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Clinical Section

The actometer: an evaluation of instrument applicability for chronic pain patients

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Summary Three experiments were conducted to determine the reliability and validity of an activity measurement device, the actometer, as an index of ambulation for chronic pain patients. In experiment I, correlations between yoked actometers during ambulation showed the instrument to be internally reliable. In experiment II, actometer readings covaried very strongly with distance, showing the device to be valid during single trial assessment. However, experiment III found the device to show poor reliability over time (i.e., substantial measurement variability for the identical distance on 3 separate days). The results suggest that, for the chronic pain population, the actometer may not be a useful instrument for reliably assessing changes in walking activity over time.

Key words: Activity measurement device; Chronic pain; Patient assessment

Introduction

One of the major goals of multidisciplinary pain management programs for chronic pain is to increase the activity levels of patients in order to help them return to a more independent and effective lifestyle [3,7]. Most programs incorporate a variety of behavioral and physical therapy interventions designed to help patients increase their 'uptime,' i.e., time spent out of a reclining position. To evaluate changes in uptime and other functional activities, chronic pain patients are often asked to keep daily diaries of the time they spent sitting upright, walking or standing, or engaging in other functional activities [3]. For some patients, the reliability and validity of activity diary data, however, may be poor [3,5]. Because of this problem, there is growing interest in the development of simple and objective measures of activity that can be used to monitor activity in chronic pain patients. Both Sanders [5] and Follick et al. [2] have developed electromechanical devices that automatically record uptime. Unfortunately, these devices, while appearing to provide reliable and valid information about activity level in pain patients, are relatively expensive and are not readily available.

Tryon [6] has recently reported that changes in patient motor activity can be very accurately tracked through the use of actometers. An actometer is a modified mechanical watch that has been converted to measure movement rather than time. Actometers are commercially available, relatively inexpensive, and easy to use. They have been used previously to assess activity level in hyperactive children and anorexics [4,8]. Though the mechanics of actometers vary with model type, all actometers are presumed to produce a measure-

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ment response that is proportional to the amount of acceleration or G force exerted by the wearer during each movement. These instruments have been reported to reliably and validly measure this G force or 'kinetic energy' [6].

The actometer could potentially provide an objective activity measure to supplement the activity diary data that are typically used in chronic pain treatment programs. However, for the instrument to be useful with this population, it should provide a reliable and valid measure of functional activity. Functional activity as applied to chronic pain treatment refers to productive behavior. This may or may not correspond to kinetic energy increases measured by an actometer. For example, if patients were able to walk progressively greater distances over the course of treatment, this would be indicative of an improvement in functional activity. Likewise, if they were able to walk at a progressively faster pace, this would also constitute an improvement in functional activity. However, if a patient was to walk the same distance at the same speed with increases only in the number or intensity of idiosyncratic movements (e.g., limping), this would not qualify as functional activity. Such a situation, however, might represent increased 'kinetic energy' since more movement would be involved. White et al. [7] allude to this distinction in their discussion of quantity vs. quality of activity.

This paper presents data on the reliability and validity of the actometer gathered in 3 different experiments with chronic pain patients. Walking was selected as the functional activity to be recorded for the following reasons: (1) it could be easily monitored using an actometer placed on the leg, (2) actometer readings could be readily compared to independent and objective measures of distance walked, and (3) an improvement in walking is an important target behavior in most chronic pain management programs.

Experiment I

The purpose of experiment I was to evaluate the internal reliability of the actometer in recording walking over a 24-h period. This was assessed by taking readings over the course of a day from 2 actometers placed on the same leg.

Method

Subjects. Fourteen consecutive inpatients referred to the Pain Management Program at Duke University Medical Center for chronic low back pain served as subjects. The mean age of the subjects (7 males, 7 females) was 42 ± 4 years.

Instrumentation. The actometer used in this study was a Motion Recorder Model 101 available from Willis and Kaulins (Waterbury, CT). This device is a modified self-winding wrist watch with a mechanism that enables it to measure kinetic energy and display this using the hands of the watch. The data are recorded in actometer units (AU). For model 101 a single AU is equal to a 1-sec movement of the second hand. In the present study, the actometer was attached to a velcro strap that was fitted to the dominant-side leg at the level of the ankle. In this position, the actometer could easily record leg movements involved in walking.

Procedure. Within 2 days of admission, patients were approached to participate in the study. They were informed that the study was intended to test a new device designed to measure activity levels in pain patients. After being informed of the requirements of the study all but 1 patient agreed to participate. Patients wore an actometer on the dominant leg at ankle level throughout the day for 4 consecutive days, removing it at bedtime.

On 1 randomly selected day during the study the patient wore 2 actometers fitted on top of each other so that internal reliability could be studied. At the end of that day readings were taken from both actometers.

Results and discussion

Pearson product–moment correlation coefficients were performed to compare the readings taken from the 2 different actometers for all subjects on the day of reliability assessment. The correlation between the 2 actometers was found to be high ($r = 0.997$, $P < 0.01$).

Experiment I was designed to assess the internal reliability of the actometer in measuring 1 index of functional activity: walking. Readings

taken simultaneously from 2 different actometers were nearly identical suggesting that the actometer is internally reliable for measuring a 1-day period of walking.

Experiment II

Experiment II assessed the validity of the actometer in the measurement of functional activity by determining the degree to which increases in distance walked during a single trial were reflected by commensurate changes in actometer readings.

Method

Subjects. Subjects from experiment I comprised the sample for experiment II.

Procedure. While wearing an actometer on the ankle of the dominant leg, patients were asked to walk 5 laps * in succession at one time. The distance of each lap increased by 32 yards (i.e., lap 1 was 32 yards, lap 2 was 64 yards, lap 3 was 96 yards, etc.). Actometer readings, in AUs, were recorded after each of the 5 laps.

Results and discussion

A separate correlation coefficient was computed for each subject to determine the degree to which actometer readings for each lap corresponded to actual distance walked. These correlations were conducted on a within-subject basis, rather than on a between-subject basis, because of pronounced individual differences in actometer units recorded for the 32 yard distance (see Table I).

As can be seen in Table I, the correlations between AU and distance were highly significant. The modal correlation was 0.999 with a lower limit of 0.973, suggesting that AU very accurately reflected increases in walking activity.

Experiment II provided evidence that the actometer accurately measured changes in the distance walked by each patient during a single assessment period. Still to be determined was whether the relationship between actometer readings and distance walked by a patient would be reliable *across* days.

TABLE I

WITHIN-SUBJECT CORRELATIONS OF ACTOMETER READINGS WITH DISTANCE WALKED AND AVERAGE ACTOMETER READINGS PER LAP FOR EXPERIMENT II

Subject	*r*	Average actometer reading per 32 yard lap
1	0.993	16
2	0.981	2
3	0.999	20
4	0.999	23
5	0.999	19
6	0.986	13
7	0.973	20
8	0.999	18
9	0.999	23
10	0.999	32
11	0.995	20
12	0.999	24
13	0.999	12
14	0.997	15

Experiment III

Experiment III evaluated the reliability of correspondence between actometer readings and distance across 3 days of recording. This experiment was necessary to demonstrate that changes in actometer measurements over the course of treatment were actually reflecting changes in walking. Experiment III also evaluated the relationship of actometer readings to speed of walking as well as to pain and stiffness ratings.

Method

Subjects. Subjects were 15 chronic pain patients admitted to the Pain Management Program shortly after the conclusion of experiments I and II.

Procedure. All patients wore a single actometer on their dominant leg throughout the day for 3 days. Patients were randomly assigned in equal numbers to 1 of the 3 predetermined distances —

* Three of the patients were only able to complete 4 sets of laps (i.e., 32 yards, 64 yards, 96 yards, 128 yards), and 3 other patients completed only 3 sets of laps.

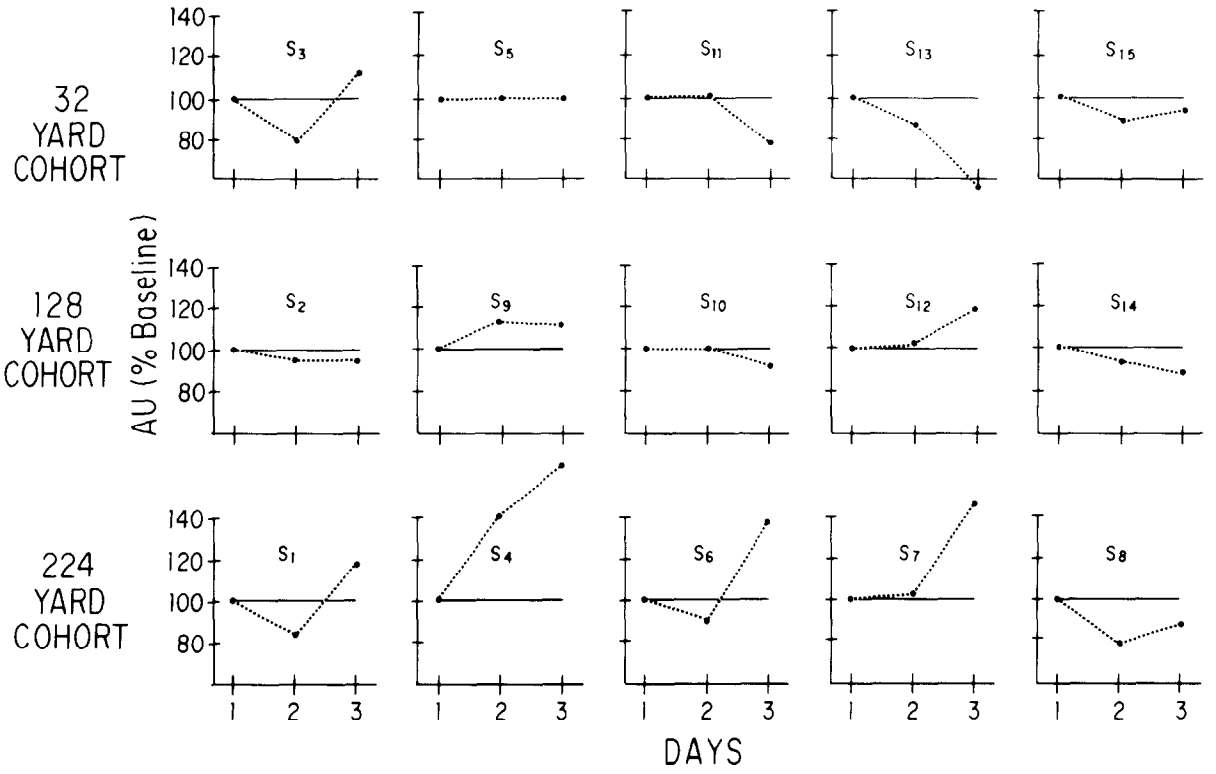

Fig. 1. Actometer readings recorded from each subject in 32 yard, 128 yard and 224 yard cohorts. Readings from day 1 were used as baseline value (solid line). Subsequent readings (dotted lines) were expressed as a percentage of that baseline value.

32 yards, 128 yards, or 224 yards. Patients walked their assigned distance alone once per day for each of the 3 days of the study. Actometer recordings were taken at the completion of each walk. Patients' walks were also timed, and 0–10 numerical ratings of pain and stiffness were taken from each patient before and after each walk. Five unit nurses also independently rated each of the 15 patients for walking impairment using a 1 = mild to 10 = severe scale.

Results and discussion

Fig. 1 displays data on actometer readings taken from each of the subjects in the 32 yard, 128 yard and 224 yard cohorts. Readings from day 1 were used as a baseline value for comparison purposes. Subsequent readings were expressed as a percentage of that baseline value. Visual inspection of Fig. 1 reveals that there was considerable variation from baseline values on days 2 and 3 of the study. Although subjects walked the same distance each day, the actometer readings recorded were often substantially higher or lower on days 2 and 3 than on day 1.

For each patient, rank order correlations were performed between the 3 daily actometer readings and walking speed for each of the 3 walks. No systematic relationship was found between actometer reading and walking speed. Rank order correlations likewise showed no relationship between actometer readings and ratings of pain or stiffness. Next, for each patient a coefficient of variation was computed for the 3 daily actometer readings to determine each patient's actometer variability across days. An average actometer reading per lap was also established for each patient. Pearson correlation across patients revealed that actometer variability was not correlated with average actometer reading per lap (r (14) = 0.01), suggesting that actometer variability was unrelated to

kinetic energy level. Finally, actometer variability *did* correlate marginally with nurse ratings of patients' levels of walking impairment (r (14) = 0.47, $P < 0.08$).

General discussion

Experiment I showed the actometer to be internally reliable in measuring a 1-day period of walking. Experiment II showed that there was a strong correspondence between actometer readings and distance walked during a single assessment period. Experiment III, however, showed that when this assessment was repeated over several days there was considerable variability in actometer readings. With the degree of variability noted, actometer readings on any 2 days would need to differ by greater than 29% before such differences could be considered to reflect true changes in walking activity. Based on our sample, the difference would need to exceed 45% before one could assume a clinical difference with 80% confidence.

The discrepancy between these findings and those of Tryon [6] can probably be explained in terms of the validation procedures and what is purported to be measured. Tryon validated the actometers with an electromechanical device that has reliable centrifugal properties, and he noted strong correspondence between actometer readings and the validation device. In the present series of experiments the dual actometers likewise showed strong intercorrelation. However, in terms of constructs, 'kinetic energy' appears to differ from 'functional activity' as it pertains to chronic pain rehabilitation and treatment. Whereas one chronic pain patient may evidence greater movement or 'kinetic energy' (e.g., limping) while walking one day compared to another, a second patient may evidence less 'kinetic energy' (e.g., by guarding or bracing). If kinetic energy as measured by the actometer were taken as a measure of functional activity for these 2 patients the logical assumption would be that one patient's daily functional activity level was increasing and the other's was decreasing. In fact, neither would be producing increases in clinically relevant activity (i.e., increased distance walked in a given period of time).

Some tentative support was found for the relationship between level of walking impairment and actometer variability. However, the strength of the correlation was modest, accounting for only 22% of patient actometer variability. Thus, one could not convincingly argue that level of walking impairment might serve to classify patients for whom the actometer accurately would reflect functional activity levels.

Tempering these conclusions may be warranted. Falk et al. [1] highlighted the importance of appropriate placement of actometers, and at times, the use of multiple actometers to produce the most meaningful data. Perhaps, for example, placement on the arm rather than or in addition to the leg would result in more accurate data than on the leg alone. Walking, however, is probably the best example of therapeutically relevant activity in chronic pain treatment as noted by the emphasis on 'uptime–downtime' measures [2,5] and back and leg reconditioning in chronic pain physical therapy programs. Thus, for assessment of walking one would question the wisdom of actometer placement anywhere other than the leg or the rationale of arm placement in addition to leg placement.

The present results suggest that actometers may not reliably measure changes in walking in chronic pain patients. Rather than indicating a deficiency in the instrument itself, the evidence suggests that kinetic energy and functional activity are divergent constructs for this population. Thus, the need for accurate recording devices to measure activity changes in chronic pain patients continues. Efforts to develop and validate other electrochemical devices are strongly indicated.

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