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HAROLD G. SEASHORE AND GRANT KOCH.

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POSTURAL STEADINESS UNDER CONDITIONS OF MUSCULAR TENSION AND FATIGUE*

HAROLD G. SEASHORE AND GRANT KOCH
Springfield College, Springfield, Massachusetts

Postural steadiness as measured by body sway has been studied elaborately by many experimenters. Histories of earlier investigations and statements of fundamental techniques are reviewed by Miles[1] and Fearing.[2] This paper is one of a series of studies of postural steadiness in relation to motor skills and body mechanics in the field of physical education; the hygienic problems of neuromuscular hypertension are projected fields of investigation. The studies reported here received their impetus from the papers by Miles and by Fearing, and more particularly, from two by Skaggs and associates.[3] The most recent paper by Skaggs was not available until after the data for these studies were gathered. It will be interesting to observe that similar conclusions appear from these two studies which have the same general purpose but which differ in details of method and problem.

The problem. The investigation set out to determine the effect of certain well-defined conditions of effort and strain upon postural steadiness as measured by body sway. For the first study, comparisons were made of body sway in ordinary stance (the control or normal records) and in four postures which involved definitely prescribed muscular tensions:

a. Locked knee. The subject forced his knees backwards. He was instructed to force them into such a rigid position that there would be pain in the muscles and joints of his lower body. Hands were kept on the hips.

b. Neck-firm. The subject, keeping his legs in normal stance, held his finger tips together at the back of his neck,

* Recommended by Dr. B. F. Skinner, June 13, 1938.

[1] W. R. Miles, Static Equilibrium as a useful test of motor control, *J. Indus. Hyg.*, 1922, 3:316-331.

[2] F. S. Fearing has three experimental articles under the general title: The factors influencing static equilibrium. They appear in the *J. Comp. Psychol.*, 1924, 4:91-121; 163-183; 1925, 5:1-24. Another paper is: The experimental study of the Romberg sign, *J. Nerv. Ment. Dis.*, 1925, 61:449-465.

[3] E. B. Skaggs, I. S. Skaggs, and M. Jardon, Attention and body sway, *Amer. J. Psychol.*, 1932, 44:749-755. E. B. Skaggs, Further studies of bodily sway, *Amer. J. Psychol.*, 1936, 49:105-108.

raised his elbows to shoulder level and pushed them backwards. He was told to exert great strain, enough to produce pain on the shoulder musculatures.

c. Running-in-place. The subject ran-in-place for 30 seconds taking 90 steps. Within 10 seconds he was harnessed in the head-gear and measured for sway. Before the exercise he was told that he might find difficulty in breathing during the recovery period and that he should subdue the motion in his respiration by breathing "vertically" rather than with a "heave." Hands were kept on hips.

d. Dynamometer. The subject, standing otherwise normally, held a dynamometer bimanually behind his back and just below his hip level at a pressure of 50 pounds at the start of the test. If the pressure dropped during the test to less than 35 pounds the trial was omitted. Fifty pounds is about one-half the maximum pull that these men could exert in the position indicated.

A second approach to the problem of steadiness under strain and fatigue was an experiment in which the total and minute-by-minute body sway over a ten-minute period were measured. The subjects stood in normal posture and with hands on the hips.

Apparatus. A local model of the Miles Ataxiameter was used. An angle was painted on the floor to facilitate the subject's taking the 45-degree stance described by Miles and Fearing. The apparatus was in a quiet room where each subject was measured individually. In the ten-minute study, four recorders, one at each work-adder, were necessary, but they worked silently and with non-vocal signals. In all trials the subjects kept their eyes closed without strain.

Procedure. In investigating the body sway in the four effort-situations, seven records were obtained from each of 53 undergraduate college men who served as subjects. Each subject came at the same hour on three alternate days. The following plan was used:

Group 1. a. Normal standing position
b. Locked knee position
c. Neck-firm position

Group 2. a. Normal standing position
b. Running-in-place

Group 3. a. Normal standing position
b. Dynamometer situation

Three crews were arranged to take groups in different order: 1-2-3, 2-3-1, 3-1-2. The normal record always was

taken before the experimental stances were described to the subject. The period of description provided adequate relaxation between trials. All trials were one minute in length. The average of several coefficients of reliability was .76.

For the ten-minute trial the 12 subjects were instructed to stand quietly and with normal postural adjustment. They were told that it would "seem like a long time." It was stressed that they should be determined not to sway no matter how long the task seemed to be. Their attitudes were excellent. They were not told of the passage of time and no extraneous clues, such as the ticking of a clock, were available.

Steadiness in the four effort-situations. The essential results of the first part of the study are given in Tables 1 to 3. Table 1 is a comparison in terms of central tendencies.

TABLE 1

COMPARISON OF ATAXIAMETER STEADINESS RECORDS UNDER CONDITIONS OF NORMAL AND TENSED STANCE

	Ave. normal	Ave. tensed	Neck-firm	Locked knee	Running-in-place	Dynamometer
Ave.	392	501	561	522	511	426
S. D.	118	131	171	136	157	126
Q_3	490	573	668	592	597	498
Med.	375	488	546	514	483	390
Q_1	289	402	444	416	416	323

TABLE 2

SIGNIFICANCE OF DIFFERENCES OBTAINED BETWEEN STEADINESS SCORES IN NORMAL AND TENSED SITUATIONS

	Obt. Diff. / S. D. Diff.
1. Ave. normal (3 trials) and Ave. effort (3 trials)	9.1
2. Dynamometer and Running-in-place	4.5
3. Dynamometer and Locked knee	5.2
4. Dynamometer and Neck-firm	7.3
5. Locked knee and Running-in-place	.5
6. Locked knee and Neck-firm	2.1
7. Running-in-place and Neck-firm	2.6
8. Normal first day and Normal third day	1.2
9. Dynamometer and Normal the same day	1.6