Exercise Prescription: A Clinical Trial

ELIZABETH LINDSAY REID, MS, AND ROBERT W. MORGAN, MD

Abstract: To assess the effectiveness of physician prescribed exercise, health education, and patient self-monitoring, 124 firefighters were medically screened and randomly allocated to a control and two treatment groups. Physiologic and reporting methods were employed to assess adherence to regular exercise at three months and six months after the initial exercise prescription. Addition of a health education program significantly improved compliance over that achieved by a physician consultation. Self-monitoring did not produce a further increase in compliance. Improvement in the treatment groups was limited to three months after prescription; at six months, the treatment and control populations had similar exercise patterns. (*Am. J. Public Health* 69:591-595, 1979.)

Out of concern for health, governments now promote fitness.[1,2] A person responding to such marketing of physical fitness often requests two services of a physician: an assessment of current fitness, and a prescription for a personal exercise program. Through an increasing demand for these services, physicians' involvement in fitness is growing. For many physicians, this role may require new knowledge and skills.

Prescribing exercise requires special knowledge. The patient's physical measurements provide the basis, but knowledge of personality and lifestyle factors provide the strategy to help the patient comply with an activity program.

As studies of health behavior grow in quality and number,[3-5] we find certain consistent responses to behavior change techniques. Mass media campaigns can raise awareness and produce behavior change,[6] personalized treatment can succeed in weight reduction and smoking cessation.[5,7,8] Although health behaviors requiring long-term changes in living patterns are promoted as one answer to accelerating health care costs,[2] many people will need professional support to alter habitual diet and exercise patterns or smoking behaviors. While some suggest a reorientation of the medical profession toward prevention to provide this support,[9] the feasibility and effectiveness of that suggestion has been questioned.[10] Physicians may hesitate to promote fitness testing and exercise programs, since a direct relationship between physical fitness and health is not clear. Many population studies have demonstrated that inactivity is associated with increased risk of heart disease.[11-13] Obesity,[14] symptoms of stress,[15] and cigarette smoking[16] are also more frequent among inactive people.

A selection factor which leads the "healthy" to exercise more than the "unhealthy" and the bias created by program drop-outs clouds the meaning of many exercise-health associations. Paffenbarger's cohort analysis of heart disease among longshoremen[17-19] provides the most convincing evidence of the protective effects of an active occupation. His complete documentation of job activity and health status for 22 years reduces the bias created by job and selective continuation. However, the accurate determination of the effect of beginning exercise for previously inactive people will require the randomized controlled trials such as those now underway.[20,21]

The success of such trials may be determined in part by ensuring compliance with the treatment strategy. We do not know if large numbers of previously inactive persons can be motivated to adhere to regular exercise. Nor do we have more than a simple understanding of what educational and behavior change methods will be most successful in ensuring this adherence. The study to be reported explores the determinants of adherence to regular physical activity.

The Independent Variables

The theoretical framework for this study derives from the Health Belief Model, first developed by Hochbaum, Rosenstock, et al,[22,23] and expanded by Becker, et al.[24] There

From the Department of Preventive Medicine and Biostatistics, University of Toronto. Address reprint requests to Elizabeth Reid, MS, Medical Division, Fire Academy, 895 Eastern Avenue, Toronto, Ontario. This paper, submitted to the Journal July 10, 1978, was revised and accepted for publication October 31, 1978.

is substantial empirical evidence of the Health Belief Model's utility in predicting preventive actions.[25-27]

The model hypothesizes that an individual should be in a state of readiness to act before the action is likely to occur. In the ready person, behavior is predicted by modifying and enabling factors such as those examined in this report. Initiation of and adherence to a regimen improves with low cost of treatment, simplicity of regimen instructions, continuity in the relationship with the health professional, a clear understanding of the action to be taken, and feedback to the patient.[28, 29] Our experimental strategies included these principles.

Behavior modification research provides evidence of other principles to encourage change in health behavior. The simple strategy of self-observation succeeds in reduction of weight[30] and cigarette smoking.[31] Exercise studies often record activity but have not tested recording as a means of improving adherence, even though reduction of resting and exercise heart rates may provide valuable reinforcement to the participant.[32-34]

To some extent, factors specific to beginning regular exercise limit exercise prescriptions. For the first six to eight weeks, muscle soreness, fatigue, and slow progress discourage continuation for the previously sedentary person. We pay special attention to this period since exercise can become self-reinforcing after these initial two months.

We selected the treatment variables in this study to test strategies that can reasonably be applied in a medical and community setting where restrictions of time and personal involvement are realities. We hypothesized that adherence to regular exercise over a period of six months would increase with each of the following additions to the exercise prescription:

- printed exercise instructions and a ten-minute consultation with a physician;
- a one-hour period of film and discussion;
- knowledge of pulse taking, quantifying, recording of daily exercise, and reporting of this information.

Methods

One hundred and twenty-four firefighters, age 24 to 56, volunteered for this study. Through medical screening, we evaluated the safety and suitability of participation for each of the volunteers.

Fifteen per cent of those who came to the screening were ineligible for the study; those with contraindications for strenuous exercise and those already in physical activity programs were excluded from the study.

To maximize the potential for prescription adherence, we selected this unrepresentative, but presumably well motivated, population of underfit firefighters.

Prior to their physical examination, all potential subjects completed a questionnaire concerning medical history, demographic factors, selected health beliefs, and practices.

Each man received a thorough physical examination. Unless declared ineligible by the study physician (according to a predetermined set of criteria) the subject performed a submaximal bicycle ergometer stress test. The physician informed the participant of his performance and compared his fitness level with the American Heart Association recommended levels.[35] In addition to this ten-minute consultation, the physician gave each subject a copy of the Physical Activity Readiness Questionnaire "Half as much"* sheet which, on one page, makes suggestions for intensity, frequency, and duration of exercise for starting and continuing exercise at each age level.[36]

Each shift of every fire station was considered a sampling unit. Out of concern for effects due to size of group, the units were stratified into "large" (three or more study participants) or "small" (less than three). Within each stratum, the units were randomly allocated to the three treatment groups. Men of Group 1 (Control n = 47) received no further instructions. For groups 2 (n = 47) and 3 (n = 30), the health educator (E.R.) visited the fire station during duty hours, showed a film, and provided written and verbal information about why and how to exercise. She emphasized basic exercise training principles as well as the need to design a personal exercise program to suit an individual's personality and lifestyle. The actual designing of the fitness program was the personal responsibility of the subject.

After teaching knowledge and skills to Groups 2 and 3, the health educator taught Group 3 units a monitoring procedure and asked participants to send weekly reports to the research office. Self-monitoring included pulse taking and quantifying daily exercise with a point system, based on Cooper's Aerobics,** and provided the subject with a graduated weekly total point goal. These records, kept for eight weeks, were sent to the project director bi-weekly.

Measurement

Maximum oxygen uptake (VO_2) was estimated on three occasions (start, three months, six months) using a bicycle ergometer, a stepwise increase of workload, and the Astrand nomogram.[38] We inferred compliance with exercise by the amount of change occurring in aerobic condition between the initial measure and each of the three months and six months re-tests. Predicting aerobic capacity from a bicycle ergometer stress test is subject to measurement error ranging from 2 or 3 per cent in a highly controlled laboratory setting,[39] to very high rates in a situation where the participant and the technician are unprepared to carry out the test carefully. The testing procedures followed here are those described by Shephard to reduce measurement error.[40] We assume measurement error to be less than 9.5 per cent. Regular exercise training for at least six weeks in untrained persons will normally lead to changes in aerobic capacity of

*"Half-as-much" is a one page guide for the new exerciser to begin a safe, graduated aerobic program without the assistance of health personnel; it was produced by the British Columbian Department of Health in conjunction with the Physical Activity Readiness Questionnaire (PARQ) which screens potential exercisers for the need for a medical examination prior to beginning vigorous exercise.

**Cooper's "Aerobics" quantifies physical activities in terms of the aerobic conditioning produced by the intensity, duration, and distance of the activity. The aerobic points represent a quantity of exercise that should produce physiologic changes.

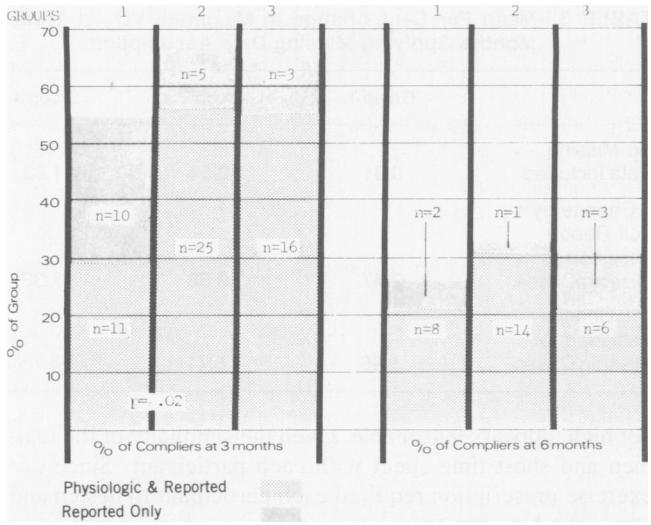

FIGURE 1—Per Cent of Compliers in Each Group at Three-Month and Six-Month Tests

approximately 10–20 per cent.[39, 41–43] A rate of change greater than 9.5 per cent will acknowledge real change. A person changing greater than or equal to 9.5 per cent is classified as a Regular Exerciser (physiologic).

Participants in all groups reported monthly on their exercise program. We defined Regular Exercisers (reporting) as those who report exercising at least twice per week for a minimum of 15 minutes of aerobic exercise. A detailed description of the development of the compliance rating derived from the reported activity is available on request to authors.

We combined physiological measures and self-reports to produce a compliance index. Compliers are those who report exercising at lease twice per week and who also increased their predicted maximum VO_2 9.5 per cent or more. Possible compliers are those who report exercising at least twice per week but *do not* increase their predicted maximum VO_2 by 9.5 per cent. All others are considered non-compliers.

In calculating compliance rates, we employed three different strategies for missing data.

Strategy 1—All missing cases are excluded from the analysis.

Strategy 2—Missing cases are assigned the mean change value of those in the same group who report the same amount of exercise. This was the method used throughout the analysis reported here.

Strategy 3—Missing cases are assigned a zero per cent change in their aerobic condition and are included in the analysis.

Results

Figure 1 compares the effectiveness of the three experimental strategies, with compliance defined by the Compliance Index (see above). At three months, the control group has 29 per cent compliers compared to 56 per cent and 55 per cent for Groups 2 and 3 respectively ($p = .02$). The mean per cent change in predicted aerobic condition, 2.46 for the control groups, and 9.88 and 7.38 respectively in the experimental groups, supports the number of compliers estimated by the Compliance Index. There is no difference between Groups 2 and 3 at three months.

Groups 2 and 3 are combined in Table 1 which compares their compliance rates with the controls (Group 1). Twenty-nine per cent of the control group and 55 per cent of the experimental groups are good compliers at three months. This difference is significant applying a chi-square analysis ($p = .01$) and a t-test of differences between mean per cent change in aerobic condition. The mean change in the control group is 2.46 and in the combined experimental groups is 8.90.

Figure 1 demonstrates the same general direction of relationships between the groups at six months as at three months. The group receiving the media presentation only

TABLE 1—Effects of Prescription Strategies on Compliance Comparing Control Treatment with the Combined Experimental Treatments

	n	Medical Problems	Drop-outs	Compliers at 3 Months (%) Physiologic	$\bar{X}$% Change in Aerobic Condition at 3 Months	Compliers at 6 Months (%) Physiologic ÷ Reported	$\bar{X}$% Change at 6 Months
Control Group 1 (physician consultation only)	47	8	1	11 (29)	2.46	10 (26)	9.66
Treatment Groups 2 & 3 (combined)	77	2	1	41 (55) $X^2 = 6.38$ $p = .01$	8.90 $t = 2.55$ $p = .01$	24 (32)	12.44 $t = 1.05$ $p = .295$

TABLE 2—Relationship of Participation in the Monitoring Procedures and Good Compliance

		n	Compliers at 3 Months (%)	Compliers at 6 Months (%)
TREATMENTS	Self-Monitoring Participants	16	10 (63)	9 (56)
	Participants Who Did Not Self-Monitor	13	1 (8)	0

$X^2 = 22.83$
$p = .0001$
Gamma = .99

TABLE 3—Mean Per Cent Change in Maximum VO_2 at Three Months Applying Missing Data Assumptions

	Group 1	Group 2	Group 3
No Missing Data Included	0.91	10.54	11.03
$\bar{x}$ Change by Self Report Assigned to Missing Cases	2.47	9.88	7.38
0% Change Assigned to Missing Cases	1.96	8.71	8.75

continues to contain the highest proportion of compliers and the greatest physiologic change. The control group loses few of its compliers during the four-to-six month period. However, in the same time frame, Groups 2 and 3 lost 40 per cent of previous compliers. Thus, at the end of six months, Groups 1, 2 and 3 contain almost identical proportions. One-third of the study population adhered to regular exercise regardless of treatment group or time period. Approximately one-third of those who started to exercise for the first three months discontinued between four and six months.

Those who continue to exercise show substantial changes in their physiological condition. The mean per cent change in aerobic condition increases in the control group from 2.46 to 9.66. A similar increase from 8.90 to 12.44 is found in the combined experimental group change. Although the number of regular exercisers decreases, the physiologic outcome measure increases.

Age is not significantly associated with compliance at the three month post-test. At six months the mean age of the non-compliers is 38.3 and that of the exercisers is 41.7 ($p = .045$).

Table 2 partitions the group assigned self-monitoring into those who carried out the self-monitoring and reporting and those who did not. No cause and effect can be inferred from these results, but self-monitoring and regular exercising were highly associated (Gamma = .99) in Group 3.

Table 3 compares the compliance rates in each of the groups applying each of the missing data strategies. The relationship between the groups remained the same although the differences between the groups changed in size and significance. We applied method 2 to handle missing data throughout the analysis since this assumption appears to produce the least bias.***

Discussion

One-half of the study population initially complied with advice to exercise. This three-months compliance rate, while not high, appears reasonable, given the simplicity of the regimen and short time spent with each participant. Since our exercise prescription required each participant to design and carry out his own exercise program, we may expect compliance to be lower than in programs where individual prescription is followed by the reinforcement of group exercise.

Twenty-nine per cent of the control prescription group are compliers at the three months test. By adding a one-hour media and verbal educational package (Groups 2 and 3), we increased the proportion to 55 per cent. However, compliance was not increased further by addition of self-monitoring.

Men who do not start to exercise regularly resist the monitoring and reporting strategy. Fifty-five per cent of the group offered this technique as an aid to their adherence completed the reports. Of the 16 men who did keep records, 10 were good compliers at three months and all but one of them continued to the six-months test. This 56 per cent compliance of the monitoring group is well above the 33 per cent found in the education only group. This association between exercising and keeping records may be the result of a third factor, e.g., a personality trait which leads to both actions. Further testing of the effect of record-keeping on compliance should involve procedures which will somehow ensure compliance with the record keeping.

Not all the subjects who reported exercising regularly changed their aerobic condition enough to be classified as compliers. If we accept the self reports as accurate, then intensity and duration of the exercise may be important factors which differentiate between compliers. Twenty-six per cent of the control group and 11 per cent of the experimental groups reported aerobic exercise at least twice per week but changed their aerobic condition by less than 9.5 per cent. It is possible that the control group was less truthful because of less contact with the project staff, but it is more likely that the information and motivation information in the experimental treatments provided the support for the adoption of training principles of intensity and duration.

The number of participants from one fire station had no statistically significant effect on compliance. However, one fire station had a large number of participants due possibly to the influence of a fitness minded district chief.

Ten cases left the study due to medical problems which were usually job-related injuries. These cases are eliminated from the analysis. Since eight out of the ten medical prob-

***A complete description of the effects of these alternate strategies is available on request.

lems come from the control group, there may be a positive bias in the percentage of compliers in this group. This uneven distribution of medical problems may be due to the control group being less active than the treatment groups and more likely to try to explain their inactivity, or to lower fitness level and/or lack of knowledge about good exercise principles which put the control group at higher risk of injury.

All groups have a very similar percentage of compliers at the end of six months. In the control group, those who continue to be compliers at six months were identified at three months. While a one-hour educational presentation initially motivated twice as many to comply as the control prescription, this effect was temporary.

This core group of compliers was doubled through an educational strategy, but the effect of the strategy was not evident six months later.

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