A Cost-Effectiveness Analysis of Exercise as a Health Promotion Activity

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Abstract: We used cost-effectiveness analysis to estimate the health and economic implications of exercise in preventing coronary heart disease (CHD). We assumed that nonexercisers have a relative risk of 2.0 for a CHD event. Two hypothetical cohorts (one with exercise and the other without exercise) of 1,000 35-year-old men were followed for 30 years to observe differences in the number of CHD events, life expectancy, and quality-adjusted life expectancy. We used jogging as an example to calculate cost, injury rates, adherence, and the value of time spent. Both direct and indirect costs associated with exercise, injury, and treating CHD were considered. We estimate that exercising regularly results in 78.1 fewer CHD events and 1,138.3 Quality Adjusted Life Years (QALYs) gained over the 30-year study period. Under our base case assumptions, which include indirect costs such as time spent in exercise, exercise does not produce economic savings. However, the cost per QALY gained of $11,313 is favorable when compared with other preventive or therapeutic interventions for CHD. The value of time spent is a crucial factor, influencing whether exercise is a cost-saving activity. In an alternative model, where all members of the cohort exercise for one year, and then only those who like it or are neutral continue, exercise produces net economic savings as well as reducing morbidity. (*Am J Public Health* 1988; 78:1417–1421.)

Introduction

Regular aerobic exercise is increasingly being viewed by health professionals as a key behavioral ingredient in reducing the risk of illness, particularly illness associated with heart disease. The "fitness craze" has emerged as an integral component of the broader concern with health promotion, with exercise explicitly recognized in the US Public Health Service's health promotion and disease prevention objectives for the nation.[1] In recent years the presumed cardiovascular benefits of exercise have received convincing empirical support.[2–4] Accordingly and increasingly, the medical profession has come to recognize and prescribe exercise as a preventive and rehabilitative therapy.

Many health promotion advocates emphasize also the economic benefits of exercise, in addition to its contribution to better health.[5] Because both the economic and medical dimensions of exercise are subjects of substantial interest, we examine the cost-effectiveness of exercise as a primary prevention medical technology. Our interests are in the health and economic implications of exercise as compared with its absence and in using exercise as an alternative to common medical interventions designed to address potential or existing heart disease. In addition, we examine the issue of whether exercise consumes more or less time than it saves in increased life expectancy.

Methods

We used decision analysis and cost-effectiveness analysis to compare a regular exercise regimen with its absence in cohorts of 1,000 35-year-old men, followed for 30 years. We defined exercise as leisure time physical activity that consumes 2,000 kcal per week. Jogging was used as an example to calculate costs, injury rates, adherence, and the value of the time spent. Exercise was considered to be a prescriptive medical intervention, analogous to chronic antihypertensive or hypoglycemic treatment. Cost-effective is a relative and subjective concept defined as "having an additional benefit worth the additional cost."[6] Beneficial programs that yield net cost savings are automatically cost-effective, but net cost saving is not necessary for a program to be judged cost-effective.

Using epidemiologic data, we estimated the number of fatal and nonfatal coronary heart disease (CHD) events that would be expected to occur over time in each cohort. We considered the consequences of CHD events to be their direct medical care cost and their effects on life expectancy and reduced quality of life. Thus, our measures of the health effectiveness of exercise were reductions in the numbers of CHD events, gains in life expectancy, and gains in quality-adjusted life expectancy. These effectiveness measures served as denominators in our cost-effectiveness ratios. The numerators of the ratio represent various measures of the difference between the incurred costs of the two strategies. We considered both direct costs and savings associated with an exercise regimen (direct costs, including equipment and clothing, as well as the medical cost of injuries, and savings consisting of the avoidance of treatment for CHD events) and indirect costs and benefits, respectively (time spent in the exercise program and healthy time gained as a result of CHD events prevented). Our outcome measures are cost (direct or direct plus indirect) per year of life saved, cost per quality-adjusted life year (QALY) saved, and cost per CHD death averted. All future costs and years of life saved were discounted at a real annual rate of 3 per cent to determine their present value. We chose to discount health benefits (future years of life saved and cases averted) to maintain a common perspective on the value of both future costs and future health effects. Costs were measured at 1985 price and wage levels.

Definitions and Rates

Health events for which rates were required in the analysis were exercise-related injuries, CHD events, and non-CHD mortality. Injury was defined as an adverse health effect severe enough for the injured person to seek medical consultation. We estimated the annual probability of such injury to be 5 per cent, with 17 per cent of those injured

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quitting jogging permanently because of the injury.[7] We assumed that the rate of injuries and quitting remained constant throughout the 30-year study period.

CHD events were considered to be death (sudden or nonsudden), myocardial infarction, or other CHD (angina pectoris and coronary insufficiency). Age-specific incidence rates for men were derived from the Framingham Heart Study.[8,9] These rates, however, represent combined population rates, which include those who do and those who do not exercise. We calculated separate rates for exercisers and nonexercisers by assuming that 10 per cent of all men exercise as defined previously and that exercise reduces the risk of CHD by 50 per cent.[10] Age-specific death rates for men for 1980 from all other causes except CHD were used.

In both the exercise and nonexercise cohorts, we separated those who experienced nonfatal CHD into subgroups and tracked them to determine the number of additional deaths occurring during the follow-up period. Annual mortality rates in these subgroups of persons with CHD histories were based on data from the American Heart Association (age-specific CHD deaths and prevalence of CHD). Persons injured due to exercise and unable to continue jogging were considered "quitters" (dropouts). We assumed that they did not engage in other forms of aerobic activity and that they experienced the CHD rates of non-exercisers from the year of quitting.

Costs

Exercise—The direct cost of exercise, the cost of equipment (running shoes, clothes, etc.), is estimated at $100 annually. Considering exercise to be a prescriptive medical intervention, we have included the cost of counseling a patient to undertake an exercise regimen as a direct cost. We assumed that this counseling would occur during a routine periodic examination and would represent 10 per cent of a 45-minute visit. We estimated the average cost of the history and examination portion of a routine physician visit to be $75.

To determine the indirect cost, we assumed five hours per week, including exercise time (nine minutes per mile, 20 miles per week) and preparation time (24 minutes, five times a week). In deriving the monetary value of this time, we used the results of a telephone survey of six exercise experts who estimated the proportions of participants in an exercise program who like it (55 per cent), dislike it (35 per cent), or are neutral (10 per cent). We assumed that those who are neutral toward exercise would value their time at $4.50 per hour (half the 1985 hourly wage.[11]) Those who dislike exercise would value their time at $9 per hour, the average hourly wage, whereas those who like exercise would view it as costless, the "enjoyment value" exactly canceling out the opportunity cost of time expended. Multiplying these monetary values by the survey proportions produced an average value of $3.57 per hour of exercise for the cohort.

Injury—For the direct medical cost of injury, we assumed that an average office visit costs $40, and 50 per cent of the injured have an x-ray taken, at an average cost of $50. For the indirect cost, we estimated the average hours of work lost because of injury.[7] Work time lost is less than one hour per injured person per year, which then multiplied by the average hourly wage, yields an estimate of $8 per injured person per year.

Coronary Heart Disease—We used published direct and indirect lifetime cost estimates for CHD.[9] Direct costs are emergency assistance, hospitalization, follow-up care, including office visits, tests, and medications, and possible coronary angiography and coronary artery bypass grafting. Indirect costs are losses of earnings due to disability and premature death. All costs were adjusted from 1980 to 1985 dollars.

Measures of Effectiveness

To measure the health effects of exercise programs, we calculated the expected number of CHD events and the gain in years of life saved to allow comparison with other preventive or therapeutic measures.[12] The gains in years of life expectancy were adjusted for changes in the quality of life due to decreased morbidity from nonfatal CHD. We calculated QALYs by assuming that each year which follows the onset of a nonfatal form of CHD is equal to .8 of a healthy year.[12] We calculated QALYs for exercise-related injuries by assuming that the quality of the time spent while injured was .9 of an equivalent uninjured time period.

Sensitivity Analysis

We performed sensitivity analyses to test several of our assumptions. First, we varied the relative risk for a CHD event from 1.5 to 2.5. In addition, we varied the prevalence of those who exercise from 10 per cent to 20 per cent; the discount rate from 0 per cent to 5 per cent; the direct cost of exercise from $100 to $200; the indirect cost of exercise from $2 to $13.50; and the QALY weight from .7 to .9.

Alternative Model

We have also considered an alternative (voluntary) approach, which ultimately would target the exercise program at those who consider it to be enjoyable, or are at least neutral. We assumed that persons who start exercising do so for a one-year trial. After that, those who like it or are neutral continue, whereas those who do not like it quit permanently. We used probabilities of liking or disliking exercise derived from the expert survey and applied the same cost assumptions.

Analysis of Time Trade-Off

Recent critiques of analysis of the life expectancy benefits of exercise have commented that exercisers consume as much time in exercise as they gain in life expectancy.[13] To examine this issue and to provide another perspective, we determined the balance between time spent on exercise and injuries and that gained from CHD prevention. In effect, this approach constitutes a time cost-benefit analysis of exercise. We used the same assumptions as in the base case cost-effectiveness analysis.

Results

Health Benefits of Exercise

Under the base case assumptions there were 78.1 fewer CHD events in the exercise cohort than in the nonexercisers (Table 1). Furthermore, because of gains in life expectancy and quality of life, there were 1,138.3 QALYs saved in the same cohort (529.8 if discounted) (Table 2).

Costs

The expected costs under the two alternatives are displayed in Table 3. Accounting for the indicated direct and indirect costs of exercise, injury, and disease, exercise does not produce economic savings. It costs $740,000 more in direct costs and $6 million more in total (direct and indirect) costs for the cohort of exercisers.

TABLE 1—Expected Events Occurring between Ages 35–64 in Cohorts of 1,000 Exercisers and Non-Exercisers

Exercise	No Exercise
Total CHD	118.9
197	
Myocardial infarcts	51.5
85.6	
Other CHD	49.3
81.9	
Deaths (initial)	18.1
29.5	
Additional Deaths*	14.2
26.7	
Total CHD Deaths	32.3
56.2	

*Deaths from CHD in cohort members whose initial event is MI or other CHD.

Cost-Effectiveness Ratios

Estimates of the cost-effectiveness of exercise in preventing CHD are presented for four different effectiveness measures: QALYs gained, years of life gained, CHD cases averted, and CHD deaths averted (Table 4). The costs per QALY gained when direct and total costs are considered are $1,395 and $11,313, respectively.

Sensitivity Analysis

Using discount rates of 0 per cent and 5 per cent produces total costs/QALY of $8,376 and $12,623, respectively (Figure 1). Using a relative risk for CHD for nonexercisers of 2.5 produces a cost/QALY of $6,596, whereas a relative risk of 1.5 produces a cost/QALY of $18,685. A prevalence rate of exercise of 20 per cent in the general population results in little change in the cost/QALY, $9,654. When QALY weights of .7 and .9 are used, the costs/QALY are $12,090 and $10,352, respectively. Doubling the direct costs of exercise to $200 increases the cost/QALY to $14,342. When the indirect cost of exercise is varied from the base case estimate of $3.57 per hour, the cost/QALY varies from no cost at $2 per hour ("break-even" point) to more than $24,061 per QALY when an average hourly wage of $9 is used (Figure 2).

Voluntary Approach to Exercise

With this alternative, voluntary approach, a gain of 345.4 QALY is expected for those who continue exercising (i.e., those who like it and those who are neutral). The results are presented in Tables 5 and 6. The health benefits are less than the QALYs gained in the main analysis (350.1 vs 529.8 QALYs); however, this voluntary approach to exercise yields net economic savings even when indirect costs are included ($23.13 million for exercisers vs $25.79 million for nonexercisers). People who do not like exercise quit and thus do not incur the cost of $9 per hour.

We determined the incremental cost and benefit of coercing those who simply do not like exercise to engage in jogging. The marginal cost-effectiveness ratio for the coerced population is $48,775 per QALY.

TABLE 2—Years of Life Lost in 1,000 Exercisers and 1,000 Nonexercisers, Ages 35–64

	Not Discounted		Discounted*	
	Exercise (N=1000)	No Exercise (N=1000)	Exercise (N=1000)	No Exercise (N=1000)
Due to CHD				
from Death	672.2	1190.5	276.9	492.1
from morbidity (QALY)	899.9	1539.9	449.8	778.2
Due to Jogging Injury	20.0	—	13.8	—
Total	1592.1	2730.4	740.5	1270.3

*Present values at 3 per cent per annum.

TABLE 3—Expected Costs ($ Million) among 1,000 Exercisers and Non-Exercisers*

	Exercise (N=1000)			No Exercise (N=1000)		
	Direct	Indirect	Total	Direct	Indirect	Total
Equipment	1.670	—	1.670	—	—	—
Exercise time	—	15.450	15.450	—	—	—
Injury	.052	.006	.058	—	—	—
Disease	1.410	13.200	14.610	2.39	23.4	25.79
Total	3.132	28.656	31.788	2.39	23.4	25.79

*Present values at 3 per cent per annum.

Analysis of Time Trade-off

When time is discounted, like any other cost or benefit, the cohort of the 1,000 men aged 35 who exercise regularly for the next 30 years spends a total of 522.7 years in exercising, whereas 530 years are gained by preventing CHD. The "benefit-cost" difference is positive by 7.3 years, representing a net gain of 2.7 days per member of the cohort. Without discounting, there are 730 years spent and 1,030 years gained, a "benefit-cost" difference of 300 years, or almost 110 days per cohort member.

Discussion

Previous studies have concluded that other disease prevention technologies are cost-effective relative to therapeutic health care expenditures,[14] and sometimes even produce net economic savings, e.g., fluoridation[15] and certain immunizations.[16,17] Recently, however, concern has been expressed that, in some instances, preventive measures for chronic illnesses may be less cost-effective than those for acute conditions, and further that preventive measures are not invariably more cost-effective than curative therapy.[18]

On the basis of our estimates and assumptions, exercise *is* a cost-effective approach to lowering the risk of CHD. Exercise costs $11,313 per QALY saved, including the cost of time spent, and $1,395 in direct costs, excluding indirect costs and benefits. These figures compare favorably with other published cost-effectiveness studies of CHD interventions.[12] Coronary artery bypass graft surgery with left main disease costs $5,000 per QALY when two-vessel disease is present. With mild angina the cost per QALY becomes $40,000. Treating hypertension varies from $25,000 per QALY (diastolic pressure of 95–104 mm Hg), to $65,000 per QALY (diastolic pressure 90–94 mm Hg). It should be

TABLE 4—Cost-Effectiveness Ratios*

	Direct Cost ($)	Total Cost ($) (Direct & Indirect)
Cost/QALY Gained	1,395	11,313
Cost/Year of Life Gained	3,433	27,851
Cost/CHD Case Averted	9,462	76,760
Cost/CHD Death Averted	30,920	250,836

*All costs and effectiveness measures discounted at 3 per cent per annum.

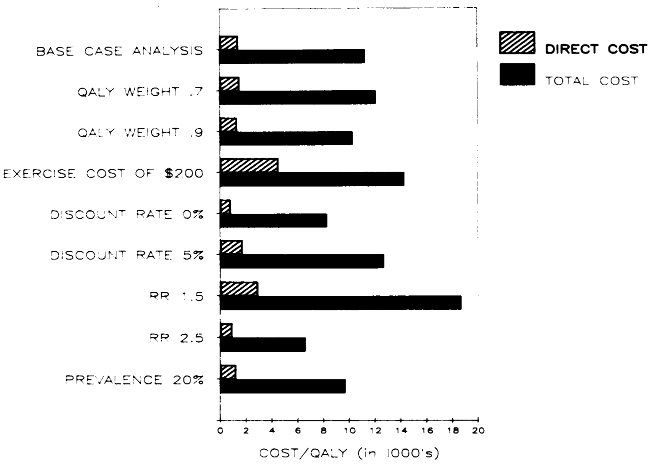

FIGURE 1—Sensitivity Analysis

emphasized, however, that these studies include direct costs only. It is conceivable that if these other CHD interventions saved a sufficient amount of productivity, then the inclusion of indirect benefits and costs would make these interventions more cost-effective.

The other cost-effectiveness studies of CHD interventions use only direct costs and savings, as is customary in cost-effectiveness analysis. We consider the indirect costs of time spent in exercise to be integral to this health intervention. An alternative approach to expressing cost-effectiveness could apply both direct and indirect costs but only direct benefits (our base case uses both direct and indirect benefits). This method results in a cost of $30,575 per QALY saved, or $75,232 per year of life saved. For the voluntary approach, exercise, which was cost saving when both direct and indirect costs and benefits were used, no longer saves money but is cost-effective at $9,180 per QALY saved, when total costs and only direct benefits are used. Thus even using this conservative approach, exercise remains comparable in cost-effectiveness to other CHD interventions. Significantly, evaluations of the costs of treatment of morbid conditions typically do not quantify the nonpecuniary costs of the disease and its treatment (i.e., the costs of pain and suffering).

The indirect cost of exercise is the most important

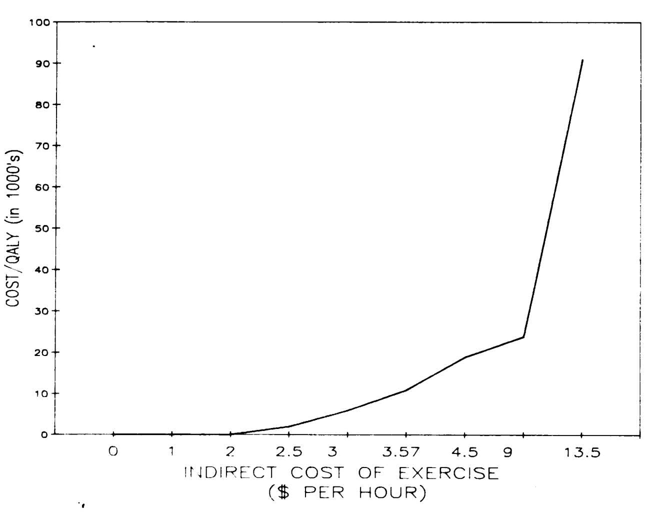

FIGURE 2—Relation of Indirect Cost of Exercise to Cost/QALY

TABLE 5—QALYs Lost under the Noncoercive Exercise Program*

	Exercise	No Exercise
Due to Death	350.1	492.1
Due to Disease	561.2	778.2
Due to Injury	9.0	0
Total	920.3	1270.3

*Present values at 3 per cent per annum.

variable in influencing the results of this analysis. If the indirect cost (time spent in exercise) were valued as "no cost", then exercise would be cost-saving. However, we treat exercise time as having opportunity cost. Although the wage rate is commonly used in economic studies as the value of leisure time, we used one-half the wage rate as our basic measure of this opportunity cost. Both theory and empirical analysis suggest that the opportunity cost of the marginal leisure hour is less than the wage rate. We have used the estimate of half the wage rate produced by one of the few studies to examine this issue empirically.[19] Note that our treatment of the indirect cost of time for those who enjoy exercise is undoubtedly conservative for many people who are (or would be) willing to pay to exercise (as demonstrated by memberships in health clubs, for example). To these people, the benefits of exercise—immediate and perceived for the future—give exercise a net positive economic value.

Our results support an approach in which physicians would strongly urge patients to begin an exercise program on a trial basis for one year, with the expectation that only those persons who find it pleasurable or those who are neutral would be encouraged to continue. Such an approach was found to yield net cost savings, whereas an all-or-nothing approach in which "exercise-haters" are forced (in the model) to comply was cost-ineffective for this group ($48,775/QALY) compared with other methods of coronary heart disease prevention ($5,000 to $30,000 per QALY).

Our study focused on only cardiovascular health benefits of exercise. Other demonstrated health benefits of exercise include weight control, stress reduction, smoking cessation, and assistance in diabetes and hypertension management.[20] Quantification and inclusion of these benefits would improve the relative cost-effectiveness of exercise, possibly considerably.

Other forms of exercise also provide aerobic cardiovascular benefits. If used in a similar analysis, walking, swimming, and bicycling would require changing several variables. For example, walking might be a more enjoyable pastime for certain participants, thus lowering the indirect costs of exercise, but walking would require more time to achieve the same cardiovascular benefit, thereby increasing

TABLE 6—Costs under the Noncoercive Exercise Program ($ Million)*

	Exercise			No Exercise		
	Direct	Indirect	Total	Direct	Indirect	Total
Equipment	1.117	—	1.117	—	—	—
Exercise time		2.80	2.800	—	—	—
Injury	.004	—	.004	—	—	—
Disease	1.780	17.43	19.210	2.39	23.4	25.79
Total	2.901	20.23	23.131	2.39	23.4	25.79

*Present values at 3 per cent per annum.

the indirect costs. It would likely also reduce the direct costs of injury caused by the exercise.

Our study focused exclusively on 35-year-old men followed for 30 years. Further studies in exercise cost-effectiveness could consider women, various racial, ethnic or socioeconomic groups, other forms of exercise, and other health benefits. Adherence to an exercise regimen would affect the results of this analysis just as would adherence to a drug therapy. Partial adherence would reduce the cost (indirect) of exercise and the injury rate but also the cardiovascular benefits conferred by exercise. Thus, additional aspects that could be studied would be to vary adherence and the number of years of participation in an exercise program.

In another analysis of the health benefits of exercise, Paffenbarger *et al*,[21] estimated that exercise adds 2.15 years to the life expectancy. If we change some of the assumptions in our analysis (no discounting, full adherence, and no QALY adjustment), the total years gained for the cohort are 1,500, which is 1.5 years per person. The difference can be attributed to the fact that Paffenbarger, *et al*, looked at mortality from all causes from a very specific cohort (Harvard alumni), whereas we looked at increases in life expectancy by preventing CHD only, using national estimates.

To perform this analysis we have had to make several assumptions and use the best available data. The analysis can be improved in the future as more knowledge is gained on exercise and CHD, and then applied in a systematic and analytic framework.

For persons who enjoy the immediate pleasure and benefits of exercise, this activity is probably also a cost-effective measure in reducing risks of CHD. For others who find exercise a less pleasant activity, its cost-effectiveness is comparable to that of some drug therapies and surgical interventions.[12] Most persons logically would prefer to prevent a morbid condition rather than develop it and have it treated. However, they may require more immediate satisfaction to undertake and maintain a regular exercise regimen than the knowledge that it will reduce their long-term risk of CHD or that it is "cost-effective."

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