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Sex Differences in Sympathetic-Adrenal Medullary Reactions Induced by Different Stressors

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Abstract. Male and female university students were exposed to two different stressors in each of two 110-min sessions, i.e., a cognitive task (color-word conflict) and repeated venipuncture. Catecholamine excretion, heart rate, and subjective reactions were measured. Control values were obtained under conditions of relaxation in the laboratory. Subjects of both sexes responded to both stressors by increased heart rate and feelings of unpleasantness and distress. The pattern of adrenaline excretion, however, differed between sexes: in males both stressors induced a significant increase, whereas in females adrenaline excretion remained on the same level under the two stress conditions as during relaxation. Noradrenaline excretion was not systematically affected by either stressor in either sex group.

Key words: Sex differences – Stress – Catecholamine excretion – Adrenaline – Noradrenaline – Venipuncture – Color-word conflict.

INTRODUCTION

The present paper forms part of a long-term research project concerned with the role played by peripheral catecholamines in adaptation to psychosocial stressors (reviewed by Frankenhaeuser, 1971, 1975). A series of studies of healthy male subjects exposed to various psychosocial stressors has shown that adrenaline secretion, as measured by its urinary excretion, is a sensitive indicator of the emotional arousal experienced in passive states, such as waiting for an unpleasant event to occur, as well as of the effort exerted when the individual is engaged in a demanding activity (e.g., Frankenhaeuser and Rissler, 1971). An increase in noradrenaline output may occur under similar conditions, but the threshold for noradrenaline release in response to psychological stress is generally much higher than that for adrenaline release.

Systematic investigations of females are scarce, and current knowledge of the part played by peripheral catecholamines in stress and adaptation is largely derived from studies of male subjects. Comparisons between sexes, based on data obtained under resting conditions (Kärki, 1956; Lambert et al., 1969), show that, when body weight is taken into account, there is no marked difference in catecholamine secretion between the sexes. However, recent studies in our laboratory, in which males and females were examined under psychosocial stress conditions, suggest that adrenaline excretion is a much less sensitive indicator of behavioral arousal in females than in males. In a field study (Johansson and Post, 1974) catecholamine excretion in males and females was compared in a nonstressful condition, i.e., while they carried out their daily routine activities, and under psychological stress, i.e., when they performed an intelligence test under time pressure. In the female group, adrenaline output remained the same during the test session as during daily activity, whereas in the male group it increased significantly during testing. Similar results (Johansson, 1972; Johansson et al., 1973) were obtained when 12-year-old boys and girls were compared under a "passive" condition, i.e., watching a non-engaging motion picture, and under an "active" condition, i.e., performing mental arithmetic. In the group of girls, adrenaline excretion was only slightly and insignificantly higher during the active than during the passive period, whereas the boys' adrenaline excretion rose significantly in the active condition.

In view of the fact that the females performed equally well or slightly better than the males in both these studies, it does not appear likely that the larger

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adrenaline release of the males was associated with a more intense effort. Nor is there any empirical support for the commonly held view that the prevailing sex-role pattern would tend to make mental work under time pressure a more challenging experience for males than for females (Maccoby and Jacklin, 1974, p. 135ff). A possibility which should be examined is that females tend to respond by adrenaline release to specific stressors only, whereas in males this is the common response to *any* kind of stressor.

In the present investigation the sex difference in catecholamine output was analyzed further by examining males and females under conditions which differed with regard to the nature of the stressor to which subjects were exposed. Interest was focussed on comparing male and female reactions to two situations, in one of which the subject played a passive, in the other an active role. In the passive situation, stress was induced by repeated venipuncture, a procedure which is generally considered moderately stressful by members of both sexes. In the active situation, the subjects performed a cognitive task (based on Stroop's color-word conflict test), which is known to elicit arousal reactions in males (e.g., Frankenhaeuser and Johansson, 1976), whereas corresponding data for females are not available.

METHODS

Subjects. The subjects were 6 male and 6 female first-year university students. The ages of the males ranged from 19–30 years (mean 22.3) and those of the females from 19–37 years (mean 22.8). The body weights of the males ranged from 69–79 kg (mean 73.0) and of the females from 50–78 kg (mean 62.3). All subjects were non-smokers. They reported being in good health at the time of the investigation.

General Design and Procedure. All subjects came to the laboratory for an introductory session in which they were acquainted with the experimental setting and the procedure, a time table was set up for the forthcoming experiments, and detailed instructions were given as to the regime that they had to follow while participating in the investigation, i.e., to refrain from drug intake and from consuming caffeine- and alcohol-containing beverages prior to experimental days, to keep stress-inducing activities at a minimum, etc. They were asked to come to the sessions fasting, and a light breakfast was served upon their arrival in the laboratory.

Each subject attended, individually, two experimental sessions and one control session. In each session, starting either at 8 or at 10 a.m., measurements were made at 30-min intervals, always at the end of the mental-work period in condition W (see below) and at corresponding points in time in the other conditions. The total time of a session, including a 20-min breakfast and various preparations, was 110 min. The interval between sessions was 1–3 days. Positional effects were counterbalanced by rotating the order of conditions between subjects.

The *control condition* (C) was spent by the subjects reading popular magazines of a bland nature and/or listening to the radio.

Under the *venipuncture condition* (V) three 15 cm^3 blood samples were drawn from the antecubital vein of the subject's nondominant arm. The intervals between venipunctures were 30 min. (The blood samples were stored for later hormone analyses, to be reported separately.) Except for the venipuncture, this session was similar to the control session.

In the *mental-work condition* (W) the subjects performed a color-word conflict task modelled on card CW of the Stroop test (1935). In essence, the test material consists of color words (red, blue, green, yellow) which are printed in different colors, the combination of words and colors being incongruent, so that the word green may be colored red, etc. The subject's task is to ignore the word and name the color of the print. In the modified version of the test designed in our laboratory (Björkvall, 1966) the color words are projected on a screen, one at a time, from a 16-mm film, and the subject has to respond to each word by marking the correct word on a response sheet with successively numbered rows; corresponding numbers are presented on a sound track synchronously with the visual stimuli in order to help the subject orient himself to the right row on the sheet. The task comprised three 20-min periods, each containing 378 stimuli. The duration of the stimuli varied randomly from 0.4–1 s. They were presented in random order at random intervals of 0.8–1.7 s. The score was the number of correct responses.

Since a possible influence of the sex of the experimenter cannot be disregarded, it should be mentioned that all blood samples were taken by a male technician, whereas in the other parts of the experiment, one male and one female experimenter each handled an equal number of male and female subjects.

Catecholamine Excretion. Before each session the subject emptied his/her bladder and 120 min later a urine sample was collected by voluntary voiding. The urine volume was measured and pH adjusted to about 3 with 2N HCl. Urine was stored at −18°C until analyzed for free adrenaline and noradrenaline by the fluorimetric method of Euler and Lishajko (1961). One female subject was unable to void and was excluded from the analysis of the catecholamine data.

Heart Rate. Recordings were made by an electronic pulse meter, via an electrode attached to the subject's ear, at three consecutive 30-min intervals.

Self-Ratings. Each subject rated his/her feelings of "unpleasantness" and "distress" at the beginning of each session and at three consecutive 30-min intervals.

The first ratings of each session were obtained by asking the subject to compare his/her present state with that typical of a familiar situation. A "standard" situation was defined for each variable: "Visiting the dentist" for unpleasantness, and "Waiting for an examination" for distress. The first ratings were expressed as percentages of the standard situation which was denoted 100. The three subsequent ratings were expressed by the subject, using graphic scales, as percentages of his/her state in terms of each variable during the preceding 30-min period. (A similar scaling procedure has been used in experiments concerned with subjective reactions to psychosocial stressors and psychoactive drugs, e.g., Frankenhaeuser and Post, 1964, 1966.)

RESULTS

Performance. Means and standard errors for the number of items correctly solved in the color-word conflict task in the male and female groups are shown in Fig. 1. The female group performed slightly, but not significantly, better than the male group. These results agree with those presented in the original report

Table 1. Means and standard errors for adrenaline (A) and noradrenaline (NA) excretion, and heart rate in male and female subjects under control, venipuncture, and mental-work conditions

Variable	Control		Condition			
			Venipuncture		Mental work	
	M	SE	M	SE	M	SE
Male group (n = 6)						
A excr. (ng/min/kg)	0.056	0.017	0.089	0.023	0.106	0.022
NA excr. (ng/min/kg)	0.401	0.091	0.265	0.045	0.353	0.051
Heart rate (beats/min)	69.7	2.75	73.1	3.02	72.8	2.90
Female group (n = 5)						
A excr. (ng/min/kg)	0.054	0.014	0.062	0.015	0.057	0.015
NA excr. (ng/min/kg)	0.232	0.045	0.250	0.035	0.252	0.053
Heart rate (beats/min)	69.9	3.69	75.7	5.56	74.0	5.39

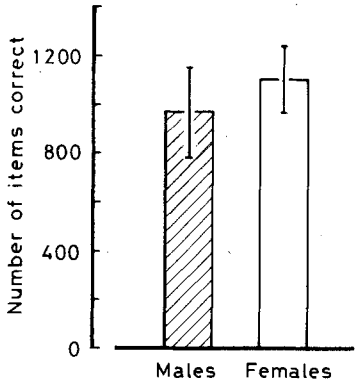

Fig. 1. Means and standard errors for scores obtained by male and female subjects in a color-word conflict test

by Stroop (1935) in which male and female college students were compared.

Catecholamine Excretion. Table 1 shows means and standard errors for adrenaline and noradrenaline excretion, expressed in relation to body weight, in the male and female groups under control, venipuncture, and mental-work conditions. Mean urine excretion varied from 0.008 – 0.016 ml/min/kg; there were no systematic differences between conditions or sex groups.

The catecholamine data are presented graphically in Fig. 2. It is seen (a) that the level of adrenaline excretion was the same in both sexes in the control conditions, (b) that venipuncture and mental work both induced an increase of adrenaline excretion in the male group but not in the female group, (c) that noradrenaline excretion was somewhat higher in the male than in the female group in the control condition, whereas (d) noradrenaline excretion was not systematically affected by either of the stressors in either group.

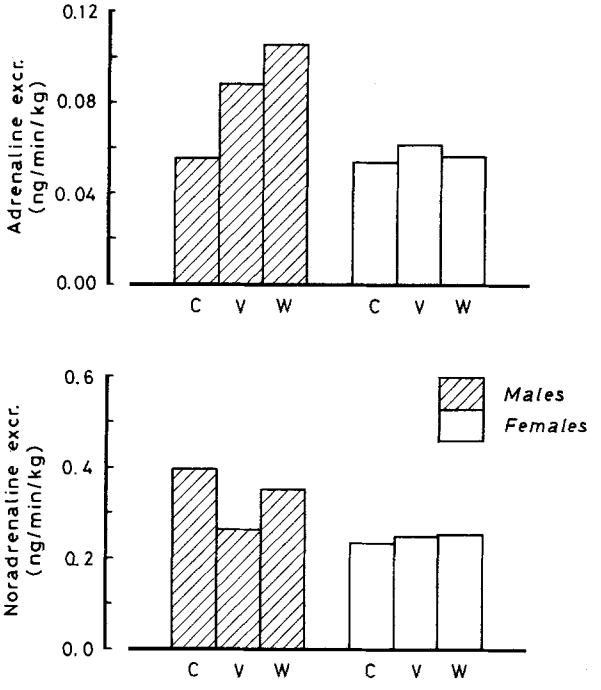

Fig. 2. Mean adrenaline and noradrenaline excretion (expressed in relation to body weight) in male and female subjects in control (C), venipuncture (V), and mental-work (W) conditions

Statistical analysis of the data showed that, in the male group the difference between conditions in adrenaline excretion was significant at the 0.01 level (F = 8.59, df = 2/10). Separate t-test of differences between pairs of conditions showed that the increase of adrenaline excretion from control values was significant at the 0.05 level both for the venipuncture (t = 3.98) and the mental work (t = 3.45) condition. The differences in catecholamine excretion between the two sexes did not reach a statistically significant level in any of the conditions.

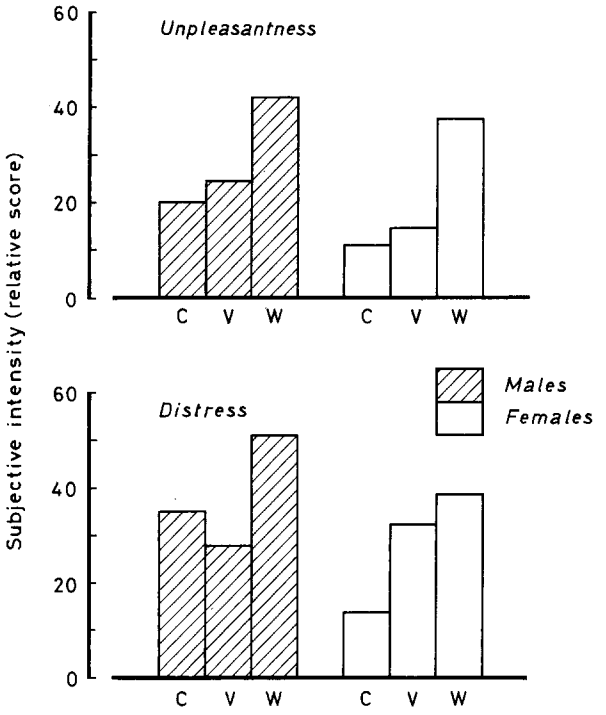

Fig. 3. Mean self-ratings for male and female subjects of "unpleasantness" and "distress" in control (C), venipuncture (V), and mental-work (W) conditions

Heart Rate. Mean heart rate in the male and female group, respectively, for each of the three consecutive measurements made at 30-min intervals in the control, venipuncture, and mental-work sessions were calculated. The main characteristic of the data was the decrease of heart rate during the course of each session. A three-way analysis of variance showed that neither differences between conditions, nor between sexes, were statistically significant, whereas the decrease from the first to the third recording was significant at the 0.01 level ($F = 17.4$, $df = 2/10$).

For each subject a mean score for the three measurements was calculated for each condition. Table 1 shows means and standard errors for the scores thus obtained from each group under the three conditions.

Subjective Variables. Each of the three self-ratings of unpleasantness and distress made at consecutive 30-min intervals in each session was expressed in relation to the ratings made at the very beginning of that session. Since there was no consistent change over time, mean scores for the three ratings of each variable were calculated for each subject. Figure 3 shows mean ratings for the male and female group, respectively, for each session. The results indicate that the subjective arousal level rose in response to both experimental treatments, reactions to mental work being somewhat more intense than reactions to venipuncture. The pattern of the subjective reactions was the same for both sex groups, except for the relatively higher male ratings of distress in the control condition. Although the trend of the data was fairly consistent, none of the differences between conditions or sex groups reached a statistically significant level.

Since all subjects used one and the same familiar situation (see above) as the standard of comparison for all ratings, it may be assumed that the unit of measurement was the same in the different conditions. However, the standard situations may well have been perceived differently, on the average, by males and females. Hence, between-group comparisons should be made with caution.

DISCUSSION

The present results were consistent with data from previous studies in our laboratory (Frankenhaeuser, 1972; Johansson, 1972; Johansson and Post, 1974) in that the females did not respond by adrenaline increase to the stress involved in performing mental work. The high performance level of the female group in the color-word conflict test as well as the self-ratings and the heart-rate data, suggest that the lack of adrenal-medullary response was not associated with less effort. Instead, it appears that other mechanisms were involved in the females' exertion of effort.

Moreover, the present data showed that the lack of adrenal-medullary reactivity in females was not specific to the "active" work situation, the "passive" venipuncture situation being characterized by a similar unresponsiveness in the female group. Again, the increase of heart rate and subjective emotional reactions indicated that the females were as aroused as the males. One practical implication of these results is that care must be taken in experimental investigations to prevent venipuncture, often considered a routine procedure, from interfering with other stressors. The effects of venipuncture are strong enough to introduce serious errors in the assessment of reactions to many commonly used stressors.

One earlier study (Levi, 1972) has reported low adrenal-medullary reactivity in females in a passive stress situation, i.e., exposure to sexually-arousing films. In male students adrenaline excretion increased significantly during the film, whereas it was relatively unaffected in female students. In this particular situation, however, the sex difference in hormone excretion was probably associated with the difference between the sexes in the intensity of the emotional reaction evoked by the film, males feeling sexually more aroused than females.

Another indication of low adrenal-medullary reactivity in females is the fact that pre-menstrual disturbances (in a group of women with "normal" menstrual complaints) do not tend to be accompanied by increased adrenaline excretion (Pátkai et al., 1975; Silbergeld et al., 1971).

Thus, data from many different sources suggest that females do not show the same degree of readiness as males to respond by adrenaline release to emotionally arousing stimuli. This appears to be true regardless of whether the situation requires passive acceptance or active effort. The data so far available show no indication of reduced adaptive capacity in females under conditions of low adrenal-medullary reactivity. This suggests that the endocrine mechanisms involved in coping are to some extent different in males and females.

It should be noted that a pronounced adrenaline increase has been demonstrated in our laboratory in females under conditions of intense examination stress (unpubl. data). Further studies will deal with inter-individual differences in catecholamine secretion among women exposed to stressors of different kinds and intensities.

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