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Importance of Sport and Exercise to Quality of Life and Longevity

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Summary

Concepts and methods of measurement of quality-adjusted life expectancy are discussed. It is argued that an improvement in the quality-adjusted life expectancy is a stronger argument for exercising than is a mere increase of life span. A physically active lifestyle probably increases quality-adjusted life years more than it augments total life span, although techniques to estimate the likely impact of exercise need refinement. Gains in the quality of life seem more likely to motivate a young person to exercise than does a promise of increased longevity because an increase in the quality of life provides an immediate reward, rather than one that occurs at some time in the distant future. Some benefits are obtained from a reduced probability of acute and chronic disease, but the main bases for improvement in the quality of life lie in an immediate enhancement of mood state and a greatly reduced likelihood of disability and dependency in old age. Given the importance of quality of life to both motivation of the exerciser and overall population health, this topic deserves greater attention on the part of exercise scientists and practitioners.

Introduction

The past 20 years have seen the emergence of a strong belief that sport and exercise are effective means of increasing both the quantity and the quality of a person's life. Moreover, this belief is increasingly emphasized in efforts to promote an increase of physical activity among the general public.

Epidemiologists who have sought to summarize the health benefits of regular physical activity, sport, and exercise have commonly focused their attention on the quantity of life, or reductions in the relative risk of death, rather than on the quality of survival, probably because indices of mortality are easily measured and seem relatively incontrovertible statistics (see, for example, the review of Paffenbarger, Hyde, Wing, Min-Lee, & Kampert, 1994). Nevertheless, there is growing recognition of the need to assess treatment-related changes in the quality of a patient's life (Kaplan, Anderson, & Wingard, 1989; Rejeski, Brawley, & Shumaker, 1996), and indeed the U.S. National Institutes of Health now requires some assessment of quality of life in most clinical trials of new medications.

The present chapter discusses issues of terminology and the nature of available

evidence before evaluating critically the respective impacts of sport, exercise, and regular physical activity on the span of life and its quality. A final section looks briefly at implications for public policy.

Issues of Terminology

Sport, Exercise, snd Physical Activity

Various consensus statements have drawn clear distinctions among sport, exercise, and physical activity (see, for example, Bouchard & Shephard, 1994). Clarification of terminology not only has theoretical interest, but is also of some practical importance in our present context.

Sport. In many European countries, the term sport is used to describe various forms of voluntary physical activity, both recreational and competitive, but in North America, the same word usually implies participation in competitive activity, whether voluntary or professional in type. There is often a strong selection of competitive athletes in terms of their body build, and this immediately has important practical implications when comparisons of mortality experience are made between athletes and the general public (Sarna, Sahi, Koskenvuo, & Kaprio, 1993). Athletic selection is also favored by personality traits that increase the risk of an early and violent death, and this trend can offset possible favorable effects of regular, vigorous physical activity on susceptibility to various chronic diseases (Polednak, 1978). Comparisons with the sedentary population are further complicated because a proportion of athletes are health-conscious individuals who seek to extend their life span by such practices as eating a prudent diet, consuming mega-doses of vitamins, and abstaining from cigarette smoking (Shephard, 1989). In terms of the health impact of the sport itself, there are often benefits from regular, intensive physical activity. However, the "weekend athlete" may engage in occasional bouts of strenuous competitive activity for which he or she is poorly prepared; the combination of an excessive intensity of effort and the emotional excitement of competition may then precipitate rather than postpone a heart attack (Shephard, 1995; Vuori, 1995). Particularly for teenagers, the impact of sport on the participant's quality of life is augmented by peer adulation of sports teams. Many sports participants also value the excitement of competition, and for such individuals, a closely competed game may do more to enhance their quality of life than an equivalent expenditure of energy on a laboratory treadmill. Nevertheless, this again is partly a question of self-selection, and those who do not engage in competitive activities may find little attraction in the bonhomie and group mores of an exercise class.

Exercise. Exercise may be defined as any form of leisure activity that is undertaken for a specific purpose, such as the improvement of health, the increase of physical fitness, or the extension of life span. Often, a physician or exercise specialist prescribes a clearly specified mode of activity, together with an appropriate intensity, frequency and duration of individual sessions (American College of Sports Medicine, 1995; Shephard, 1994). In theory, such exercise is the most effective method of enhancing health because the dose is carefully regulated to optimize its conditioning effect. However, in practice, the actual dose of physical activity may be less than adequate, because of poor attendance at exercise sessions or fears to implement the prescription on the part of the individual or those supervising exercise classes. Moreover, the "sameness" of a prescribed activity may limit its contribution to the quality of life. Sometimes, a person feels compelled to conform to the recommendations of the health specialist and may even suffer from

feelings of guilt if for any reason the exercise prescription cannot be filled.

Physical activity. Physical activity is a much broader rubric than either sport or exercise. It encompasses both of these items, but it also includes vigorous occupational activity, domestic chores, energy spent in commuting to and from work, and active leisure pursuits other than sport and exercise.

Automation has greatly reduced the energy cost of much traditional "heavy work," to the point that now such employment usually has little impact on either health or longevity. Nevertheless, there are still a few occupations that demand a substantial daily energy expenditure. For example, the postal carrier must each day carry a heavy bag of mail over a substantial distance, climbing a flight of steps to the front door of most houses (Shephard, 1983). Walking and cycling are the commonest forms of active leisure for most city-dwellers. In young adults, the chosen speed of walking is often too low for this activity to have any beneficial influence on health, but in older adults, brisk walking can demand a large fraction of the individual's maximal oxygen intake (Shephard, 1997a).

Leisure activities may contribute more to the quality of life than an equivalent investment of time in a regimented program of exercise classes. Spontaneous leisure avoids the unpleasant coercion of a formal exercise class, and what for some people is the "stress" of meeting preassigned targets. The activities that are selected can be varied in type, and they can be built into the normal daily schedule, thus overcoming one common excuse for inactivity ("a lack of time"). Moreover, some leisure pursuits such as fast walking can be pursued in a pleasant recreational environment; conversation with a companion is possible, and other interesting pursuits such as the study of urban architecture or the fauna and flora of various habitats can be integrated into exercise sessions. Such secondary interests boost the impact of a given activity session on the individual's quality of life. The main practical limitation of spontaneous leisure activity from a public health point of view is that the intensity of effort is unregulated, and particularly in a young adult, the chosen intensity of effort may be insufficient to have a conditioning effect.

Quality of life. The overall quality of life is influenced by personal perceptions of a wide variety of factors that include physical functions such as mobility and the capacity for self-care; a reasonable level of intellectual and emotional function; social dimensions such as opportunities for intimacy and social contact; opportunities for appropriate role performance within the family, the community, and the workplace; feelings of comfort, well-being, and self-efficacy; and the extent of any pain or other symptoms (Rejeski et al., 1996; Wenger & Furberg, 1990).

An individual's quality of life on any given day is located somewhere along a continuum. At one end of the scale lies an optimal quality of life. This can be assigned an arbitrary multiplier of 1.00. If a person were to enjoy such a quality of life on a continuing basis throughout a calendar year, this would give that individual one quality-adjusted life-year (QALY) of survival. At the other end of the scale, the quality of life has dropped to near zero. The individual concerned loses the will to survive, refusing to eat or pressing for euthanasia. Such a state can be assigned an arbitrary multiplier of zero. Too often, a doctor who is faced with this circumstance attempts to extend life span by drastic and/or costly measures, ranging from forced or intravenous feeding to heart/lung transplants. Such an approach may increase longevity, but it does nothing to augment the individual's QALY.

Some authors (for example, Fries & Spitz, 1990, and Kaplan & Bush, 1982) have

attempted to distinguish what they term a health-related quality of life from the social and environmental factors that influence the total quality of the life experience, but it is plain that patients do not draw such a nice distinction. Social and environmental factors (including the availability of aids for daily living and the support of family, friends, and caregivers) exert a strong influence upon an individual's perceptions of the quality of life and health status (Hart, Bowling, Ellis, & Silman, 1990; Vetter, Lewis, & Llewellyn, 1992). Moreover, some interventions (for example, involvement in a group exercise program) can have an impact (usually favorable) on the social and psychological dimensions of quality of life, as well as influence medical outcomes for the individual (Fisher et al., 1993). It thus seems best to regard quality of life as a gestalt that integrates the individual's instantaneous appraisal of all factors influencing the life experience, ranging from ill health and physical disability to a sense of self-efficacy and pride in performance, and embracing also such psychosocial influences as the extent of independence and opportunities for contacts with friends and relations.

Some authors speak also of healthy life expectancy (Robine & Ritchie, 1991), active life expectancy (Kinsella, 1992) or quality-adjusted life-expectancy (Butler, 1992; Fitzpatrick et al., 1992; R. Kaplan, 1985; Shephard, 1982; Wood-Dauphinee & Küchler, 1992). These terms integrate an individual's experience over the entire life-course, in effect discounting the observed longevity for periods when health or physical activity is impaired or the individual's quality of life is less than ideal.

Available Evidence

Longevity

Studies of longevity may count the actual ages of death in active and inactive populations. or the likelihood of death can be predicted from instruments such as the Health Hazard Appraisal Questionnaire (Shephard et al., 1982a). The latter approach looks at an individual's lifestyle and uses this information to compute the likelihood of death from each of the 12 most commonly fatal conditions over the next 10 years; pooling of this information yields an appraised age, which exceeds the individual's calendar age by a margin that depends on the extent of risk-taking behavior (including a lack of regular exercise).

Plainly, the weightings adopted when evaluating responses to the Health Hazard Appraisal Questionnaire are arbitrary and apply with varying degrees of precision to different populations. The counting of deaths might thus seem a more secure method of investigating the impact of regular physical activity upon life span. However, the observed mortality rate is a complex number, determined by both the positive and the negative effects of exercise. Moreover, an accurate determination of survival rates depends on the investigator's success in tracing all members of a given cohort; this can be quite a difficult task in the very mobile society of North America. Finally, the death of an athlete may receive more publicity than that of a sedentary person, so that the counting of deaths may be more complete for athletes than for any comparison group that has been chosen.

If a study lasts no more than a few months, it may be possible to assign people to exercise programs on a random basis. Such an approach can yield useful data to examine the impact of regular physical activity on Health Hazard Appraisal scores (Shephard et al., 1982a). However, the calculation of survival curves requires that large cohorts be followed over periods of 10 years or longer. It is then necessary to accept a nonrandom assignment of subjects. Comparisons can be drawn between athletes and

nonathletes, heavy workers and those holding sedentary jobs, those with active vs. sedentary leisure pursuits, or those who enter a study with high vs. low levels of aerobic fitness. One somewhat more sophisticated variant of this approach is to compare those who adopt exercise over a period of 10 years or more with those who cease exercising over the same interval (Paffenbarger & Lee, 1996). Plainly, there are many differences between those who choose or maintain physical activity and those who are sedentary or drop out of exercise programs. Although the analysts may attempt to control for these extraneous factors by the use of covariance techniques, it is likely that such adjustments will be incomplete. For example, some studies have merely distinguished smokers vs. nonsmokers, ignoring possible differences in patterns of smoking between those who are active and those who are sedentary. Given the major influence of smoking on longevity, this is an important criticism. A further difficulty is that the initial categorization of habitual physical activity does not always persist; those who were involved in university sports teams may become inactive in middle age (Montoye, Van Huss, Olson, Pierson, & Hudec, 1957), and seniority rules may allow those who were classed as heavy workers to gain physically easier employment as they become older (Shephard, 1997b).

Quality of Life

Assessment of the quality of life holds even greater challenge than the determination of average survival prospects. The investigator needs a measuring technique that is reliable and valid within a given cultural setting, yet responds well to subtle differences in a person's quality of life. There are many possible instruments, but few are widely accepted. Moreover, alternative approaches may yield widely differing estimates of a person's quality of life (Spiegelhalter et al., 1992). Options include the interpretation of the quality of life as a gestalt, use of detailed generic questionnaires, disease-specific instruments, and function-specific assessments.

Gestalt approach. Early measures such as the Karnofsky Index (Karnofsky & Burchenal, 1949) represented the quality of life as a single number. Although reasonably reliable and valid relative to other assessments, the Karnofsky Index has been criticized as failing to capture the conceptual domain of quality of life (Grieco & Long, 1984). Other options within the gestalt rubric include a category rating, a magnitude estimation, a health utility measure, a time trade-off, and a "standard gamble" (Feeny, Furlong, & Torrance, 1996; Guyatt, Dego, Charlson, Levine, & Mitchell, 1989; D. L. Patrick & Erickson, 1993; Spiegelhalter et al., 1992; Torrance, 1987).

In the standard gamble, the individual is asked to imagine that there is now some wonder drug that promises a perfect quality of life, but this new treatment has the disadvantage of carrying a substantial mortality. A computer terminal is used to display the relative likelihoods of cure and death in the form of a pie chart. The probability of the two outcomes is then varied until the person agrees that there is nothing to choose between acceptance of his or her current health status and adoption of the proposed new treatment.

A single score of this type is useful when comparing the impact of various types of physical activity on overall population health in order to make recommendations for future resource allocation (Oldridge, 1997). The main disadvantage is that the global score gives no indication which aspects of function have enhanced the quality of life, so that it is difficult to decide *why* one type of physical activity is more effective than another.

Generic instruments. Generic instruments sometimes look at a single concept, such as a person's tendency to report symptoms, the

number of bed-rest days that are taken each year, or the demands on health services as seen in medical billings for the individual (Shephard, Corey, Renzland, & Cox, 1982b). More commonly, generic instruments ask the subject to rate many components of health (physical, emotional, and social function), along with items such as role performance, pain, and other symptoms. Examples of generic instruments include the Sickness Impact Profile (Bergner. Bobbit, Carter, & Gilson, 1981), the Nottingham scale (Hunt, McEwen, & McKenna, 1986), the massive 44-scale Index of Health-related Quality of Life (Rosser & Kind, 1978), a 36-item short form of the Rand Corporation questionnaire (Jenkinson, Coulter, & Wright, 1993) and the simple 6-scale "Euroqol" instrument (Williams & Kind, 1992).

Much reliable and detailed information may be obtained, but there are several disadvantages to this type of approach:

1. In order to cover a variety of potential clinical problems, the instrument includes many questions that the individual may perceive as irrelevant. This reduces cooperation, and frequent negative responses limit the overall sensitivity of the instrument (D. Patrick & Deyo, 1989; McHorney, Ware, Rogers, Raczek, & Lu, 1992). Generic questionnaires are often more appropriate to evaluation of a rehabilitation program than to a study of the influence of sport on the quality of life of a young adult.
2. Separate ratings are obtained for such items as mastery, fatigue, and dyspnea. It then becomes difficult to assess the overall quality of life, particularly if different test scales show contradictory trends. Any attempts to select weighting factors that will allow scores to be combined require subjective value judgments, and it seems inherently improbable that a single weighting system will be appropriate and stable in all ages, socioeconomic groups and disease conditions (Fletcher et al., 1992a).
3. Some responses to a generic questionnaire (for example, those covering social relationships) may remain relatively static, resisting improvement from a lifestyle intervention such as an increase of physical activity (Fitzpatrick et al., 1991).
4. Because of the number of functions that must be assessed, only scanty information is collected on the ability to undertake various types of physical activity. For example, the Quality of Well-being Scale of R. M. Kaplan and Bush (1982) examines only the individual's ability to engage in very low levels of physical activity; almost all young and middle-aged adults would engage in a much higher level of physical activity than that which is discussed.
5. Because of the time demanded to complete a detailed questionnaire, people are unwilling to be tested repeatedly. Although information can be obtained about a person's immediate status, it is difficult to administer followup tests to examine changes in the quality of life over a number of years of survival.

Disease-specific instruments. Examples of disease-specific instruments include the arthritis impact scale (Meenan, German, Mason, & Dunaif, 1982), the back pain disability questionnaire (Roland & Morris, 1983), and various indices of cardiac and pulmonary rehabilitation outcome (Oldridge, 1997; Pashkow et al., 1995).

Disease-specific instruments can be quite successful when comparing the impact of various types of physical activity on patients with a specific disease, but they are much less helpful when evaluating population health. It is difficult to compare scores obtained in those with one form of disability

with results obtained using a different instrument in people with some other type of disease or disability, and most scales of this type are not suitable for the ostensibly healthy adult.

Function-specific instruments. Function-specific instruments such as the Activities of Daily Living scale, the Profile of Mood States (McNair, Lorr, & Doppleman, 1971), the Psychological General Well-being index (Dupuy, 1984), or the symptom rating test (Kellner & Sheffield, 1973) have been suggested as halfway houses between generic and disease specific instruments (Fletcher et al., 1992b).

Such tests can demonstrate improvements in function, mood state, and well-being in both health and disease, but it is difficult to relate any gains in score that result from an increase in habitual physical activity to alterations in life expectancy or QALY.

General limitations of current methodology. None of the currently available methods is ideal, and whichever method is chosen, quality-of-life scores remain relatively crude. Results may be biased by response acquiescence, particularly in elderly individuals (Moum, 1988). It also remains unclear whether an increase in quality-of-life multiplier from 0.1 to 0.2 units has the same significance as an increase from 0.9 to 1.0 units. Indeed, Wagstaff (1991) has advanced equity arguments for the development of a nonlinear quality-of-life scale; from the public health point of view, we should be more concerned about moving people off the lower end of the scale than in making minor improvements to the well-being of those for whom life is already relatively satisfactory.

If an exerciser feels better, but the quality-of-life score remains unchanged, it is possible that activity has boosted some aspect of function that is important to the individual, yet cannot be detected by what is a rather crude measuring instrument (Deyo & Inui, 1984). Gains in some aspect of the quality of life that is of particular importance to the individual may develop more quickly than gains in other areas, and this response may be masked by calculating a global score (Rejeski et al., 1996). Moreover, we are looking at perceptions of function and the patient's coping strategies, rather than some objective index of performance. Thus, changes in the quality of life may correlate quite weakly with gains in physical fitness (Jasnoski, Holmes, Solomon, & Aguiar, 1981; Rejeski et al., 1996; Woodruff & Conway, 1992).

There is sometimes a conflict between an anticipated shortening of life span and an expected increase in the quality-adjusted life span (for instance, regular bouts of vigorous sport or exercise may enhance the quality of life for a 90-year-old who enjoys physical activity, but at this age such a lifestyle may also shorten calendar survival). It is important that any conflict between the two outcomes not be obscured by calculations that combine duration and quality of life (Fletcher et al., 1992a, b).

It is generally agreed that young adults do not value late health benefits as much as do older individuals because the rewards are much more distant; nevertheless, there is still considerable controversy concerning an appropriate discounting of QALY to allow for what are termed age-related time preferences (Spiegelhalter et al., 1992). Age affects not only the responses of the subjects, but also the approach adopted by the investigators; young researchers do not always make a correct assessment of what is important to older people. Quality-of-life instruments have now been developed specifically for the testing of elderly people (Fletcher et al., 1992b; George & Bearon, 1980; Kane & Kane, 1981). Analysis of the results is further complicated because certain benefits such as an extension of life span diminish as a person becomes older. This inevitably

makes the use of simple QALYs an ageist instrument of public policy (Busschback, Hessing, & de Charro, 1993; Harris, 1991); when measured in such units, the dividends will almost always be greater if resources are allocated to the young rather than to the elderly. One possible alternative is to express treatment-related gains in QALY as a percentage of the individual's anticipated residual life span (Spiegelhalter et al., 1992).

Finally, any change in an individual's perceived quality of life does not reflect simply the response to a given program of physical activity. The reported score depends on a wide range of perceptions of health, function, and mood state. Particularly during the final years of life, there is a strong interaction between the quality of a person's life and the immediate physical and social environment (Birren, 1983; Golant, 1985; Mor-Barak, Miller, & Syme, 1991; Pearlman & Uhlmann, 1988; Sherbourne, Meredith, Rogers, & Ware, 1992). The availability of adapted housing and simple aids to daily living do much to enhance the quality of life at this stage (Hart et al., 1990); other positive factors include the survival of a spouse (Latten, 1989; Moore, Stambrook, Gill, & Lubusko, 1992, Sherbourne et al., 1992), a secure financial status (Pearlman & Uhlmann, 1991), a well-developed spirituality and/or religious beliefs (Oldridge, 1997), and the opportunity to make a productive contribution to the community (Birren, 1983).

Impact of an Increase in Physical Activity

Most developed nations have experienced substantial reductions in mortality from cardiovascular disease, with associated gains in average life expectancy over the past 30 years. These changes reflect advances in medical and surgical treatment, combined with changes in personal lifestyle (the greater prevalence of regular physical activity, a prudent diet, and abstinence from cigarette smoking). Changes in smoking patterns have been particularly important. A young man who stops smoking can extend his life span by an average of 8 years. There is also some cross-sectional evidence that longevity can be increased by 1 to 2 years if regular exercise is begun at the age of 35 years (Paffenbarger & Lee, 1996; Paffenbarger et al., 1994). However, any such extensions in life span raise an important and challenging question. If preventive measures such as stopping smoking and exercising regularly avert a sudden and premature death from cardiac arrest, will the individual who has adopted a prudent lifestyle merely survive to endure an extended period of ill health as one of the growing population of frail elderly individuals?

Fries (1989) has hypothesized that preventive measures reduce the prevalence of ill health and disability and thus yield not only an extension of life span, but also a compression of the final years of morbidity, when the quality of life becomes poor. More pessimistically, Kramer (1980) and Gruenberg (1977) have argued that medical technology is merely prolonging the survival of those who are already in poor health. In support of the latter view, Robine and Ritchie (1991) noted that the average life expectancy in the United States had increased by 3.1 years in men, and 3.0 years in women between 1970 and 1980. Over this same interval, however, disability-free life expectancy had shown no change in women, and a gain of only 0.7 years in men.

In the remainder of the present chapter, we will argue that habitual physical activity can increase not only life span, but also the quality of life. Indeed, the benefits associated with an enhanced mood state, reduced dependency, and reductions in the incidence of

acute and chronic illness seem to offer the regular exerciser a larger and more persuasive reward than a mere extension of life span.

Longevity

Evidence concerning the impact of habitual physical activity upon longevity is conflicting, in part because sport, exercise, and even heavy work are largely self-selected. On one hand, studies of those who were athletes as young adults in general have found no advantage of longevity relative to sedentary controls (Montoye et al., 1957; Polednak, 1978). On the other hand, substantial prolongation of survival has been described in endurance athletes (Sarna et al., 1994) such as cross-country ski champions (Karvonen, Klemola, Virkajarvi, & Kekkonen, 1974), but much of this advantage may reflect a combination of a favorable body build and lifelong abstinence from cigarettes. Perhaps the most convincing evidence that regular exercise *causes* an extension of life span has been drawn from a longitudinal study of Harvard alumni (Paffenbarger & Lee, 1996). Individuals from this well-educated group who had adopted regular physical activity (estimated at about 8 MJ/week, 2000 kcal/week) by the age of 35 to 44 years lived 1–2 years longer than those who spent less than 2 MJ/week (500 kcal/week) on deliberate leisure activity. Benefit was still seen after statistical adjustment of the data for age, cigarette smoking, hypertension, overweight-for-height, alcohol consumption, early parental death, and chronic disease at entry to the study. The extension of life span appeared to be somewhat greater for those who engaged in sports or other activities with an intensity greater than 4.5 METS (25 kJ/min, 6 kcal/min) than for more moderate activities such as walking. Benefit was also seen in those who had adopted physical activity over an average 12-year followup, but not in those who had ceased exercising over the same interval. The potential for extension of life span diminished progressively as the age of the individual increased, and in those who did not begin exercising until the age of 75 to 84 years, the benefit was only a 2-month increase in survivorship.

A study by Pekkanen et al. (1987) reported a substantial difference in cumulative mortality curves between active and inactive segments of the Finnish population. However, the survival curves for the two segments of the Finnish population came together around the age of 80 years, so that the

Table 1. Relationship Between Reported Level of Physical Activity at Age 50 Years and Level of Institutional Support as a Senior Citizen

Activity at age 50 years (arbitrary units, Mean + SD)	Level of disability
9.3 ± 9.8 (n=286)	None
8.1 ± 8.9 (n=126)	Minor
7.7 ± 9.4 (n=173)	Major
4.1 ± 6.6 (n=25)	Institutionalized

From "Geriatric Benefits of Exercise as an Adult." by R. J. Shephard and W. M. Montelpare, 1998, *Journal of Gerontology*, 43, pp. M86–M90.

oldest subjects did not extend their survivorship by exercising regularly.

In support of a differential effect of age on the benefits of exercise, Linsted, Tonstad, and Kuzma (1991) reported that whereas the all-cause mortality of highly active Seventh Day Adventists aged 50–59 years was only 63% of that for their inactive peers, by the age of 80 to 89 years, the highly active subjects had a 10% greater risk of death than did their sedentary contemporaries.

It might be questioned whether the reason for this reversal of benefit is that age increases the risk that exercise will precipitate sudden death (Vuori, 1995). This could be true for that minority of old people who engage in very intensive activity although the observations of Vuori (1995) suggest that on a population-wide basis, the risk of death per exercise session actually diminishes with age, probably because most older people are quite cautious about exercising too vigorously.

Quality of Life

Most people have some scope to enhance the quality of their life, even as young adults. This potential increases with age, as disability and resulting dependency increase. R. M. Kaplan et al. (1991) estimated that the total discrepancy between life expectancy and well-life expectancy was 11.5 years for men and 15.6 years for women. Likewise, in a survey of several different countries, Robine and Ritchie (1991) noted that relative to calendar age, there was a loss of 8.8 to 14.6 well years in men and 10.8 to 17.0 well years in women.

The exact quality of life multipliers for each age category have yet to be determined, but the principles of analysis have been discussed in a previous review (Shephard, 1996).

Healthy Middle-Aged Adults

Most healthy middle-aged adults live at some intermediate point between the two poles on the quality-of-life scale. Their quality of life is not Utopian, and the multiplier may be 0.9 rather than 1.0. Thus, each calendar year of survival gives them 0.9 rather than 1.0 QALY. This implies that they have the potential to enhance their multiplier by 0.1 units, and if this potential were to be realized, they would gain (0.1×35), or 3.5 QALY, between the ages of 30 and 65 years.

Mood state. The main problem for the young and middle-aged adult is a less than optimal mood state. Many people indicate that the reason they exercise is because it "makes them feel better." A reduction of fatigue and an increased energy level are commonly reported immediate dividends of physical activity (Thayer, 1989). It has thus been suggested that regular physical activity can counter depression and enhance mood state. However, randomized controlled trials of exercise and mood state are rare, particularly in the general, nondepressed population, and it would be dangerous to conclude that an increase of physical activity will always enhance mood state and thus improve quality of life. Even if current exercisers are correct in their perception of benefit, they are a self-selected group, and there may be at least an equally large group of nonexercisers (who are not usually seen by sports medicine experts) who find that exercise causes a deterioration in their mood state.

There is some empirical evidence that exercise can improve mood state in young and middle-aged individuals although the benefit seems greater in those who are initially depressed than in those who are initially in at least moderate mental health (North, McCullagh, & Tran, 1990). A moderate association between physical activity and mood state is also found in the elderly although there is as yet little experimental evidence that the association is a causal one (Brown, 1992; Gauvin & Spence, 1996; O'Connor, Aenchbacher, & Dishman, 1993). Where data