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Resting Pulse Rate Reference Data for Children, Adolescents, and Adults: United States, 1999–2008

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Abstract

Objective—This report presents national reference data on resting pulse rate (RPR), for all ages of the U.S. population, from 1999–2008.

Methods—During 1999–2008, 49,114 persons were examined. From this, a normative sample comprising 35,302 persons was identified as those who did not have a current medical condition or use a medication that would affect the RPR. RPR was obtained after the participant had been seated and had rested quietly for approximately 4 minutes.

Results—RPR is inversely associated with age. There is a mean RPR of 129 beats per minute (standard error, or SE, 0.9) at less than age 1 year, which decreases to a mean RPR of 96 beats/min (SE 0.5) by age 5, and further decreases to 78 beats/min (SE 0.3) in early adolescence. The mean RPR in adulthood plateaus at 72 beats/min (SE 0.2) ($p < 0.05$ for trend). In addition, there is a significant gender difference, with the male pulse rate plateauing in early adulthood, while the female resting pulse plateaus later when middle-aged. There are two exceptions, that is, infants under age 1 year and adults aged 80 and over, when the mean RPR is statistically and significantly higher in females than in males (females under age 20 have an RPR of 90 beats/min, SE 0.3, and males under age 20 have an RPR of 86 beats/min, SE 0.3, $p < 0.05$; females aged 20 and over have an RPR of 74 beats/min, SE 0.2, and males aged 20 and over have an RPR of 71 beats/min, SE 0.3, $p < 0.05$). After controlling for age effects, non-Hispanic black males have a significantly ($p < 0.001$) lower mean RPR (74 beats/min) than non-Hispanic white males (77 beats/min) and Mexican-American males (76 beats/min). Among females, non-Hispanic black females (79 beats/min) and Mexican-American females (79 beats/min) had statistically and significantly ($p < 0.01$) lower mean RPRs compared with non-Hispanic white females (80 beats/min). Among males, the prevalence of clinically defined tachycardia (abnormally fast heart rate, RPR 100 beats/min) is 1.3% (95% CI = 1.1–1.7), and the prevalence of clinically defined bradycardia (abnormally slow heart rate, RPR < 60 beats/min) is 15.2% (95% CI = 14.1–16.4). For adult females, these prevalences are 1.9% (95% CI = 1.6–2.3) for clinical tachycardia and 6.9% (95% CI = 6.2–7.8) for clinical bradycardia. Controlling for age, males have higher odds (2.43, 95% CI = 2.09–2.83) of having bradycardia, and notably lower odds (0.71, 95% CI = 0.52–0.97) of having tachycardia than women.

Conclusions—The data provides current, updated population-based percentiles of RPR, which is one of the key vital signs routinely measured in clinical practice.

Keywords: NHANES pulse reference • U.S. population

Introduction

Resting pulse rate (RPR) is one of the key vital signs routinely measured in clinical practice. For routine clinical practice, it is important to have reference ranges for healthy people and reference ranges that are specific for the U.S population. Such U.S. population-based reference ranges for RPR were first reported based on the first U.S. National Health and Nutrition Examination Survey (NHANES I) data, collected from 1971–1975 (1,2). Unfortunately, however, U.S. reference ranges for RPR have not been updated since that time.

NHANES I data showed significant age and gender variation in RPR and provided some of the initial epidemiologic evidence that RPR may be an independent risk factor for cardiovascular disease. Specifically, over a follow-up period of 6–13 years, data from the NHANES I Epidemiologic Follow-up Study showed a 40% elevated relative risk for a coronary heart disease (CHD) incidence in older white males with a baseline pulse greater than 84 beats/min. This was compared with older white males with a baseline pulse less than 74 beats/min, controlling for multiple risk factors (3,4). In addition, this study showed that

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in specific demographic subgroups, CHD incidences increased among those with an elevated pulse rate. This was also true for white females, black males, and black females. Females aged 50–64 years with an RPR greater than 76 beats per minute at baseline were 47% more likely to subsequently suffer from a coronary event when compared with women with an RPR of less than or equal to 62 beats/min (5). Later studies indicate that a relatively high RPR has direct detrimental effects on the progression of coronary atherosclerosis, on the occurrence of myocardial ischemia and ventricular arrhythmias, and on left ventricular cardiac function (6). A number of recent studies suggest that RPR is an independent predictor of both cardiovascular and all-cause mortality among males and females (7,8). The purpose of this report is to provide updated national RPR reference range data for the U.S. population based on NHANES 1999–2008 survey data.

Methods

NHANES is conducted to assess the health and nutritional status of the civilian, noninstitutionalized U.S. population. Prior to 1999, NHANES surveys were conducted periodically. The survey became continuous in 1999. Nationally representative samples are selected annually using a complex, multistage sampling design that employs probability, stratified, and cluster sampling to produce U.S. national prevalence estimates. Publicly available data files are released biannually. For NHANES 1999–2008, non-Hispanic black persons, Mexican-American persons, adolescents aged 12–19, adults aged 60 and over, pregnant women (1999–2006 only), and people of low income were oversampled to obtain more reliable statistical estimates for those specific demographic subgroups. In-person household interviews and health examinations are used to collect NHANES data. All NHANES health examinations are conducted in a mobile examination center (MEC), which provides a standardized environment for data collection. NHANES is conducted with Institutional Review Board approval and documented consent from all participants (9).

Sample size and exclusion criteria

From 1999 through 2008, 63,882 people were included in the eligible sample, 51,623 people (about 80%) were interviewed in the household, and 49,114 people were examined at the MEC. Of those examined, 1,324 participants had missing resting pulse data, and 180 participants had "recorded age at the time of interview" but not at "physical exam time." Therefore, 47,610 participants were available for data analysis (75% of the total eligible sample). The purpose of the RPR study was to define the normative U.S. reference range for resting pulse, therefore, exclusion criteria were used to create an analytic study sample that was free of physiological, pathological, and pharmacologic factors that could have an effect on the resting pulse.

Specifically excluded from our analytic sample were the following: 11 participants with pulse rates greater than or equal to 200 beats/min; 740 participants with white blood cell counts of greater than or equal to 12.9 x 10^9/L or who had a high-sensitivity C-reactive protein of 10 mg/dl and greater (that is, those likely to have a current infectious illness); 9,083 participants currently taking prescription medications that could affect the heart rate (decongestants, adrenergic agonists for glaucoma, amphetamine, dextroamphetamine, digitalis, β-blockers, calcium channel blockers, and β-agonist bronchodilators); 1,331 pregnant women; 523 participants with irregular pulses; and 462 participants with abnormal thyroid function (TSH less than 0.34 IU/L or greater than 5.6 IU/L). The total sample available for the normative analysis of RPR was 14,200 adults (aged 20 and over) and 21,102 children and adolescents (under age 20), which was 72% of the total participants examined in the MEC.

Heart rate measurements and criteria

RPR was obtained by the examining physician in the MEC. The participant's pulse was taken by physical examination in the seated position after he or she had been seated and resting quietly for approximately 4 minutes. For children aged 4 and under, the physician counted the heart rate for 30 seconds by auscultation of the heart at approximately the left fourth intercostal space, midclavicular line, using the bell device of the pediatric stethoscope. For participants over age 4, a radial pulse rate was obtained manually by counting for 30 seconds. All obtained RPRs were multiplied by two to provide a 60-second RPR in beats per minute (10). Resting electrocardiogram was not obtained in NHANES 1999–2008.

To ensure accurate results, there was thorough physician training on the collection of pulse-rate data and extensive quality control monitoring of the pulse-rate data collection. A methodological limitation of the cross-sectional measurement of RPR was that the measurement was obtained only on a one-time basis for each participant. For each RPR, there was both sampling measurement error and some degree of biological variation in measurement. These could not be directly assessed given the available data; however, during NHANES survey years 2001–2002, second-day repeat examinations were performed for a selected convenience sample of NHANES participants. Analysis of this data for RPR showed an intraclass correlation of 0.69 between the values for RPR obtained on the two different exam days (data not shown).

In addition to estimating means and percentiles for RPR in the major U.S. demographic subgroups, estimates were produced for the prevalence of clinically abnormal rapid heart rate (tachycardia) and slow heart rate (bradycardia). Two definitions were used to explain the prevalence of clinical tachycardia and bradycardia:

1. The traditional "clinical consensus" definition that is employed as a

standard in clinical practice (tachycardia = RPR > 100 beats/min; bradycardia = RPR < 60 beats/min).

2. A revised clinical guideline based on an analysis of current cardiology practice and epidemiologic survey data (tachycardia = RPR > 90 beats/min; bradycardia = RPR < 50 beats/min) (11–18).

Statistical analyses

The analyses of RPR provide population means, standard errors of the means, and selected percentiles (1%, 2.5%, 5%, 10%, 25%, 50%, 75%, 90%, 95%, 97.5%, and 99%). All estimates were weighted using the NHANES MEC examination sample weights to produce nationally representative estimates. The NHANES examination sample weights incorporate the differential probabilities of participant selection and include adjustments for the oversampling of selected populations, noncoverage, and nonresponse. Statistical analyses used SAS (Release 9.2; SAS Institute Inc, Cary, N.C.) and SUDAAN (Release 10.0; Research Triangle Institute, Research Triangle Park, N.C.), with standard errors estimated using the SUDAAN Taylor series linearization. The LOESS procedure (Proc SGPLOT) in SAS was used to create the smoothed graphs. This procedure uses locally weighted polynomial regression to fit a smoothed line. The reliability of the estimates was determined using the relative standard error (RSE), a calculated figure defined as the ratio of the standard error to the mean. A recommended RSE greater than 30% was used to identify unreliable estimates (9). Percentile values that did not meet the standard of reliability or precision were replaced with asterisks (*) in all tables. The differences between gender means were tested using *t*-tests, and a regression analysis was used to test for linear trend in age. Regression analysis also was performed using the Satterthwaite-adjusted *F*-test to assess the independent contribution of race and ethnicity to RPR controlling for the covariates of sex, age, and age squared. An alpha level of less than or equal to 0.05 was considered statistically significant. Prevalence estimates for race and ethnicity and gender subgroups were age adjusted (9). For reporting the results of the normative analysis, age was categorized according to the "NHANES 1999–2000 Analytic Guidelines," which are based on the survey sample domains: less than 1, 1, 2–3, 4–5, 6–8, 9–11, 12–15, 16–19, 20–39, 40–59, 60–79, and greater than 80 (9). Race and ethnicity, based on self-reported information, was classified as non-Hispanic white, non-Hispanic black, and Mexican American. Participants not fitting the above self-classifications were classified as "other." Estimates are not shown separately for persons in the residual "other" racial-ethnic group, although these persons are included in the totals and strata for the analyses by age groups and sex (10).

Results

An overall analysis of the results for the U.S. population (1999–2008) confirms the findings of previous NHANES studies, concluding that there is significant variation in RPR by age and sex (Table 1). Table 1 illustrates the inverse association of RPR with age with a rapid mean pulse rate of 129 beats/min, characteristic of infancy decreasing to a mean pulse rate of 96 beats/min by age 5 years. Thereafter, there is a slower decrease in RPR during childhood and early adolescence to the 83–78 beats/min range. Mean RPR rate then again decreases slightly and plateaus in adulthood at a mean of 72 beats/min. These decreases of RPR are statistically significant (*p* is less than 0.05 for trend). Similarly, a statistical analysis of RPR was performed by gender (data not shown), confirming that there are significant gender differentials in RPR as well (*p* is less than 0.05). Because of the known differences in RPR within these major demographic subgroups, the normative U.S. population's RPR statistical estimates for the study are presented by age and gender subgroups.

RPR in children and adolescents

The overall mean RPR for male children and adolescents is 86 beats/min. The mean RPR ranges from 128 beats/min in male infants under age 1 to 72 beats/min in male adolescents aged 16–19 (Table 2). Figure 1 presents the smoothed 5th and 95th percentile, median (50%), and interquartile (25% and 75%) ranges for males, and shows the decrease in mean RPR that occurs during the transition from infancy to early adulthood (Figure 1; note that persons with a current medical condition or medication use that would affect the RPR are excluded). The graph demonstrates the decline in RPR that typically occurs between infancy and early childhood, as well as the more gradual decline to lower RPRs (which are more typical for adults) around ages 15–20.

The general trends for female children and adolescents are similar to those for male children and adolescents (Table 3). The overall mean RPR for female children and adolescents is 90 beats/min. The mean RPR ranges from 130 beats/min for female infants under age 1 year to 79 beats/min in female adolescents aged 16–19 (Table 3). Figure 2 presents the smoothed 5th and 95th percentile, median (50%), and interquartile (25% and 75%) ranges for females, again showing the decrease in mean RPR from infancy to early childhood, as well as the more gradual decline to lower RPRs, where RPR values are more similar to those prevalent among adults (Figure 2). This figure excludes persons with a current medical condition or medication use that would affect the RPR. Figure 2 indicates that a change to the lower mean RPR for adolescent females may begin to occur around ages 15–20.

RPR in adults

The overall mean RPR for adult males is 71 beats/min. The range of mean RPRs in males is similar across

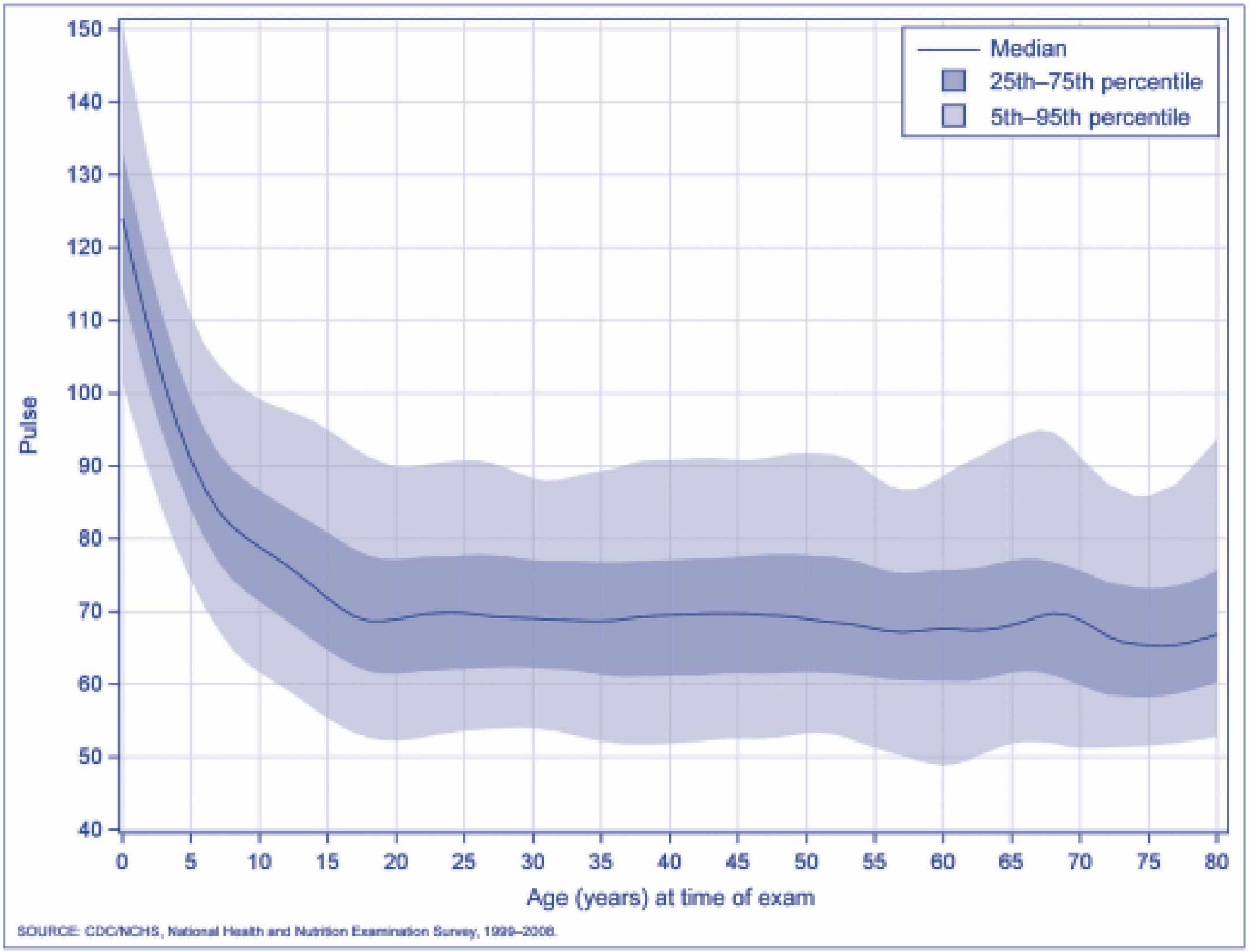

Figure 1. Resting pulse rates for U.S. males, by age: National Health and Nutrition Examination Survey, 1999–2008

the four adult age groups: 71 beats/min in those aged 20–39; 71 beats/min in those aged 40–59; 70 beats/min in those aged 60–79; and 71 beats/min among those aged 80 and over (Table 2). Similarly, Figure 1 presents the smoothed 5th and 95th percentile, median (50%), and interquartile (25% and 75%) ranges for males, showing very little change in median RPR among males from early adulthood into old age.

The overall mean RPR for women is 74 beats/min (Table 3). The mean RPR is 76 beats/min among females aged 20–39 and 73 beats/min among females aged 40 and over. Figure 2 presents the smoothed median (50%) and interquartile (25% and 75%) RPR ranges for females. The overall trends in RPR by increasing age from childhood to adulthood are similar to those found in males.

Statistical analysis of age and RPR

Further statistical analysis was performed to assess the effects of increasing age on RPR. An analysis of mean RPR by age categories confirms that RPR decreased significantly with increasing age (p is less than 0.0001 for trend) for children and adolescents of both sexes. In a similar analysis for the adult age ranges, for males, there was no statistically significant trend in RPR across the four adult age groups (p is greater than 0.05 for trend); however, this was not the case for adult females, where a significant trend in decreasing RPR was seen across the four adult age groups (p is less than 0.05 for trend).

Figure 3 is a box-and-whisker plot where the horizontal line represents the median, the diamond represents the mean, the box represents the interquartile range (25th and 75th percentile) distribution, the top and bottom horizontal lines (the ‘‘whiskers’’) represent the largest and smallest values not considered outliers, while the circles represent outlier observations. This figure excludes persons with a current medical condition or medication use that

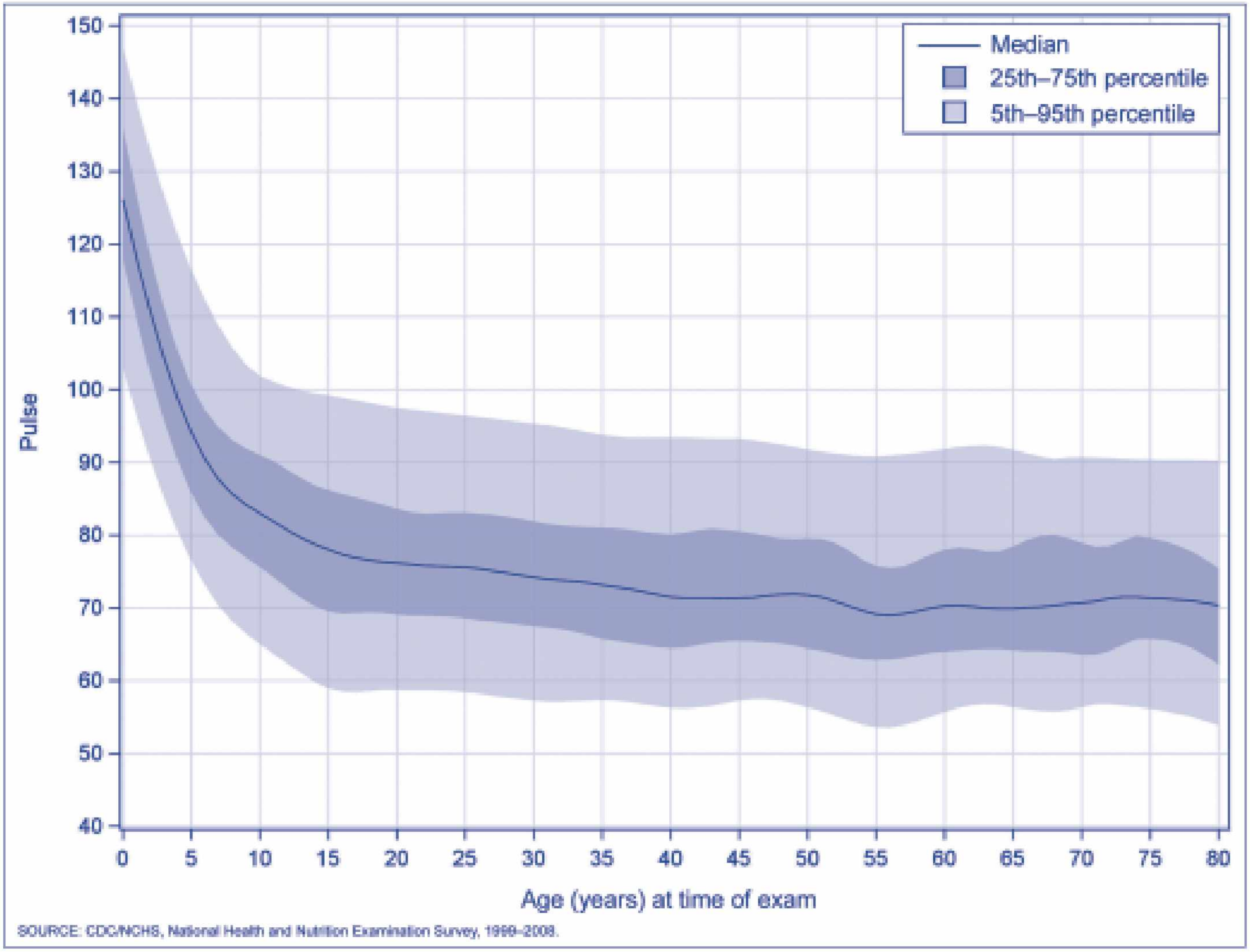

Figure 2. Resting pulse rates for females, by age: National Health and Nutrition Examination Survey, 1999–2008

would affect the RPR. Figure 3 displays RPR values by sex and age group. These graphs suggest that for males, the age-associated decrease in RPR plateaus to a relatively steady-state adult level around age 16, while for females the age-associated decrease in RPR appears be more gradual, plateauing much later in adulthood around age 40. To further assess these findings, a gender-specific regression analysis was performed in which ordinal age groups were contrasted against each other sequentially, controlling for the covariate race and ethnicity. The analysis shows that for males up to age 19, all mean RPR comparisons between successive age groups has statistically significant decreases in mean RPR (Satterthwaite-adjusted $F = p < 0.01$, data not shown). However, this pattern changes when the mean RPR for the 16–19 age group is contrasted with the 20–39 age group. With this contrast, the mean RPR difference between the age groups is no longer statistically significant (Satterthwaite-adjusted F, $p = 0.18$), providing statistical evidence that this age range in males represents the transition to adult RPR values. A similar analysis was performed for females. For females, the statistically defined transition point from progressive significant decreases in the mean RPR by age group to a plateau where no statistically significant differences occur is observed between the 40–59 and the 60–79 age groups (data not shown).

Figure 4 shows histograms overlaid by smoothed normal curves representing the frequency distribution of RPR by age groups and sex. This figure excludes persons with a current medical condition or medication use that would affect the RPR. Overall, the curves appear to approximate the normal distribution with a few outliers on both the left and the right of the curves. The curves also appear to be progressing from a platykurtic to a leptokurtic shape, which suggests the narrowing of the distribution with increased age.

Statistical analysis of sex and RPR

When the mean RPRs for males and females are compared within each of the

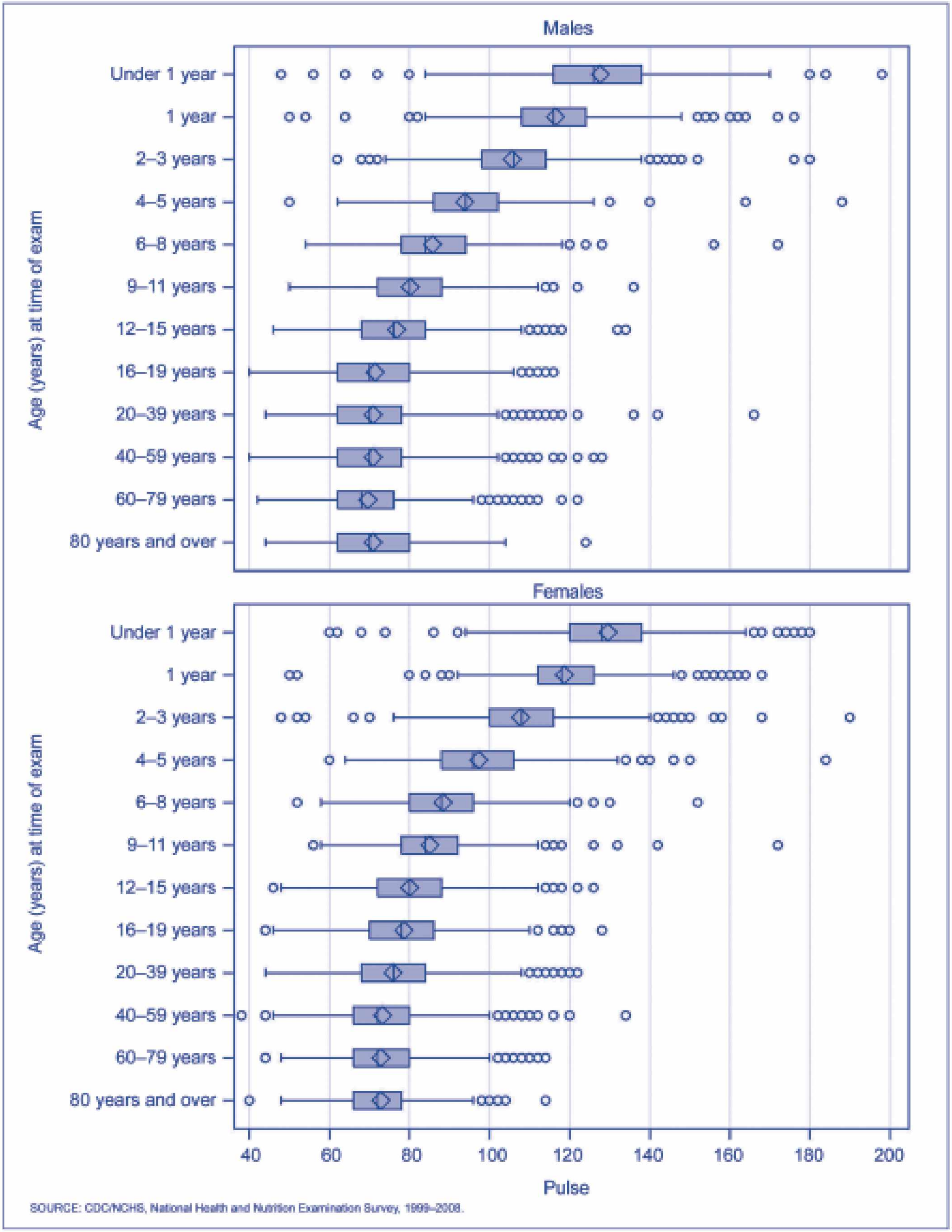

Figure 3. Box plot of resting pulse rate for U.S. males and females, by age group: National Health and Nutrition Examination Survey, 1999–2008

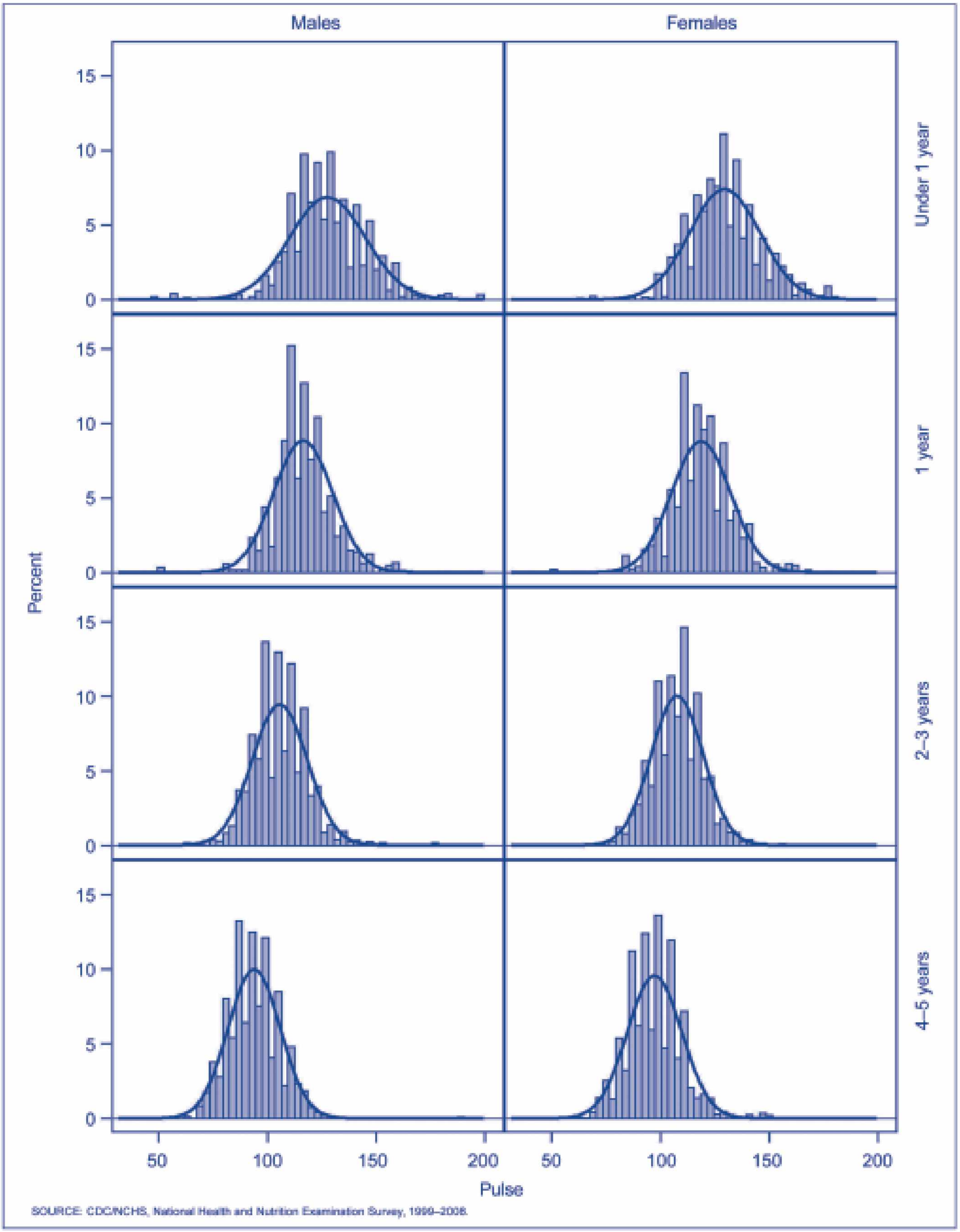

Figure 4A. Histograms and smoothed distributions of resting pulse rate for U.S. males and females, by age group: National Health and Nutrition Examination Survey, 1999–2008

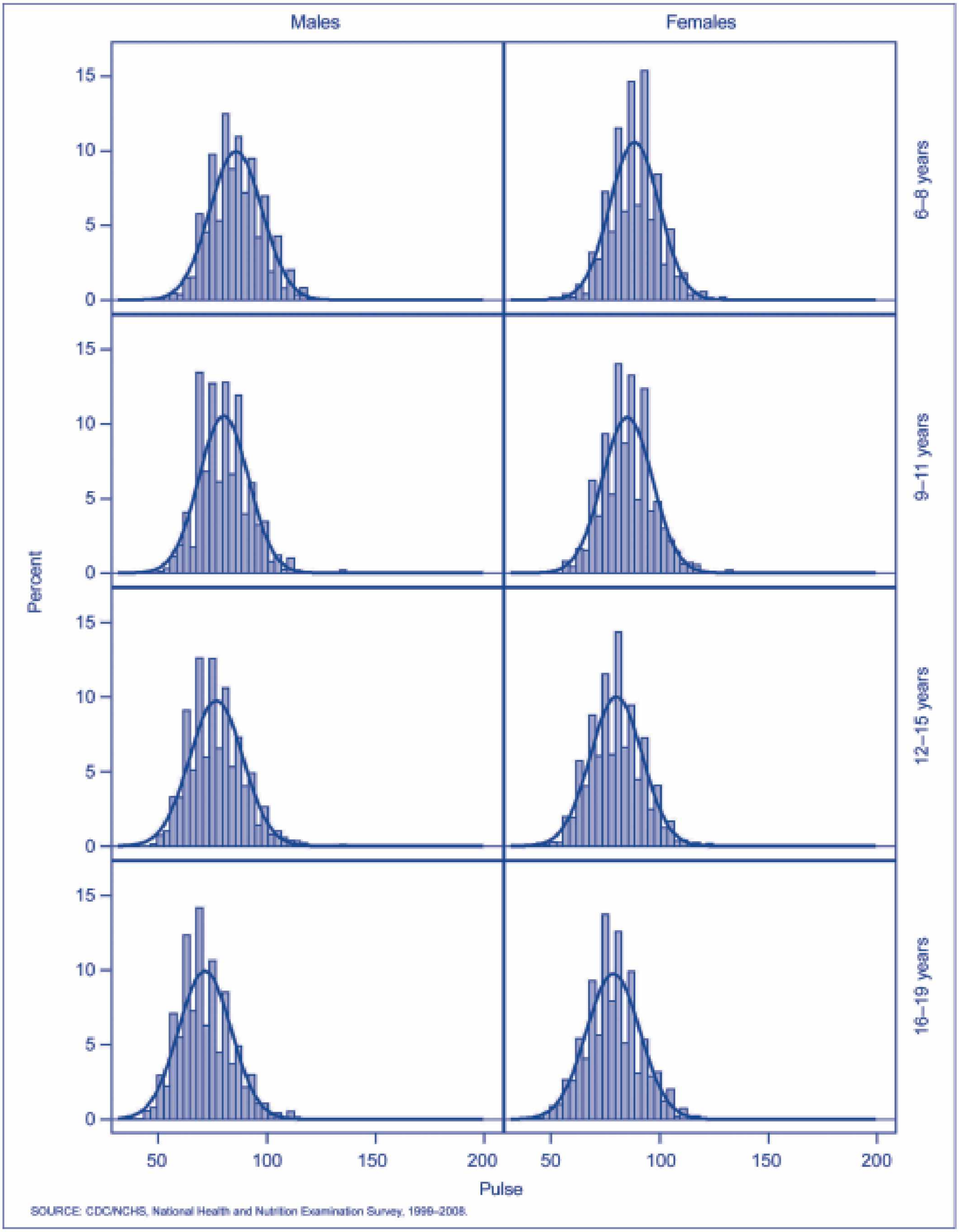

Figure 4B. Histograms and smoothed distributions of resting pulse rate for U.S. males and females, by age group: National Health and Nutrition Examination Survey, 1999–2008

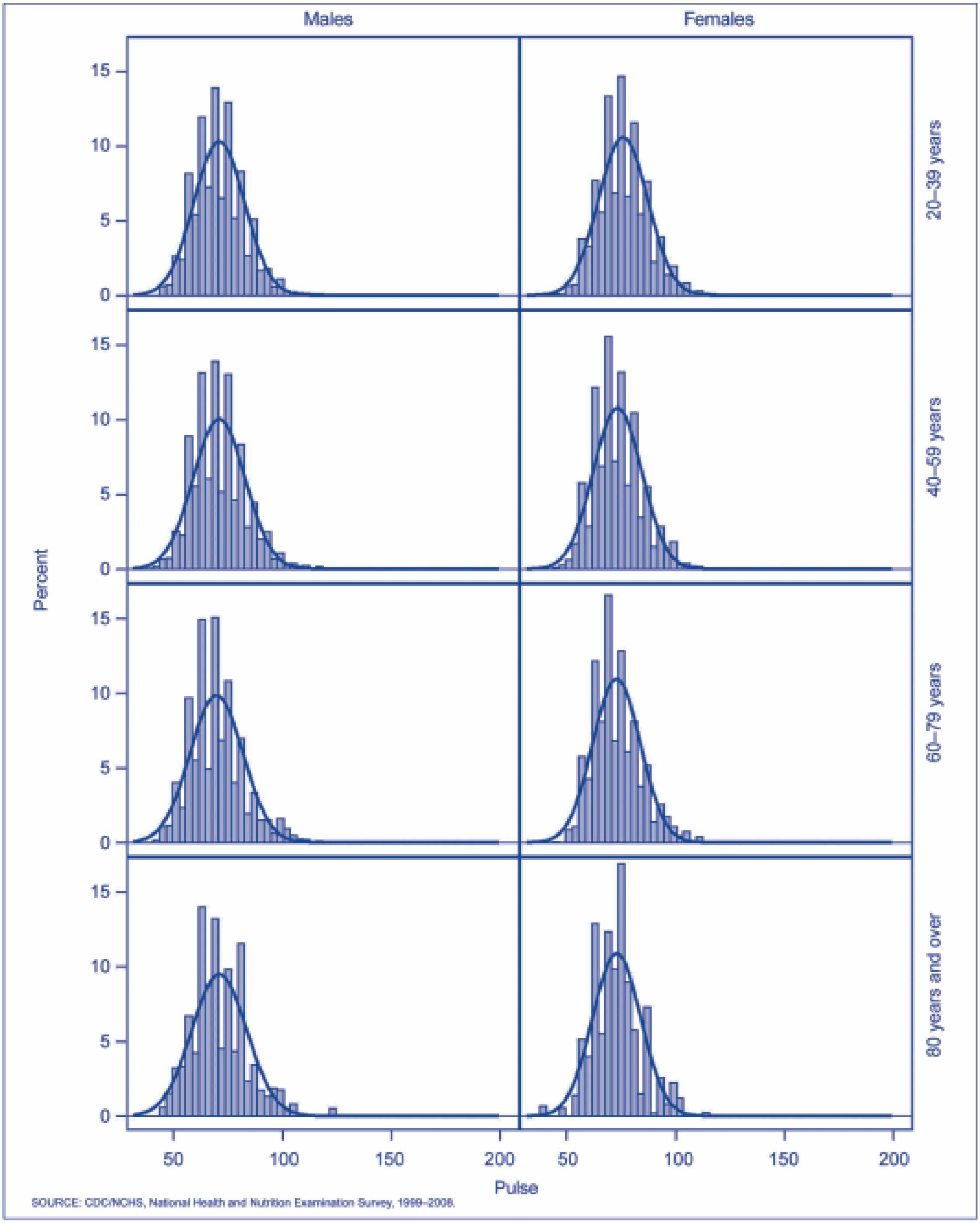

Figure 4C. Histograms and smoothed distributions of resting pulse rate for U.S. males and females, by age group: National Health and Nutrition Examination Survey, 1999–2008

eight childhood and adolescent age groups (Tables 2 and 3), mean RPRs are found to be significantly different by sex, with female children and adolescents having a higher RPR than male children and adolescents. The exception is infants under age 1 year (means infant males = 128 beats/min, infant females = 130 beats/min; $p > 0.05$). When comparing male RPRs with female RPRs within each of the four adult age categories, female mean RPRs were significantly higher than male mean RPRs (p is less than 0.05), except for the oldest age group (80 and over), in which the difference between sex is no longer statistically significant ($p > 0.05$).

RPR by race and ethnicity

RPR varied across adult racial and ethnic categories, but more so in females than in males. An analysis was performed using age-adjusted prevalence estimates for the main race and ethnicity subgroups stratified by sex. After controlling for age, non-Hispanic black males have a significantly ($p > 0.001$) lower mean RPR (74 beats/min) than non-Hispanic white males (77 beats/min) and Mexican-American males (76 beats/min). Among females, both non-Hispanic black females (79 beats/min) and Mexican-American females (79 beats/min) have a statistically significantly ($p < 0.01$) lower mean RPR when compared with non-Hispanic white females (80 beats/min).

Prevalence of tachycardia and bradycardia

The NHANES 1999–2008 normative sample data for RPR in adults aged 20 and over was used to estimate the prevalence of abnormally fast heart rate (tachycardia) and abnormally slow heart rate (bradycardia). Both the clinical consensus definition of tachycardia (RPR greater than 100 beats/min) and bradycardia (RPR less than 60 beats/min) and the revised clinical guideline of tachycardia (RPR greater than 90 beats/min) and bradycardia (RPR less than 50 beats/min) are presented (11–17). When using the traditional clinical definitions, the estimated prevalence of clinical tachycardia in the normative sample is 1.3% (95% CI = 1.1–1.7), and the prevalence of clinical bradycardia among adult males is 15.2% (95% CI = 14.1–16.4). For adult females, the overall prevalence of clinical tachycardia in the normative sample is 1.9% (95% CI = 1.6–2.3) and the prevalence of clinical bradycardia is 6.9% (95% CI = 6.2–7.8). By the traditional clinical definitions, males have higher age-adjusted odds (that is, 2.43; 95% CI = 2.09–2.83; $p < 0.05$) of having bradycardia and lower age-adjusted odds (that is, .71; 95% CI = 0.52–0.97; $p < 0.05$) of having tachycardia as compared with women.

A more detailed analysis of the prevalence of clinical bradycardia and tachycardia was performed in the four adult age groups (20–39, 40–59, 60–79, and 80 and over). For adult males, there are no statistically significant differences in the prevalence rates for either bradycardia or tachycardia across the four adult age groups. In contrast, there are statistically significant differences in frequency of bradycardia across the four adult age groups for females (Satterthwaite-adjusted chi-square = $p < 0.0001$). The lowest frequency of bradycardia is seen among females aged 20–39 (5.4%; 95% CI = 4.4–6.5) and the highest rate is seen among females aged 40–59 (8.5%; 95% CI = 7.4–9.7).

An additional analysis was performed using the newer revised clinical guidelines for tachycardia (RPR greater than 90 beats/min) and bradycardia (RPR less than 50 beats/min). By these criteria, the estimated prevalence of tachycardia among men in the normative sample is 5.2% (95% CI = 4.6–5.9), while the prevalence of bradycardia is 1.6% (95% CI = 1.2–2.0). Among adult females, the overall prevalence of tachycardia is 8.4% (95% CI = 7.6–9.2) and the prevalence of bradycardia is 0.3% (95% CI = 0.1–0.5). Overall, comparing males with females and adjusting for the effect of age, males have significantly higher odds (that is, 6.38; 95% CI = 3.05–13.36; $p < 0.05$) of having bradycardia and lower odds (that is, 0.59; 95% = CI 0.52–0.68; $p < 0.05$) of having tachycardia.

Using the revised clinical criteria, a more detailed analysis of the prevalence of bradycardia and tachycardia was performed for the four adult age groups (20–39, 40–59, 60–79, and 80 and over). Among males, there are no statistically significant differences in the prevalence rates for either bradycardia or tachycardia across the four adult age groups. In contrast, there are statistically significantly differences in frequency of tachycardia across the four adult age groups for females (Satterthwaite-adjusted chi-square = $p < 0.0001$). The highest frequency of tachycardia is seen among females aged 20–39 (9.7%; 95% CI = 8.6–11.0), and the lowest rate is seen among females aged 60–79 (7.1%; 95% CI = 5.5–9.1). Similar to adult males, there are no statistically significant differences in the prevalence rates for bradycardia in females across the four adult age groups.

Discussion

The tables and figures in this report present updated, population-based means, medians, selected percentiles, and ranges for RPR in the United States, based on a normative sample of children and adults in NHANES 1999–2008. These estimates are given by specific age subgroups, sex, and the major U.S. race and ethnicity groupings. The most recent U.S. reference data published for RPR is based on data from NHANES I (1971–1975), which were collected almost four decades ago (1,2). In NHANES I, resting pulse for children aged 1–5 years was obtained as a seated, resting radial pulse rate rather than being obtained by heart auscultation as it was in NHANES 1999–2008. For NHANES I adults, only results for those aged 25–74 were published. These included RPR estimates based on a seated, 30-second resting radial pulse as was done in NHANES 1999–2008, but NHANES I also included a detailed 20% subsample of RPR estimates taken from electrocardiographic (ECG) tracings obtained in the supine (recumbent) position. However, the NHANES ECG data were not used to produce U.S. national prevalence estimates for RPR. It was used solely for a multivariable analytic study to identify the major factors that influence RPR, so no comparisons can be made between the NHANES I ECG data and the current study.

The general trends for childhood and resting pulse demographic subgroups such as age and sex appear similar when the earlier NHANES I reports are compared with the current NHANES estimates. For example, the figures from NHANES I demonstrating the decline in RPR with increasing age from infancy to adulthood are similar in configuration to the current NHANES figures (NHANES I figures not presented). There are, however, some apparent differences. The previous NHANES I analysis shows no consistent change in RPR between ages 25 and 74 for male and female participants. This suggests that there was generally a plateau in RPR across the entire adult age range. The NHANES 1999–2008 data confirms the same pattern for adult males, but shows a somewhat different pattern for adult females. For females, an apparent plateau in RPR is not reached until later in life (ages 40–59). In addition, the absolute magnitude of estimates of RPR central tendency appear to be systematically higher in the NHANES I data than in the current NHANES data. For example, mean RPR for adult white males aged 25–74 during NHANES I ranges from 77.4 to 79.8 beats/min, whereas during NHANES 1999–2008, normative sample mean RPR in adult non-Hispanic white males aged 20 and over ranges from 69 to 71 beats/min. The comparable ranges for females are 80.1 to 81.8 during NHANES I, and 73 to 76 beats/min during NHANES 1999–2008. Other patterns seen in the data appear similar between the two surveys—for example, there is a slightly higher RPR among females when compared with males, and a slightly higher RPR in non-Hispanic whites when compared with other race and ethnic groups.

The samples used in NHANES I and in the current NHANES are different. Specifically, in NHANES I, estimates were based on almost the entire examined population (only pregnant women and a few outlier observations were excluded). More detailed exclusions or adjustments for medication use and other variables in the current analysis likely influenced the RPR results for population subgroups analyses. These more recent estimates are based on a normative sample of the U.S. population, excluding many conditions that would cause secondary variations in RPR, such as a current infectious illness or certain prescription medications that are known to influence the resting heart rate. Another factor to consider is that it is unclear if the NHANES I resting pulse was measured after an examinee had been seated and resting quietly for approximately 4 minutes as was done in NHANES 1999–2008. There may be systematic differences in the methodology used in the two NHANES surveys resulting from systematic differences in sample selection and data collection protocols. For example, whereas the current survey reports categories by race and ethnicity, NHANES I reported categories by race only; furthermore, whereas race and ethnicity is self-reported in the current survey, race was reported by the interviewer in NHANES I (18). The basis for the NHANES I summary RPR estimates thus was systematically different from the current NHANES 1999–2008 estimates.

There are methodological limitations associated with obtaining RPR estimates in a cross-sectional study such as NHANES, as in for example, the onetime assessment of an individual's RPR, and reliance on self-reported information for the participant's age and race and ethnicity status. Although there was dedicated examiner training and quality control monitoring, the RPR data were obtained manually and therefore are subject to some degree of human error. Moreover, the basic data for RPR was obtained as a 30-second sample with the 30-second pulse rate, then multiplied by two to produce an RPR in beats per minute. This process produces only even numbers, which may result in less precise results. The NHANES I RPR obtained by electrocardiogram is generally considered to be more precise; however, it too was a calculated value. For example in clinical practice, if the heart rhythm is regular, the RPR is calculated by an electrocardiogram by measuring the time in tenths of a second between two successive heartbeat wave forms, and then adjusting this number to produce an estimate of RPR in beats per minute.

The NHANES I study used a variation of this technique in which the heart rate was calculated separately for each of the 12 electrocardiographic leads. These 12 values were then averaged to produce a final summary RPR measurement. The current RPR estimates in the NHANES 1999–2008 study are, however, directly comparable with the approach commonly used to obtain RPRs in pediatric and adult clinical practice in the United States, and thus are potentially more relevant as reference estimates. However, there is increasing clinical use of automated devices to measure both pulse and blood pressure, and it is unclear how these reference data would compare with RPR data collected by these newer methods. Finally, as was recently suggested by Black et al., RPR is easily measured and may provide valuable population-level information on cardiac health (19).

Further limitations may exist, specifically, NHANES 1999–2008 did not collect body temperature measurement, so we could not exclude those who had febrile illnesses during the exam. We also were unable to exclude those persons currently taking nonprescription medications that could potentially affect the pulse rate, because these data were not collected in NHANES 1999–2008. Similarly, we did not control for herbal medicines or caffeinated beverages that could transiently affect the heart rate. Finally, while we constructed a "normative" sample for our analysis, it should not be inferred that all individual examinees selected for this subsample were in a "normal" state of health, as we were unable, given the NHANES data collection protocol, to exclude all potential medical illnesses that might affect the RPR.

Conclusion

This report provides normative data on RPR using a large, recently obtained, population-based national sample. In particular, the data on resting pulse from NHANES 1999–2008 provide RPR reference range estimates to update those previously published using NHANES I RPR data. The current findings show that RPR decreases with age for males and females. With the exception of persons aged 80 and over, the average female mean RPR was higher than for males. The mean difference between the adult gender groups was 3 beats/min. While the clinical relevance of such a difference for an individual may be limited, it is statistically significant (on a population level it may, in fact, be important), given that increases in RPR appear to be an independent predictor for adult cardiovascular disease. The current finding that males, when compared with females, were twice as likely to have bradycardia and almost 30% less likely to have tachycardia by traditional clinical criteria was significant. These differences are more pronounced if the recently proposed clinical guidelines are employed. These results, and the finding that self-reported race and ethnicity has a small but significant effect on mean RPR, could potentially also be of public health importance. However, further confirmations of the findings in this report are needed before the public health significance of these findings can be properly assessed.

References

1. Gillum RF. Epidemiology of resting pulse rate of persons ages 25–74 data from NHANES 1971–74. Public Health Rep 107(2):193–201. 1992.
2. Gillum RF. Resting pulse rate of children aged 1–5 years. J NA Med Assoc 83(2):153–8. 1991.
3. Gillum RF. The epidemiology of resting heart rate in national sample of men and women: Associations with hypertension, coronary heart disease, blood pressure, and other cardiovascular risk factors. J Am Heart 116(1 Pt 1):163–74. 1988.
4. Gillum RF, Makuc DM, Feldman JJ. Pulse rate, coronary heart disease, and death: The NHANES I epidemiologic follow-up study. J Am Heart 121(1 Pt 1):172–7. 1991.
5. Hsia J, Larson JC, Ockene JK, Sarto GE, Allison MA, Indrix SL, et al. Women's Health Initiative Research Group. Resting heart rate as a low tech predictor of coronary events in women: Prospective cohort study. BMJ 338:b219. 2009.
6. Martins D, Tareen N, Pan D, Norris K. The relationship between body mass index, blood pressure and pulse rate among normotensive and hypertensive participants in the third National Health and Nutrition Examination Survey (NHANES). Cell Mol Biol (Noisy-le-grand) 49(8):1305–9. 2003.
7. Fox K, Borer JS, Camm AJ, Danchin N, Ferrari R, Lopez Sendon JL, et al. Heart Rate Working Group. Resting heart rate in cardiovascular disease. J Am Coll Cardiol 50(9):823–30. 2007.
8. Zhang GQ, Zhang W. Heart rate, lifespan, and mortality risk. Ageing Res Rev 8(1):52–60. 2009.
9. National Center for Health Statistics. The National Health and Nutrition Examination Survey (NHANES) analytic and reporting guidelines [online]. 2006. Available from: http://www.cdc.gov/nchs/nhanes/nhanes2003-2004/analytical_guidelines.htm.
10. National Center for Health Statistics. National Health and Nutrition Examination Survey (NHANES) physician examination procedures manual. 2007. Available from: http://www.cdc.gov/nchs/data/nhanes/nhanes_07_08/manual_pe.pdf.
11. Spodick DH. Normal sinus heart rate: Appropriate rate thresholds for sinus tachycardia and bradycardia. J South Med 89(7):666–7. 1996.
12. Spodick DH. Recalibration of normal sinus heart rate: Clinical thinking and epidemiologic support. Clin Cardiol 16(10):702. 1993.
13. Spodick DH. Survey of selected cardiologists for an operational definition of normal sinus heart rate. Am J Cardiol 72(5):487–8. 1993.
14. Spodick DH. Normal sinus heart rates: 60 and 100 bpm are too high. Postgrad Med 99(2):263–4. 1996.
15. Spodick DH. Is there such a thing as normal sinus rate? J Br Heart J 70(5):486–7. 1993.
16. Spodick DH. Redefinition of normal sinus heart rate. Chest 104(3):939–41. 1993.
17. Spodick DH. Normal sinus heart rate redefined. J Eur Heart J 14(7):865. 1993.
18. National Center for Health Statistics. National Health and Nutrition Examination Survey [online]. Available from: http://www.cdc.gov/nchs/nhanes/nhanesi.htm.
19. Black A, Murray L, Cardwell C, Smith GD, McCarron P. Secular trends in heart rate in young adults, 1949 to 2004: Analyses of cross sectional studies. Heart 92(4):468–73. 2006.

Table 1. Overall estimates for U.S. national resting pulse rate: National Health and Nutrition Examination Survey, 1999–2008

Age group	*n*	Mean	SE mean	Percentile 1st	2.5th	5th	10th	25th	50th	75th	90th	95th	97.5th	99th
Under 1 year	1,903	129	0.9	90	99	103	108	116	126	137	149	156	162	174
1 year	1,345	118	0.7	83	91	95	100	108	116	123	133	138	145	158
2–3 years	2,255	107	0.4	78	82	86	90	97	105	113	119	124	131	138
4–5 years	1,764	96	0.5	70	72	75	79	86	94	102	110	114	119	126
6–8 years	2,476	87	0.3	60	64	68	71	78	85	93	101	105	109	116
9–11 years	2,366	83	0.4	57	60	63	67	73	81	89	96	101	106	112
12–15 years	4,500	78	0.3	52	56	58	62	68	76	85	93	98	103	108
16–19 years	4,493	75	0.3	48	51	54	58	64	73	82	90	95	101	105
20–39 years	6,506	73	0.2	48	51	54	57	64	71	79	87	92	98	103
40–59 years	4,968	72	0.2	47	51	54	57	62	70	78	86	91	96	102
60–79 years	2,310	72	0.3	47	50	54	56	62	69	77	85	91	97	102
80 years and over	416	72	0.7	†	51	54	57	62	70	77	86	93	98	101

† Standard error not calculated by SUDAAN.

NOTES: SE is standard error. Data exclude persons with a current medical condition or medication use that would affect the resting pulse rate.

Table 2. Resting pulse rate estimates for U.S. males, by age group: National Health and Nutrition Examination Survey, 1999–2008

Age group	*n*	Mean	SE mean	Percentile 1st	2.5th	5th	10th	25th	50th	75th	90th	95th	97.5th	99th
Under 1 year	972	128	1.1	84	98	102	107	115	125	137	148	155	160	171
1 year	712	116	0.8	†	91	95	100	107	114	122	131	137	146	156
2–3 years	1,148	106	0.4	75	82	85	89	96	104	112	119	124	131	139
4–5 years	864	94	0.6	69	71	74	78	84	92	100	108	112	116	120
6–8 years	1,212	86	0.5	59	63	66	70	76	83	92	100	105	109	114
9–11 years	1,130	80	0.5	56	59	61	66	70	78	86	94	97	102	110
12–15 years	2,190	77	0.4	52	54	57	60	66	74	83	91	97	102	108
16–19 years	2,411	72	0.4	46	50	52	56	61	69	78	87	92	95	104
20–39 years	3,445	71	0.3	47	50	52	55	61	69	76	84	89	95	101
40–59 years	2,559	71	0.3	46	49	52	55	61	68	77	85	90	95	104
60–79 years	1,147	70	0.5	45	48	50	54	60	67	75	84	91	98	102
80 years and over	197	71	1.1	†	48	51	54	61	68	78	86	94	97	†

† Standard error not calculated by SUDAAN.

NOTES: SE is standard error. Data exclude persons with a current medical condition or medication use that would affect the resting pulse rate.

Table 3. Resting pulse rate estimates for U.S. females, by age group: National Health and Nutrition Examination Survey, 1999–2008

				Percentile										
Age group	*n*	Mean	SE mean	1st	2.5th	5th	10th	25th	50th	75th	90th	95th	97.5th	99th
Under 1 year	931	130	1	96	99	104	108	118	127	137	150	156	163	174
1 year	633	119	0.8	82	92	95	101	110	117	125	135	139	143	158
2–3 years	1,107	108	0.5	78	83	88	91	98	107	114	120	125	130	137
4–5 years	900	97	0.6	70	73	76	81	87	95	104	110	117	122	132
6–8 years	1,264	88	0.5	61	66	69	73	79	87	94	101	106	109	117
9–11 years	1,236	85	0.5	58	63	66	69	76	83	91	98	103	107	113
12–15 years	2,310	80	0.4	54	57	60	63	70	79	87	94	99	103	110
16–19 years	2,082	79	0.4	50	54	58	62	69	77	85	94	99	103	108
20–39 years	3,061	76	0.3	52	55	57	60	66	74	82	89	95	99	104
40–59 years	2,409	73	0.3	51	53	56	59	64	71	79	86	92	97	101
60–79 years	1,163	73	0.4	52	54	56	59	64	70	78	86	92	96	102
80 years and over	219	73	0.9	†	53	56	59	64	71	77	85	93	98	100

† Standard error not calculated by SUDAAN.

NOTES: SE is standard error. Data excludes persons with a current medical condition or medication use that would affect the resting pulse rate.

Table 4. Resting pulse rate estimates of U.S. males, by race and ethnicity: National Health and Nutrition Examination Survey, 1999–2008

				Percentile										
Characteristics	*n*	Mean	SE mean	1st	2.5th	5th	10th	25th	50th	75th	90th	95th	97.5th	99th
Mexican American														
Under 1 year	350	128	1.2	95	101	106	110	116	124	136	149	158	161	†
1 year	240	117	1.1	†	91	94	99	108	115	122	132	140	154	†
2–3 years	347	104	0.6	†	80	84	87	94	102	110	115	121	124	132
4–5 years	265	95	1.0	†	70	74	77	84	93	101	110	114	120	†
6–8 years	407	87	0.7	60	63	66	69	76	84	92	103	109	115	120
9–11 years	377	82	0.6	56	61	64	66	72	80	88	94	98	103	105
12–15 years	748	76	0.6	50	56	57	60	66	74	82	90	96	100	108
16–19 years	799	72	0.5	49	51	54	57	62	68	77	86	91	95	100
20–39 years	906	70	0.5	47	50	52	55	61	67	75	83	88	95	102
40–59 years	580	70	0.4	47	50	53	55	60	68	76	84	90	94	101
60–79 years	314	70	0.6	47	50	52	54	59	65	76	84	90	93	102
80 years and over	26	66	2.2	§	†	†	59	65	69	75	80	†	§	§
Non-Hispanic white														
Under 1 year	319	128	1.5	†	98	102	107	115	125	138	148	156	161	†
1 year	223	117	1.2	†	91	95	102	107	114	122	132	138	†	†
2–3 years	376	106	0.6	82	83	87	90	96	104	112	120	126	133	139
4–5 years	268	94	0.8	70	71	74	78	84	92	99	107	112	115	118
6–8 years	318	86	0.7	†	63	67	70	77	84	93	101	104	109	†
9–11 years	297	80	0.5	†	59	63	66	71	78	85	94	98	102	†
12–15 years	554	78	0.6	53	56	58	62	68	76	84	92	98	102	109
16–19 years	630	73	0.6	47	49	53	56	62	70	80	88	93	97	103
20–39 years	1,424	71	0.4	46	50	53	56	62	69	77	85	89	95	100
40–59 years	1,210	71	0.4	46	49	52	55	61	69	77	85	91	96	104
60–79 years	534	69	0.6	44	47	50	54	60	67	75	83	90	98	101
80 years and over	141	71	1.2	§	†	52	55	61	67	78	86	94	98	†
Non-Hispanic black														
Under 1 year	167	129	1.4	†	98	104	110	116	125	138	149	158	160	†
1 year	163	115	1.0	§	†	92	99	106	112	121	130	134	140	†
2–3 years	287	103	0.8	§	74	79	86	95	102	110	117	122	126	†
4–5 years	239	92	0.8	†	70	74	77	82	89	97	105	110	117	†
6–8 years	361	83	0.7	†	62	64	67	73	80	88	97	101	105	113
9–11 years	351	78	0.6	53	56	58	62	69	76	84	90	93	96	99
12–15 years	683	72	0.4	†	52	54	57	63	70	78	86	89	93	98
16–19 years	777	67	0.5	45	48	51	53	58	65	72	79	83	88	95
20–39 years	727	69	0.4	†	50	51	54	59	66	75	83	88	93	102
40–59 years	516	70	0.5	45	48	53	55	60	68	77	84	89	93	99
60–79 years	197	72	1.0	†	†	48	54	60	68	79	89	98	105	†
80 years and over	21	68	2.3	§	§	§	†	57	67	76	†	†	§	§

† Standard error not calculated by SUDAAN.
§ Percentile not calculated by SUDAAN.

NOTES: SE is standard error. Data exclude persons with a current medical condition or medication use that would affect the resting pulse rate.

Table 5. Resting pulse rate estimates of U.S. females, by race and ethnicity: National Health and Nutrition Examination Survey, 1999–2008

				Percentile										
Characteristics	*n*	Mean	SE mean	1st	2.5th	5th	10th	25th	50th	75th	90th	95th	97.5th	99th
Mexican American														
Under 1 year	379	129	1.4	87	100	106	108	116	125	137	150	157	163	167
1 year	203	119	1.3	†	95	97	99	107	116	126	139	146	†	§
2–3 years	341	107	0.7	†	82	86	89	96	106	114	122	127	136	†
4–5 years	292	97	0.7	70	75	78	82	87	95	103	111	116	120	127
6–8 years	407	88	0.8	†	68	71	72	78	86	94	103	108	111	113
9–11 years	393	86	0.7	60	64	66	70	76	83	91	100	105	109	113
12–15 years	801	79	0.5	56	58	61	64	70	76	85	93	97	103	107
16–19 years	706	77	0.5	48	53	58	62	68	75	83	90	94	98	105
20–39 years	759	75	0.4	52	56	58	60	66	72	80	87	92	99	103
40–59 years	569	73	0.7	47	53	56	59	64	70	77	85	90	92	†
60–79 years	308	73	0.6	†	54	56	59	64	70	77	87	94	100	†
80 years and over	25	75	2.4	§	†	†	62	67	72	76	92	†	†	§
Non-Hispanic white														
Under 1 year	290	131	1.5	†	100	106	109	119	127	138	151	156	164	†
1 year	177	120	1.0	†	92	96	103	110	118	126	135	139	†	†
2–3 years	324	109	0.8	78	82	87	94	100	107	114	120	126	131	137
4–5 years	268	97	0.9	†	71	76	80	87	96	104	110	118	122	†
6–8 years	341	89	0.7	59	66	70	73	81	88	94	102	106	109	†
9–11 years	321	86	0.7	58	63	66	70	77	84	91	98	103	107	†
12–15 years	563	81	0.6	55	58	60	63	71	80	88	95	100	104	110
16–19 years	553	79	0.6	50	53	57	61	70	77	86	95	100	103	110
20–39 years	1,294	76	0.3	52	54	57	60	67	74	82	91	96	100	107
40–59 years	1,120	73	0.4	52	53	56	58	64	71	79	87	93	97	101
60–79 years	593	73	0.4	52	54	56	59	64	70	78	86	91	97	103
80 years and over	155	73	1.1	†	52	56	58	64	71	77	85	93	†	§
Non-Hispanic black														
Under 1 year	156	130	1.5	†	100	105	110	115	128	139	153	159	†	§
1 year	168	117	1.2	†	†	95	101	108	118	123	131	138	140	†
2–3 years	289	107	0.7	§	†	87	90	97	105	112	119	123	127	135
4–5 years	237	95	0.8	§	†	75	78	86	94	101	108	111	115	†
6–8 years	370	87	0.7	†	65	67	72	78	85	93	101	105	108	112
9–11 years	391	82	0.8	†	60	63	67	72	80	88	96	101	105	†
12–15 years	750	78	0.4	52	56	60	62	68	76	84	91	95	99	103
16–19 years	608	77	0.5	†	54	56	60	68	75	83	91	95	99	107
20–39 years	655	76	0.4	53	55	58	61	67	74	81	88	94	97	103
40–59 years	470	74	0.5	†	53	56	59	65	71	80	87	92	96	99
60–79 years	159	74	0.8	†	52	55	58	64	71	79	88	95	100	†
80 years and over	22	72	2.6	§	§	†	†	63	68	73	†	†	§	§

† Standard error not calculated by SUDAAN.
§ Percentile not calculated by SUDAAN.

NOTES: SE is standard error. Data exclude persons with a current medical condition or medication use that would affect the resting pulse rate.

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