or death, whichever occurred first.

In the main analyses, we conducted four Cox regression models for each outcome using a quintile categorization of RHR. We chose quintile categorization as an illustrative way to analyze the associations while allowing for potential non-linearity. Graphical inspection of the Schoenfeld residuals for RHR did not reveal violations of the proportional hazards assumption. The first model only adjusted for birth and conscription years. The second model included physical and cardiovascular covariates, and the third model added psychiatric disorders, IQ, and childhood SES. The fourth model also adjusted for cardiorespiratory fitness in the subset of men with exercise test data. The models were conducted with adjustment of standard errors for the non-independence of brothers using a robust sandwich estimator.

Further analyses were conducted to study the associations between RHR and specific crime types. We classified violent crimes as severe or less severe based on whether they were associated with custodial sentences (imprisonment, forensic psychiatric inpatient care, or closed institutional youth care) or not, and conducted separate Cox regression models for the two. We also conducted separate Cox models for sexual crimes in men without non-sexual violence, and for drug crimes, property crimes, and traffic crimes in men without violent convictions. A follow-up analysis of RHR and age at first conviction was also conducted among men with follow-up until age 40 and who had their first violent conviction by that age (N = 27,313).

We conducted several sensitivity analyses to rule out possible alternative explanations. First, we tested the associations of RHR and crimes after excluding men who had any convictions before conscription. This was done to rule out the possibility that having conducted crimes could have influenced RHR. Second, because antisocial outcomes occurring later in life may have a partly different background than those occurring at a younger age, we investigated associations between RHR and crimes which took place before the age of 30. Third, to rule out any potential bias due to time periods with low coverage for RHR data, we evaluated the associations with criminality using only data from the conscription years with more complete RHR coverage (determined by comparing the number of observations with non-missing RHR value with other variables from the conscription). Further, we compared men with and without an RHR value on the outcome measures and covariates. Finally, to complement missing RHR data and to replicate the results using another measure of autonomic functioning, we repeated the analyses using systolic blood pressure (SBP), known to correlate with RHR[20] and available from the conscription testing for 1,222,567 men.

Results

Baseline characteristics of the 710,264 men with RHR data are presented in Table 1. Mean (SD) age at conscription was 18.2 (0.46) and the mean (SD) of RHR was 72.2 (12.8). Table 2 displays the rates of all studied outcomes by quintiles of RHR during the follow-up. During 12,869,207 person years of follow-up, a total of 40,093 men were convicted of a violent crime. The mean follow-up time was 18.1 years for violent crimes, 16.1 years for non-violent crimes and accident injuries, and 18.7 years for assault injuries. For all outcomes, the length of follow-up ranged from 1 month to 35.7 years. Figure 1 shows the Kaplan-Meier survival curves for violent criminality; curves for the other outcomes are Supplementary Figures 1-3.

Association with criminality and with injuries due to assaults and accidents

Table 3 gives results of the Cox regression models in the full sample. Having a lower RHR predicted an increased hazard of violent criminality. Compared to men in the highest quintile of the RHR distribution (RHR ≥ 83 bpm), those in the lowest quintile (RHR ≤ 60 bpm) had 24% higher hazard of violent crimes when only birth and conscription years were adjusted for (First model). Adjusting for physical and cardiovascular covariates in the second model, and for psychiatric morbidity, IQ, and childhood SES in the third model resulted in even higher hazard ratios. Adjustment for cardiorespiratory fitness in the fourth model did not reduce the associations.

Associations with non-violent criminality were similar but somewhat weaker, whereas associations with assault and accident injuries were of the same magnitude as those with violent crimes.

Association with subtypes of crime

Results for specific crime types are given in Table 4. Adjusting for all covariates, low RHR was a stronger predictor of severe than less severe violence (hazard ratio [95% CI]: 1.67 [1.55–1.79] *vs*. 1.42 [1.36–1.49]). With the exception of sexual crimes, the risk for all crime types was higher among men with a lower RHR. Age at first violent conviction was on average 0.32 (95% CI: 0.54–0.10) years lower for men in the lowest RHR quintile as compared with the highest quintile (eTable 1).

Sensitivity analyses

In sensitivity analyses, the observed associations with RHR were not affected by excluding men with convictions before conscription, excluding crimes after age 30, or excluding conscription years with poor coverage for RHR (eTable 2). Comparison of men with and without RHR data revealed no systematic differences (eTable 3). Analyses using SBP instead of RHR replicated the association with violent and non-violent crimes, and with assault injuries (eTable 4). Adjusting for all covariates, men in the lowest SBP quintile (SBP<120 mmHg) had 38% (95% CI: 34–42%) higher hazard of violent crime than men in the highest SBP quintile (SBP≥140 mmHg). The correlation between RHR and SBP was moderate (ρ = 0.25, 95% CI: 0.25–0.25).

Discussion

In a nationwide sample of 700,000 men we found lower RHR in late adolescence to predict an increased risk of violent criminality in adulthood, confirming findings from previous smaller studies on RHR as a predictor of adult criminal behavior.[10–13] After taking physical, cardiovascular, psychiatric, cognitive, and socioeconomic effects into account, the effect increased, resulting in 49% higher risk among men with the lowest RHR as compared to those with the highest RHR.

Our results confirm that in addition to being associated with aggressive and antisocial outcomes in childhood and adolescence,[6,7] low RHR increases the risk for violent and non-violent antisocial behaviors in adulthood. Notably, our results present population-based estimates from a sample more than 100 times larger than the combined samples used in the earlier meta-analyses of children and adolescents. In addition, our findings are longitudinal whereas earlier evidence mostly comes from cross-sectional studies, reducing the likelihood that the results are due to criminal behavior leading to low RHR.

To our knowledge no previous study has tested whether low RHR also predicts non-antisocial behavioral outcomes whose risk might be elevated due to risk taking, as would be predicted by the main theoretical accounts of the RHR–antisocial behavior association.[5,8,9] We hypothesized that low fear response or stimulation seeking tendencies would increase the risks of being a victim of an assault and being involved in accidents. Official register data of injury-related medical treatments and deaths confirmed that these outcomes were indeed predicted by RHR.

Our findings on the severity of violence and specific crime types are also novel. Low RHR was a stronger predictor of severe than less severe violence. Besides the association with violence, lower RHR predicted an increased risk for different types of crime, with the exception of sexual crimes. In line with previous studies[10], our primary analysis combined non-sexual and sexual violent crimes. The finding that RHR did not predict sexual offending in men without (non-sexual) violent crimes is interesting, and future studies should aim at clarifying the separate physiological risk factors for sexual and violent crimes.

Our findings are compatible with the theoretical interpretations of low RHR reflecting low arousal or low fear responding. In the low arousal theory, antisocial behavior, including violence, is viewed as stimulating for some individuals. The view is supported by the findings that sensation seeking tendencies are associated with aggressive and risk-taking behaviors.[14,21] The fearlessness theory, on the other hand, is based on the assumption that although measured at physical rest, RHR indexes a physiological reaction to a mildly stressful testing situation.[5] It is supported by studies using other autonomic measures at manipulated experimental conditions: antisocial children and adolescents are characterized by reduced fear conditioning as indexed by skin conductance and eye blink startle responses to aversive stimuli.[22,23] Two recent studies of adolescents reported sensation seeking as a possible mediator in the association between RHR and aggression.[24,25] The present data, however, could not differentiate between the two theoretical accounts.

Further, individual differences in heart rate are influenced by genetic differences,[26,27] and at least one twin study has found low RHR and antisocial behavior to be genetically correlated in childhood.[28] Understanding the genetic and environmental mechanisms linking low RHR with the risk for antisocial behavior should be a major goal for future research.

Our results should be considered in combination with some limitations. First, our study only included men, and the results may not generalize to women. Second, officially registered criminal convictions were studied which could have biased the results because not all committed violent and non-violent criminal acts result in convictions. However, it is unclear how RHR might be related to the risk of being convicted, and the analyses were adjusted for factors such as IQ, SES and psychiatric morbidity, which could influence the likelihood of convictions. Further, the observed associations with inpatient and outpatient treatments and deaths due to injuries supported the validity of the crime data. Third, RHR data were only available for approximately half of the conscripted cohorts of men. Men with missing RHR were not found to differ systematically from those with RHR, and the analyses were repeated with similar results using SBP which was available for a much larger sample.

Conclusions

Among Swedish men, lower RHR in late adolescence predicted an increased likelihood of committing violent and non-violent crimes, being a victim of an assault, and being involved in accidents. The associations were not explained by physical, cardiovascular, psychiatric, cognitive, or socioeconomic factors. RHR and other autonomic measures merit further study in the development and prevention of violence and antisocial behavior.

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Author Contributions: Dr Latvala had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: All authors.

Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: Latvala.

Critical revision of the manuscript for important intellectual content: All authors.

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Figure title: Kaplan-Meier survival curves for violent criminality by quintiles of resting heart rate

Table 1. Baseline characteristics of men born 1958–1991 by quintiles of resting heart rate measured at mandatory military conscription

	Resting heart rate quintiles						
Variable	1st (35–60 bpm)	2nd (61–67 bpm)	3rd (68–74 bpm)	4th (75–82 bpm)	5th (83–145 bpm)	Total sample	N
Mean (SD) age at conscription (years)	18.2 (0.45)	18.2 (0.45)	18.2 (0.46)	18.2 (0.46)	18.2 (0.47)	18.2 (0.46)	710 264
Mean (SD) resting heart rate (bpm)	55.2 (4.3)	64.1 (2.0)	70.8 (2.0)	78.3 (2.3)	91.3 (7.9)	72.2 (12.8)	710 264
Mean (SD) height (cm)	180.1 (6.4)	179.8 (6.5)	179.7 (6.5)	179.6 (6.6)	179.3 (6.6)	179.7 (6.5)	709 143
Mean (SD) weight (kg)	71.6 (9.6)	71.3 (10.3)	71.3 (10.8)	71.5 (11.6)	71.9 (12.9)	71.5 (11.1)	709 052
Mean (SD) body mass index (kg/m^2)	22.1 (2.6)	22.0 (2.8)	22.0 (3.0)	22.2 (3.2)	22.3 (3.6)	22.1 (3.1)	709 044
Mean (SD) systolic blood pressure (mm Hg)	125.6 (10.6)	127.2 (10.5)	128.7 (10.5)	130.2 (10.5)	133.3 (10.8)	129.1 (10.9)	707 398
Mean (SD) diastolic blood pressure (mm Hg)	66.6 (9.0)	66.7 (9.0)	66.9 (9.2)	67.4 (9.4)	68.9 (9.8)	67.3 (9.3)	709 034
Mean (SD) general cognitive ability (stanines)	5.3 (1.8)	5.3 (1.8)	5.2 (1.9)	5.2 (1.9)	5.2 (1.9)	5.2 (1.9)	707 035
Any psychiatric disorder, N (%)	11 425 (8.6)	12 375 (9.0)	14 593 (9.4)	14 064 (9.7)	14 083 (10.1)	66 540 (9.4)	710 264
Childhood SES, N (%)							710 264
Low	49 768 (37.5)	53 192 (38.8)	61 892 (39.8)	58 494 (40.2)	57 823 (41.5)	281 169 (39.6)	
Medium	49 419 (37.3)	49 526 (36.1)	55 048 (35.4)	50 527 (34.8)	47 014 (33.7)	251 534 (35.4)	
High	27 278 (20.6)	27 889 (20.3)	31 557 (20.3)	29 941 (20.6)	28 857 (20.7)	145 522 (20.5)	
Missing	6 130 (4.6)	6 510 (4.8)	7 190 (4.6)	6 392 (4.4)	5 817 (4.2)	32 039 (4.5)	
Mean (SD) maximal workload (W)	290.9 (48.2)	279.8 (48.2)	273.0 (47.8)	267.7 (47.8)	259.1 (45.8)	274.0 (48.7)	572 610

Table 2. Rates of violent and non-violent criminality, and assault and accident injuries by quintiles of resting heart rate

	Resting heart rate quintiles					
Variable	1st (35–60 bpm)	2nd (61–67 bpm)	3rd (68–74 bpm)	4th (75–82 bpm)	5th (83–145 bpm)	Total sample
No of men	132 595	137 117	155 687	145 354	139 511	710 264
No of violent crimes	7 634	8 076	9 163	8 146	7 074	40 093
Person years at risk	2 237 629	2 444 727	2 862 720	2 711 143	2 612 988	12 869 207
Rate (95% CI) per 10 000 person years at risk	34 (33–35)	33 (32–34)	32 (31–33)	30 (29–31)	27 (26–28)	31 (31–31)
No of non-violent crimes[a]	19 398	20 597	23 563	21 594	19 102	104 254
Person years at risk	1 868 486	2 032 506	2 381 334	2 267 204	2 220 691	10 770 221
Rate (95% CI) per 10 000 person years at risk	104 (102–105)	101 (100–103)	99 (98–100)	95 (94–97)	86 (85–87)	97 (96–97)
No of treatments and deaths due to assaults	3 690	3 697	3 954	3 470	3 047	17 858
Person years at risk	2 313 934	2 529 226	2 963 510	2 800 945	2 689 264	13 296 879
Rate (95% CI) per 10 000 person years at risk	16 (15–16)	15 (14–15)	13 (13–14)	12 (12–13)	11 (11–12)	13 (13–14)
No treatments and deaths due to accidents	48 365	48 173	53 014	47 055	41 694	238 301
Person years at risk	1 938 697	2 152 060	2 546 534	2 434 755	2 373 870	11 445 916
Rate (95% CI) per 10 000 person years at risk	249 (247–252)	224 (222–226)	208 (206–210)	193 (192–195)	176 (174–177)	208 (207–209)

[a]Among men not convicted of violent crimes

Table 3. Cox proportional hazard ratios (95% confidence intervals) for violent and non-violent criminality, and for assault and accident injuries

	Model adjusted for birth and conscription years	Model additionally adjusted for height, weight, body mass index, and diastolic blood pressure	Model further adjusted for cognitive ability, psychiatric morbidity, and childhood SES	Model adjusted for all covariates and cardiorespiratory fitness[a]
Violent crime				
RHR quintiles: 1st (35–60 bpm)	1.24 (1.20–1.28)	1.28 (1.23–1.32)	1.39 (1.35–1.44)	1.49 (1.44–1.55)
2nd (61–67 bpm)	1.21 (1.18–1.25)	1.25 (1.21–1.29)	1.33 (1.29–1.38)	1.39 (1.34–1.44)
3rd (68–74 bpm)	1.19 (1.15–1.22)	1.21 (1.17–1.25)	1.27 (1.24–1.32)	1.32 (1.27–1.36)
4th (75–82 bpm)	1.11 (1.08–1.15)	1.13 (1.09–1.16)	1.16 (1.12–1.20)	1.19 (1.15–1.23)
5th (83–145 bpm)	1	1	1	1
Non–violent crime				
RHR quintiles: 1st (35–60 bpm)	1.20 (1.17–1.22)	1.21 (1.18–1.23)	1.25 (1.23–1.28)	1.33 (1.30–1.36)
2nd (61–67 bpm)	1.17 (1.15–1.19)	1.18 (1.15–1.20)	1.21 (1.19–1.24)	1.26 (1.23–1.29)
3rd (68–74 bpm)	1.14 (1.12–1.17)	1.15 (1.13–1.17)	1.18 (1.15–1.20)	1.20 (1.18–1.23)
4th (75–82 bpm)	1.10 (1.08–1.12)	1.10 (1.08–1.13)	1.12 (1.10–1.14)	1.13 (1.10–1.15)
5th (83–145 bpm)	1	1	1	1
Assaults injuries				
RHR quintiles: 1st (35–60 bpm)	1.31 (1.25–1.38)	1.34 (1.28–1.41)	1.39 (1.33–1.46)	1.41 (1.33–1.49)
2nd (61–67 bpm)	1.27 (1.21–1.33)	1.29 (1.22–1.35)	1.32 (1.26–1.39)	1.30 (1.23–1.38)
3rd (68–74 bpm)	1.19 (1.14–1.25)	1.21 (1.15–1.27)	1.23 (1.18–1.29)	1.22 (1.16–1.29)
4th (75–82 bpm)	1.10 (1.05–1.16)	1.11 (1.06–1.17)	1.13 (1.08–1.19)	1.09 (1.03–1.15)
5th (83–145 bpm)	1	1	1	1
Accident injuries				
RHR quintiles: 1st (35–60 bpm)	1.36 (1.34–1.38)	1.37 (1.35–1.39)	1.39 (1.38–1.41)	1.31 (1.29–1.33)
2nd (61–67 bpm)	1.26 (1.25–1.28)	1.27 (1.25–1.29)	1.29 (1.27–1.30)	1.23 (1.21–1.25)
3rd (68–74 bpm)	1.20 (1.18–1.22)	1.21 (1.19–1.22)	1.22 (1.20–1.23)	1.18 (1.16–1.20)
4th (75–82 bpm)	1.11 (1.10–1.13)	1.11 (1.10–1.13)	1.12 (1.10–1.13)	1.09 (1.08–1.11)
5th (83–145 bpm)	1	1	1	1

RHR, resting heart rate; bpm, beats per minute
[a] Data on cardiorespiratory fitness available for 572,610 men.
All hazard ratios: $P < .001$

Table 4. Cox proportional hazard ratios (95% confidence intervals) for specific violent and non-violent crime types

	Model adjusted for birth and conscription years	**Model adjusted for all covariates**[a]
Severe violent crime[b]		
RHR quintiles: 1st (35–60 bpm)	1.29 (1.21–1.37)	1.67 (1.55–1.79)
2nd (61–67 bpm)	1.28 (1.20–1.36)	1.50 (1.40–1.61)
3rd (68–74 bpm)	1.25 (1.17–1.32)	1.43 (1.34–1.53)
4th (75–82 bpm)	1.15 (1.08–1.23)	1.25 (1.17–1.34)
5th (83–145 bpm)	1	1
Less severe violent crime in men with no severe violence[c]		
RHR quintiles: 1st (35–60 bpm)	1.22 (1.17–1.27)	1.42 (1.36–1.49)
2nd (61–67 bpm)	1.19 (1.15–1.24)	1.36 (1.30–1.42)
3rd (68–74 bpm)	1.15 (1.11–1.19)	1.26 (1.21–1.31)
4th (75–82 bpm)	1.10 (1.06–1.14)	1.17 (1.12–1.22)
5th (83–145 bpm)	1	1
Sexual crime in men with no non-sexual violent crime		
RHR quintiles: 1st (35–60 bpm)	0.95 (.80–1.14)	1.06 (.87–1.30)
2nd (61–67 bpm)	1.04 (.88–1.24)	1.17 (.97–1.41)
3rd (68–74 bpm)	1.02 (.86–1.20)	1.09 (.91–1.30)
4th (75–82 bpm)	1.14 (.97–1.34)	1.19 (1.00–1.41)
5th (83–145 bpm)	1	1
Drug-related crime in men with no violent crime		
RHR quintiles: 1st (35–60 bpm)	1.19 (1.15–1.23)	1.43 (1.38–1.49)
2nd (61–67 bpm)	1.14 (1.11–1.18)	1.31 (1.26–1.36)
3rd (68–74 bpm)	1.13 (1.09–1.16)	1.23 (1.19–1.28)
4th (75–82 bpm)	1.07 (1.04–1.11)	1.12 (1.08–1.16)
5th (83–145 bpm)	1	1
Property crime in men with no violent crime		
RHR quintiles: 1st (35–60 bpm)	1.20 (1.15–1.24)	1.43 (1.37–1.49)
2nd (61–67 bpm)	1.17 (1.13–1.22)	1.32 (1.27–1.37)
3rd (68–74 bpm)	1.17 (1.12–1.21)	1.27 (1.22–1.31)
4th (75–82 bpm)	1.10 (1.06–1.15)	1.14 (1.10–1.19)
5th (83–145 bpm)	1	1
Traffic crime in men with no violent crime		
RHR quintiles: 1st (35–60 bpm)	1.18 (1.15–1.21)	1.28 (1.25–1.32)
2nd (61–67 bpm)	1.16 (1.13–1.19)	1.23 (1.20–1.26)
3rd (68–74 bpm)	1.14 (1.11–1.17)	1.18 (1.15–1.21)
4th (75–82 bpm)	1.10 (1.08–1.13)	1.12 (1.09–1.15)
5th (83–145 bpm)	1	1

[a]Adjusted for birth and conscription years, height, weight, body mass index, diastolic blood pressure, cognitive ability, psychiatric morbidity, childhood SES, and cardiorespiratory fitness

[b]Severe violent crimes (N convictions: 10,911) were associated with custodial sentences (imprisonment, forensic psychiatric inpatient care, or closed institutional youth care)

[c]Less severe violent crimes (N convictions: 27,325) were not associated with custodial sentences

Hazard ratios for sexual crimes: $P > .05$; all other hazard ratios: $P < .001$