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Gender-Related Heart Rate Differences in Human Neonates

EMESE NAGY, HAJNALKA ORVOS, GYÖRGY BÁRDOS, AND PETER MOLNÁR

Institute of Behavioural Sciences [E.N.], Semmelweis Medical University, 4 Nagyvárad sq., H-1089 Budapest, Hungary; Department of Obstetrics and Gynaecology [H.O.], Albert Szent-Györgyi Medical University, H-6722 Szeged, Hungary; Department of Physiology and Neurobiology [G.B.], Eötvös Loránd University, H-1089 Budapest, Hungary; and Institute of Behavioural Sciences [P.M.], Debrecen Medical University, H-4012 Debrecen, Hungary

ABSTRACT

The aim of the present study was to examine gender-related differences in heart rate of human neonates controlled for their behavior. Previous studies could not find any difference in male and female fetuses and newborns, although this gender-dependent difference clearly exists in children and adults. The heart rate of 99 newborns (47 girls and 52 boys) was measured with simultaneous video recording of their behavior. Results proved that alert newborns showed the same difference as adults: boys had a significantly lower baseline heart rate than girls. This suggests that heart rate is gender-dependent from birth onward. **(*Pediatr Res* 47: 778–780, 2000)**

Abbreviations

SIDS, sudden infant death syndrome
HR, heart rate
HRV, heart rate variability

Baseline HR of human adults is gender-related. Stein *et al.* (1) found higher baseline HR in females, but this difference decreased with age. Pearl (2) found the same pattern in 10–18-y-old children in whom corrected QT intervals (which varied directly with the HR) were significantly longer for girls than for boys.

However, studies with fetuses and infants have not yet revealed the same gender-related difference. Genuis *et al.* (3) assessed HR of 212 fetuses between 14 and 41 wk of gestation and found no significant gender difference in the baseline fetal HR at any recorded gestational age (GA). Fleisher *et al.* (4) examined 14 male and 17 female fetuses from 20 to 36 wk of gestation for 4-wk intervals and found no difference in HR according to gender at any age. Stramba-Badiale *et al.* (5) analyzed 9725 electrocardiograms recorded on the fourth day of life and reported that the gender-related differences in QT interval observed in the adult population are not present at birth.

Harper *et al.* (6) examined the developmental sequence of HR in 22 normal infants and 22 siblings of SIDS victims by using 12-h polygraphic recordings at the first week and at the first, second, third, fourth, and sixth months of age. HR was higher in siblings of SIDS victims, but gender did not significantly contribute to HR. Richards *et al.* (7), sequentially recording the ECG from 110 full-term infants up to 6 mo of age, found higher mean HR in male infants at 32–45 d and at 73–134 d but not earlier or later, independent of the size of the sample.

These data are challenging. Is the gender-related difference in HR absent in newborns and infants, developing only later? Or is the difference reversed at a particular stage of infancy, as Richards *et al.* (7) suggested (*i.e.* HR is higher in male infants), and there is a developmental turn-around later in childhood when the HR of females increases?

A methodologic problem also exists: Is "blind" monitoring (lacking behavioral control) of the ECG an adequate method for assessing gender-related differences in HR in neonates or infants, inasmuch as the behavior of the babies is usually variable? According to the results of Janz *et al.* (8), whole-day monitoring of HR is an appropriate method for measuring physical activity and maturation but not for revealing any gender differences.

The aim of the present study was to examine gender-related differences in baseline HR of human neonates controlled for state of alertness and activity by monitoring their behavior with video recording.

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Correspondence: Emese Nagy, M.D., Institute of Behavioural Sciences, Semmelweis Medical University, 4 Nagyvárad sq., H-1089 Budapest, Hungary.
Present address (E.N.): Center for Human Development Research, Department of Psychiatry and Behavioral Sciences, University of Texas Houston Medical School, UT-MSI, 1300 Moursund Street, Houston, TX 77030, U.S.A.
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METHOD

Subjects. With the consent of the mothers, 99 healthy newborn infants (52 boys and 47 girls) ranging in age from 0 (3 h) to 7 d were examined at the Department of Obstetrics and Gynecology of the Albert Szent-Györgyi Medical University, Szeged, Hungary. All infants were healthy, 60 with normal single delivery (35 boys and 25 girls) and 39 with cesarean section (17 boys and 22 girls). All infants had a 1-min Apgar score of 7 or more, 5-min Apgar score of 8 or more, 10-min Apgar score of 10, and had no known medical problems during pregnancy or complications during delivery. Four mothers (4.04%) smoked; therefore, the data from their babies were removed. The analysis below, therefore, is based upon the data of 48 boys and 47 girls. The present study was approved by the Institutional Review Board of Albert Szent-Györgyi Medical University.

Recorded variables. GA of the newborns in weeks, their weight at birth in grams, head circumference in centimeters, and age postpartum at the time of the examination in days were recorded. Alertness was coded using Prechtl's scale (9). Mean HR was measured in beats/min, and HRV was represented by the SD of the HR. These latter values were then transformed into natural logarithms (ln HRV) to obtain the normal distribution as suggested by McCabe *et al*. (10).

Procedure. The examination room was the same for every newborn, with constant illumination and ambient temperature (28°C). The conditions and environment of the room, a separate but integral part of the neonatal ward, were constant for every newborn. Newborns were selected randomly and were examined 30–90 min after feeding, which proved to be the optimal time for examining newborns—awake but in a quiet state. All babies were dressed alike. After attaching the disposable electrodes onto their chest and replacing their shirt, they were loosely swaddled. We placed the babies on their backs on an examining table facing a Panasonic 240-type video camera. The length of the R-R intervals was within ±±2.5 ms accuracy, and the calculated HR values were measured by a Primedic-Mobicard-type ECG instrument using disposable chest electrodes. Data were stored for later analysis in a computer.

All sessions were fully video recorded with time codes added later. The examination lasted for approximately 10 min for each newborn at the same time of day, between 5:00 and 7:00 pm. A 1-min interval during the time-coded video recordings was selected and marked for each newborn, during which the baby was in an alert but quiet state (Prechtl-4 state) with open eyes, was neither distressed nor crying, and neither sleepy nor sleeping. Extra care was taken to include only those recordings in which all babies were in comparable states with neither a too low or too high arousal or activity level. Using these selection criteria, we significantly reduced intervening factors that produce increased variability. HR data belonging to this selected interval were analyzed subsequently.

Data processing. Data were analyzed by ANOVA grouped according to gender and/or weight at birth for HR and HRV, weight, and head circumference. In case of significant results, individual group differences were tested *post hoc*. Correlations among the measurable variables were also calculated.

Finally, the possible indirect effect of the weight at birth and HRV, respectively, on HR was tested by analysis of covariance (ANCOVA) (11). Before running the test, changes in HR as a function of the age (days from birth) was tested by ANOVA, and possible HR differences between d 0 and 1 were also compared separately for both genders. Although none of these tests yielded a significant time effect, only d 0 and 1 were included in ANCOVA. A $p < 0.05$ level of significance was accepted throughout.

RESULTS

Table 1 summarizes descriptive statistics of the recorded variables. The only significant difference revealed by ANOVA (gender × delivery) was found in HR ($F_{3,\,91} = 4.88$, $p < 0.01$). This effect was solely due to the gender ($F_{1,\,94} = 11.97$, $p < 0.001$) and not to the way of delivery ($F_{1,\,94} = 2.16$, NS). Variability (ln SD: $F_{3,\,91} = 0.20$, NS), weight at birth ($F_{3,\,91} = 2.08$, NS), and head circumference at birth ($F_{3,\,91} = 1.20$, NS) showed neither gender nor delivery differences according to ANOVA. The day of examination also had no significant effect on the measured HR ($F_{3,\,91} = 0.06$, NS).

These results clearly show that there are significant gender differences in the HR but not in any other measured variables, and this difference is not directly associated with other variables. This is further supported by the correlation coefficients represented in Table 2.

It is evident from Table 2 that whereas weight at birth and circumference of the head correlated with the GA and also with each other (higher in boys than in girls), they failed to correlate with HR and HRV.

Although ANOVA and the correlation test excluded the direct functional relationship between HR with weight at birth, indirect effects could not eliminated. To examine this possibility, we ran ANCOVA to test gender differences adjusted for the weight at birth. This analysis ($F_{1,\,54} = 7.56$, $p < 0.01$) clearly proved that gender differences were highly significant even after being adjusted for weight at birth; hence, even indirect effects may be excluded.

A gender-dependent significant difference was found in the HR of the boys, which significantly correlated negatively with their ln HRV. No such significant relationship was found in girls (linear regression, boys: B = −1.88, T = −2.49, $p < 0.01$; girls: B = −5.5, T = −1.073, $p = 0.28$).

Table 1. *Descriptive statistics of the recorded variables*

	GA (wk)	Weight (g)	Head (cm)	HR (beat/min)	ln HRV
Total	39.1 ± 0.11	3451 ± 43.98	33.8 ± 0.15	132.3 ± 1.25	1.75 ± 0.03
Boys	39.08 ± 0.16	3515.42 ± 62.96	33.99 ± 0.2	128.28 ± 1.40	1.73 ± 0.04
Girls	39.15 ± 0.14	3384.68 ± 58.35	33.57 ± 0.2	136.48 ± 1.88	1.78 ± 0.05

Table 2.

	Boys					Girls				
	GA	Weight	Head	HR	Age	GA	Weight	Head	HR	Age
Weight	0.69					0.25				
Head	0.54	0.60				0.20	0.52			
HR	0.00	0.04	0.02		0.17	−0.19	−0.14	−0.08		0.26
HRV	0.18	0.23	0.15	−0.35	0.28	0.13	0.04	−0.17	−0.16	0.10

Significant correlations are set in bold.

DISCUSSION

According to this state-controlled video-recorded study, the HR of newborn infants revealed the same gender-related differences found in older children and in adults: newborn male infants have lower baseline HR than newborn females. This difference cannot be explained by other variables examined in the present study and seems to be primarily gender determined. These results suggest that the same gender-related differences in HR that appear throughout life are already present at birth.

Our data also show, at least as inferred from our sample, that this difference is not or not only mediated by weight at birth or HRV because adjusting for these variables did not eliminate the significance of the results. Because there has not yet been any data suggesting gender-related differences in cardiac output in newborn infants, one possibility is that stroke volume may differ. If that were so, a further question is whether this difference is due to altered cardiac muscle activity, heart volume, or altered peripheral resistance. Further investigation is needed to clarify this problem, which may bear some clinical significance.

It may be of interest whether the statistically significant difference in HR has a real physiologic significance. One may argue that 8 beats/min is a small difference to have physiologic value (*i.e.* about 6% of the total HR). We believe that if the difference persists over the entire life, it may have some constitutional/functional background and significance. These results reveal the need for research concerning possible underlying mechanisms such as respiratory sinus arrhythmia, differences in stroke volume, cardiac output, size of heart, hormonal environment, *etc*. and also the potential impact on health and disease, *e.g.* SIDS and developmental disorders.

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