A TITRATION SCHEDULE ON A TREADMILL

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A technique is presented utilizing a titration schedule to measure performance decrement as a function of continuing heavy muscular exertion. A treadmill is equipped with a reversible motor controlling the velocity control of the treadmill itself. This provides a constant acceleration of the treadmill unless a subject-controlled, spring loaded switch is depressed. If this switch is depressed, the treadmill decelerates at a constant rate. A subject is instructed to walk at maximum rate at all times, controlling the velocity of the treadmill with the switch. A performance record is obtained from a tachometer-generator on the treadmill delivering current to a recorder.

The titration type of schedule involves an ongoing, forced monitoring by a subject of a subjective phenomenon and the production of a graded response to control the physical stimulus which produces that phenomenon. It has been used successfully in studies of audition (1), vision (2) and pain (3, 4).

The application of the titration principle to the study of performance on a treadmill should allow an objective measurement of changes in performance as a function of continued effort; *i.e.*, the process of fatigue. It produces a series of measurements by the subject of his own performance capacity, rather than the single end-point measure of total time of exertion produced by the standard, fixed-pace treadmill tasks. In addition, it should prove more useful than self-paced, non-forced (subject powered treadmills) in that it forces the series of measurements by a continued intensification of the physical stimulus until the response is made. It allows the study of the correlation of physiological changes with performance changes.

METHOD

The apparatus consisted of a variable speed treadmill set at a 5.0% grade. The velocity control of the treadmill, which in its usual application is in a fixed position during a run, was connected by a belt to the output of a reversible, variable speed Graham drive

system. Thus, the rotation of the Graham drive unit produced changes in the velocity of the treadmill belt. One direction of rotation of the Graham drive system produced a constant acceleration of the treadmill, while the other direction of rotation by the Graham drive produced a constant deceleration. The speed of the Graham drive was set to produce as acceleration or deceleration of 2 ft per min per sec.

The direction of rotation of the Graham drive was controlled by a spring loaded switch held by the subject as he walked on the treadmill. As long as the switch was depressed, the treadmill decelerated, when the subject released the switch the treadmill immediately began to accelerate and would continue to do so until the subject again depressed the switch.

A continuous record of the velocity of the treadmill was recorded from a tachometer-generator placed against the drive wheel. An Esterline-Angus recorder graphically reproduced the current changes produced by the tachometer-generator. The recorder was operated at a paper speed of 1 cm/min.

The subjects wore light clothing and rubber-soled gym shoes. The experiments were performed in a controlled temperature chamber at 80°F. Before his first experimental session each subject was given brief instruction and allowed to practice on the treadmill. About 5 min of practice time was permitted.

For all three experimental sessions each subject was instructed to walk as fast as he could at all times and to decelerate the treadmill only when he absolutely had to slow

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down. Running was not permitted. The subjects were not told how long they had walked, nor could they see their velocity records while walking. The first session was terminated

when the subject's walking velocity fell to 60% of his initial velocity. The other two sessions were terminated when the velocity fell to 70% of the subject's initial velocity.

Fig. 1. Three performance records of a subject with the instructions to walk at maximum possible speed at all times. Velocity recorded in ft per min. Recorder speed at 1 cm per min.

This change in the value at which the subjects finished the experiment was made due to excessive fatigue and high pulse rates produced by continuing the experiment past a 30% performance decline.

It is interesting to note that the pulse rate of the subject whose record is shown in Fig. 1 was 182 beats per min while seated, immediately after finishing the first session, although he had still been able to perform at 60% of his initial walking velocity. Such results would probably not be obtained with a less motivated subject.

The experimental sessions were minimally 48 hr apart.

RESULTS

A typical velocity record for the three sessions of one subject is presented in Fig. 1. It can be seen from the shapes of the performance decrement curves that the method of measurement is sensitive to ongoing performance changes and that it yields fairly consistent results from session to session for a given subject.

DISCUSSION

Four basic measurements are inherent in the data generated by this procedure: (1) the

measures of the subject's maximum capability at a number of points in time during the continuing exertion. These are reflected in the peak upward excursions of the record. For example, the trial 1 record of subject E shows 30 peaks in a 22.5 min period. (2) The maximum downward excursions of the record reflect the points of renewed effort; (3) the changes in the length of each pen excursion, *i.e.*, the distance between maximum exertion and renewed effort points; and (4) the pattern of decline of the overall envelope of pen activity as a function of continued work. This last is probably the best general indicator of performance changes.

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