

1. Report No. FAA-AM-78-40		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle STRESS IN AIR TRAFFIC CONTROLLERS: A RESTUDY OF 32 CONTROLLERS 5 TO 9 YEARS LATER			5. Report Date		6. Performing Organization Code
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9. Performing Organization Name and Address FAA Civil Aeromedical Institute P.O. Box 25082 Oklahoma City, Oklahoma 73125			10. Work Unit No. (TRAIS)		11. Contract or Grant No.
12. Sponsoring Agency Name and Address Office of Aviation Medicine Federal Aviation Administration 800 Independence Avenue, S.W. Washington, D.C. 20591			13. Type of Report and Period Covered		
15. Supplementary Notes Work was performed under Task AM-C-77-PHY-102.			14. Sponsoring Agency Code		
16. Abstract Thirty-two subjects who had participated in air traffic controller stress studies 5-9 years earlier were restudied with regard to urinary excretion of 17-ketogenic steroids, epinephrine, and norepinephrine. All subjects showed decreases in excretion of 17-ketogenic steroids. Eight of the subjects had taken noncontroller jobs; these subjects showed work-related increases in epinephrine excretion whereas the 24 controllers who remained active in controlling aircraft showed work-related decreases in epinephrine excretion. There were no significant findings related to norepinephrine excretion. It is concluded that the active controller group shows evidence of reduced chronic stress. Various interpretations of this finding include less stress at their new facilities, greater experience in their jobs, improvements in the entire traffic control system, and the effects of normal aging.					
17. Key Words Stress Air Traffic Controllers Urine Analysis			18. Distribution Statement Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 8	22. Price

STRESS IN AIR TRAFFIC CONTROLLERS: A RESTUDY OF
32 CONTROLLERS 5 TO 9 YEARS LATER

INTRODUCTION

The concept of stress is implicit in management of the air traffic control (ATC) work force. Numerous studies of air traffic control specialists (ATCSs) and their workplace have been carried out by the Government and by outside contractors with the goal of quantitatively describing stress experienced by ATCSs in the performance of their work. Many of these studies have been carried out at high-density facilities, leading to the popular belief that all ATCSs are under unusually high levels of stress. This idea has been recognized by the Congress in Public Law 92-297, which provides retirement at age 50 for those ATCSs who have been actively engaged in ATC work for 20 years. Optional retirement by other civil servants, with a few exceptions, is not available until age 55 with 30 years of service.

Studies of ATCS stress necessarily represent a temporal excerpt from the ATCSs' lives and their validity is based on the assumption that the persons under study are in a stabilized condition when data are collected. Career progression, normal aging, and accumulated experience may cause long-term changes in stress levels. The purpose of this follow-on study is to evaluate such long-term changes.

METHODS

ATCSs who had participated in past stress studies were identified; most could be located through FAA's Personnel Management Information System. Letters were sent to those ATCSs who could be located soliciting their participation in the study. Insulated mailing cartons containing urine collection vessels and instructions were sent to the 32 ATCSs from five original facilities who replied affirmatively. They ranged in age from 29 to 50 years.

ATCSs were instructed to void and discard urine prior to retiring, and to collect all urine voided on arising. They were then to cease collecting until they arrived at work when they were instructed again to void and discard and collect in one vessel all subsequent urine voided during the workday. The collection regimen was repeated for the next sleep-and-work period. Two successive rest-and-work periods are thus represented.

Studies at the Civil Aeromedical Institute (CAMI) demonstrated that urine collected into vessels containing an excess of dry boric acid showed no deterioration of 17-ketogenic steroids and catecholamines at room temperature for 3 days. However, ATCSs were asked to refrigerate or freeze the specimens after collection until they were mailed. Commonly, specimens were still partially frozen or cold when received at CAMI. Specimens were logged in at CAMI as they were received and were then stored in a freezer until a sufficient number was accumulated for automated analysis.

Analyses of urine specimens were carried out for 17-ketogenic steroids (17-KGS), epinephrine (E), norepinephrine (NE), and creatinine (CR) as previously reported (1). Values for the three stress indicator hormones (SIH) are expressed as the creatinine-based ratio (SIH wt/100 mg creatinine).

RESULTS

Eight of the ATCSs had been promoted or had transferred for other reasons to supervisory or other noncontroller jobs. Table 1 shows a comparison of changes in urine biochemicals of those 8 with changes for 24 other ATCSs who remained active in air traffic control positions. The data in the table may be summarized as follows: (i) Most members of both groups showed decreases in 17-KGS excretion both at rest and at work in the second study. (ii) Most members of the active controller group showed increases in E excretion at rest, while equal numbers of noncontroller subjects showed increases and decreases in E excretion at rest. (iii) Most active controllers showed a decrease in E excretion at work. Most noncontroller subjects showed increases in E excretion at work. At rest, equal numbers of noncontrollers showed increases and decreases in NE excretion. At work, slightly more noncontrollers showed decreased NE excretion than showed increases. Most active controllers showed increases in NE excretion at rest and decreases at work.

A biochemical composite stress index (C_s) was developed in this laboratory in order to provide an integrated presentation of data from the battery of biochemical measurements. The details of the index have been published (2). Briefly, the index is based on the idea that the product of resting and working values for each of the SIHs gives a more realistic view of stress than does the excretion increment (or decrement) from rest to work. However, because the SIHs appear in such unequal quantities in the urine, each individual mean value (rest and work) is divided by a grand mean derived for that SIH from all the measurements made on ATCSs in all past studies

TABLE 1. Number of Subjects and Directions of Change in Urine Biochemistry
From the First Study to the Second Study

Type of Work, Second Study *	Total Number	17-KGS		E		NE	
		REST	WORK	REST	WORK	REST	WORK
		No. Showing Increase	No. Showing Decrease	No. Showing Increase	No. Showing Decrease	No. Showing Increase	No. Showing Decrease
NONCONTROLLER	8	0(0)** 8(60)	0(0) 8(74)	4(55) 4(29)	5(75) 3(41)	4(23) 4(28)	3(20) 5(28)
ACTIVE CONTROLLER	24	2(86) 22(38)	4(57) 20(44)	19(115) 5(9)	6(42) 18(29)	18(43) 6(29)	7(23) 17(25)

* All subjects were active controllers in the first study.

** Numbers in parentheses are the mean percent increase/decrease for each hormone.

in this laboratory. This adjustment causes each SIH to assume equal importance in the calculation of C_s . C_s is the average of indexes calculated for each of the three SIHs, c_{st} (17-KGS), c_e (E), and c_{ne} (NE).

Table 2 shows a comparison of individual indexes and C_s for active controllers and noncontrollers and the changes from first to second studies. The 17-KGS index, c_{st} , is significantly lower in the second study than it was in the first. For the noncontrollers, c_e is lower in the second study with marginal significance. C_s is lower in the second study for both groups because of the strong effect that c_{st} has on the average. The norepinephrine index, c_{ne} , showed no significant change for either group.

The data in Table 2 are shown diagrammatically in Figure 1. This figure is based on the theorem that says the sum of the lengths of internal lines emanating from a common point in, and perpendicular to the sides of, an equilateral triangle is equal to the altitude of the triangle (3). The values of c_{st} , c_e , and c_{ne} can be expressed as lines originating from a common point and diverging at angles of 120° , the lengths of which are proportional to the values of the individual indexes. Perpendiculars to the free ends of the diverging lines form an equilateral triangle whose area is proportional to C_s , the average of c_{st} , c_e , and c_{ne} . The lengths of the internal lines give a ready appreciation of the relative contributions of 17-KGS, E, and NE to total stress. It is apparent that total stress is reduced in the noncontrollers to a greater degree than in the active controllers.

DISCUSSION

Because of the small number of controllers represented in this study, conclusions are guarded if not tentative. With that caveat in mind, it can be pointed out that both groups showed a decrease in 17-KGS excretion level. This finding can be interpreted to mean that chronic stress is less in the second study than in the first. It should be mentioned again that only five first-study facilities are represented; O'Hare, Houston Intercontinental and Opa Locka Air Traffic Control Towers; Los Angeles TRACON; and Miami Air Route Traffic Control Center. Because all of these original facilities had comparatively high stress levels, it is not unexpected that chronic

TABLE 2. Stress Indexes for Noncontrollers and Active Controllers: Comparison of First and Second Studies

Type of Work, Second Study	Stress Index--Mean Values			
	First Study	Second Study	Change	P <
ACTIVE CONTROLLER				
c_{st}	0.84	0.33	-0.51	0.001
c_e	0.53	0.68	+0.15	0.05
c_{ne}	0.70	0.69	-0.01	NS
c_s	0.69	0.57	-0.12	0.05
NONCONTROLLER				
c_{st}	0.78	0.19	-0.59	0.001
c_e	0.48	0.47	-0.01	NS
c_{ne}	0.73	0.54	-0.19	NS
c_s	0.66	0.40	-0.26	0.05

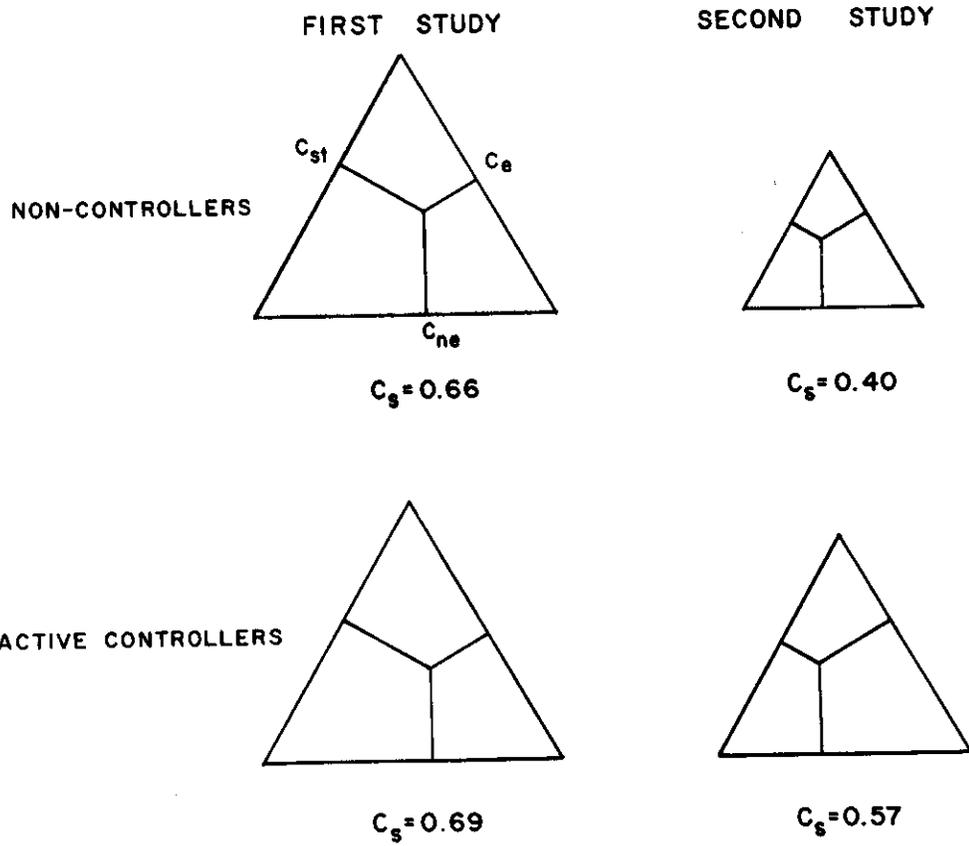


FIGURE 1. Diagrammatic representation of stress in noncontrollers and active controllers. Comparison of first and second studies.

stress of the group would be reduced when a move was made somewhere else. The possibility also exists that with time the job becomes easier for some people--a sort of counter-burnout phenomenon.

An additional explanation may be based on improvement in the work situation. An earlier study showed that the introduction of ARTS-III was associated with a reduction in 17-KGS excretion (4). There was an interval of 5 to 9 years from the first until the second study, a period during which many improvements were made in the ATC system.

These ATCSs were 5-9 years older at the time of the second study, which may also explain the decrease in 17-KGS excretion. Reduction in 17-KGS is known to accompany the normal process of aging (5-7).

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