

## A Tribute to Professor Jeremiah Morris: The Man Who Invented the Field of Physical Activity Epidemiology

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We in the West are the first generation in human history in which the mass of the population has to deliberately exercise to be healthy. How can society's collective adaptations match? (1)

### INTRODUCTION

So wrote Professor Jeremiah Morris (hereafter, simply Jerry) near the end of a long and remarkably productive life that exemplified his commitment to intellectual and physical activity. It is fitting that these words are from the foreword Jerry wrote for the textbook *Epidemiologic Methods in Physical Activity Studies* (2), a discipline it can be fairly argued he was instrumental in creating and developing. Many would say that he played a pivotal role in the emergence of physical activity epidemiology as a recognized discipline and as a critical contributor to understanding modern determinants of health and disease. The quote also reflects Jerry's ever-present global insight regarding public health issues that was reflected in his personal life as well as his extensive and influential research. Jerry was indefatigable in his efforts to promote public health and reduce health disparities. He continued his academic work and his passionate pursuit of knowledge to the end of his life, with 11 papers published in the scientific literature during his 10th decade. His

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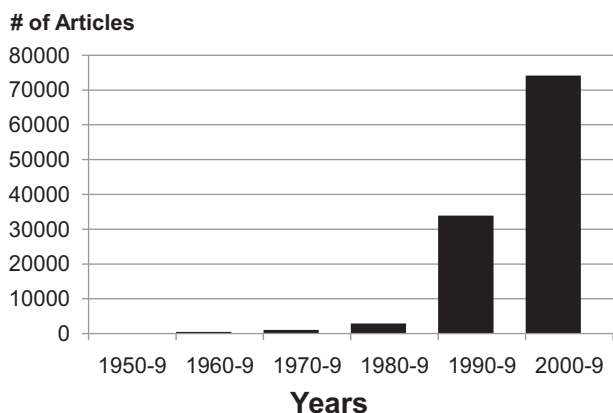
children reported that, while cleaning his house and office after his death, they found evidence of at least a half dozen projects he was pursuing. This continuing commitment to an active life of both mind and body underlies the extraordinary accomplishments and influence of this exceptional man. In this article, our intent is to provide an overview of his enduring achievements and influence and, perhaps, a glimpse of his personality. In so doing, we hope to renew the memories of those who knew him or his work and introduce him to new generations who will continue to learn from him.

The focus of this report is on Jerry's contributions to the field of physical activity epidemiology, but he made other important contributions as well. He was especially concerned with social equality and health and, in fact, described himself as a two-headed hedgehog (see sidebar on Michael Marmot's personal reflections about Jerry).

### A New Discipline—and Its Development over 50+ Years

Jerry was born in Glasgow, Scotland on May 6, 1910 to Jewish immigrant parents. An article based on an interview with Jerry and published a few weeks before his death (3), and obituaries (e.g., Telegraph Media Limited (4)) provide additional information about the background and body of work of this remarkable man. After returning from military service in World War II, Jerry, along with other scientists and public health officials, became aware of the modern epidemic of coronary heart disease. The cause was unclear, but some evidence led Jerry and others to suspect that occupation might be a factor. Jerry's observations in London transport workers and postal workers helped him develop the hypothesis that sedentary work was a factor in the development of coronary heart disease. These investigations became classics of the epidemiologic literature, studied by students for decades after publication, and in fact are still being cited in the peer-reviewed literature.

The first systematic reports on physical activity and health were published in the 1950s. Fig. 1 shows the exponential growth in articles on this topic published over the next 60 years, from fewer than 200 articles during the period



**FIGURE 1.** Number of published articles on physical activity, fitness, and cardiovascular disease—1950 through 2009. Web of Science search terms: “physical activity or physical fitness and cardiovascular disease or coronary heart disease”. Number of articles in each time interval: 142; 493; 1,083; 2,939; 33,932; and 74,162 respectively.

1950–1959 to nearly 75,000 articles in the most recent decade. The present report pays tribute to Jerry’s contributions to this area of investigation and to the broad fields of social medicine, the science of epidemiology, physical activity and public health in the United Kingdom, and physical activity research over the past 50+ years.

### Influence on Epidemiology

Jerry is perhaps best known for his seminal contributions to understanding the health benefits of exercise and the harms of social inequality. Indeed, his crucial contribution to helping establish chronic disease epidemiology may be partly overlooked because some of his insights have become integrated into standard practice. As he noted in 2004, “Today, epidemiology is a mature science, with journals and textbooks and university degrees and university departments. It’s commonplace to have an epidemiological aspect within clinical articles. In my time there was nothing like this. We were creating epidemiology as we went along” (5). For Jerry and his contemporaries, the development of epidemiological methodology was in dialectical relationship to the investigation of concrete influences on population health, in his case, of course, with a particular focus on exercise. Thus, while Jerry introduced his groundbreaking 1957 textbook *Uses of Epidemiology* (6) by writing, “I am concerned mainly with epidemiology as a way of learning, of asking questions and getting answers that raise further questions: that is, as a method,” he presented the material almost exclusively in terms of solving practical questions. In contrast to many other textbooks, there was no abstract presentation of a methodology floating free above the heads of the populations supposed to be the beneficiaries of epidemiological investigation.

At the end of *Uses of Epidemiology* (6), a summary chapter noted: “Epidemiology is the only way of asking some questions in medicine, one way of asking others (and no way at all to ask many)”. The seven uses of epidemiology described in the book were as follows:

1. “In historical study of the health of the community and of the rise and fall of diseases in the population; useful ‘projections’ into the future may also be possible.
2. For community diagnosis of the presence, nature, and distribution of health and disease among the population, and the dimensions of these in incidence, prevalence, and mortality, taking into account that society is changing and health problems are changing.
3. To study the workings of health services. This begins with the determination of needs and resources, proceeds to analysis of services in action and, finally, attempts to appraise. Such studies can be comparative between various populations.
4. To estimate, from the common experience, the individual’s chances and risks of disease.
5. To help complete the clinical picture by including all types of cases in proportion; by relating clinical disease to the subclinical; by observing secular changes in the character of disease, and its picture in other countries.
6. In identifying syndromes from the distribution of clinical phenomena among sections of the population.
7. In the search for causes of health and disease, starting with the discovery of groups with high and low rates, studying these differences in relation to differences in ways of living; and, where possible, testing these notions in the actual practice among populations.”

In summary, these seven points include prominent current concepts in epidemiology. These include attention to epidemiological transitions, clinical epidemiology and clinical practice, broad public health concerns, and a focus on etiology.

The groundbreaking nature of *Uses of Epidemiology* has been discussed from a variety of perspectives (7–11). What is clear from the seven “uses” is that, at this early stage of conceptualization, some visionary epidemiologists saw epidemiology’s potential for across-the-board contributions to medicine and public health. For example, in this view the workings of health services are a legitimate target for epidemiological investigation. This had not generally been the case prior to Jerry’s intervention. In recent years, a participant at a 1952 conference on research requirements for health and medical care, at which Jerry was the keynote speaker, reported that this viewpoint represented a landmark in the history of health services research in the United States (12). For Jerry, epidemiology included study of the current and predicted disease burden of populations, the

study of prognosis, understanding comorbidity—including that produced by common underlying risk processes for different outcomes—and contributing to the effective deployment of health services.

While seven functions of epidemiology were treated comprehensively in *Uses*, Jerry viewed etiologic investigation as fundamental and central to epidemiology's contributions. In the first edition, the chapter on etiology covered about one third of the book; it increased to approximately one half by the third and final edition in 1975 (13). Furthermore, much of the material in the chapters regarding the six other uses of epidemiology refers to how those areas can contribute to or capitalize on the findings of epidemiologic studies of disease etiology.

One concern of *Uses of Epidemiology* that recent epidemiological textbooks have not emphasized is the history and geography of disease. The book began with a lively summation of disease trends in Britain; it was particularly concerned with the increasing male-female disparity in death rates, as little improvement in male death rates was observed from the 1930s to the mid-1950s, a period during which female death rates declined consistently. The important contribution of ischemic heart disease and lung cancer to this disparity was made clear. These two conditions—together with peptic ulcer—were causes of an increasing proportion of deaths beginning mid-century and therefore received much attention in the book. Regarding the causes of disease, the large-scale historical changes and differences between countries were considered key indicators of whether factors were plausible etiological agents: "To survive, a hypothesis on etiology must be consistent with such facts of life" (6). This engagement with "ecological" data—sometimes dismissed as of limited inferential value in more recent considerations of epidemiological methodology—was reflected in Jerry's dissatisfaction with the stress hypothesis of peptic ulcer. Psychosomatic causes—"stress"—were the main focus of research on peptic ulcer etiology over the period during which the three editions of *Uses of Epidemiology* appeared. The time trends for peptic ulcer, however—rapid increases followed by rapid declines—didn't fit the stress hypothesis. As Jerry pointed out, the decline in incidence of the disease "would suggest to anyone in sympathy with 'psychosomatic' theories... that the type of personality disposed to the disease is less common—unfortunately not a testable proposition; [or] that the environment is less of a strain—which is scarcely conceivable" (13). In the first edition of *Uses of Epidemiology* he noted, with regard to the increases in peptic ulcer seen up to the mid-century in Britain and the marked international differences in the prevalence of peptic ulcer, that "there may well be gold awaiting the imaginative traveler (6)". Imaginative travelers, of course, identified *Helicobacter pylori* as the major cause of the disease, but they weren't

epidemiologists (14). Perhaps greater early attention to the epidemiological principles laid down by Jerry would have allowed epidemiologists to contribute earlier to identifying such an important treatable cause of disease.

Changes in disease rates were taken by Jerry to indicate the environmental dependency of disease burden. Addressing the data on male and female mortality, Jerry asked rhetorically: "What are the social changes that underlie the biological changes expressed in the figure?" (6) This notion of how the social literally becomes biological should be at the heart of the epidemiological enterprise. It was critical to the early days of public health in the form of the sanitary movement and can be seen in the more recent emergence of social epidemiology as a major influence on epidemiologic methods and perspectives (15). Jerry's own lifetime research on the 'modern epidemic' of coronary heart disease in relation to physical activity of work and, later, leisure-time exercise in the increasingly sedentary population, illustrates this perspective.

Much more could be said about Jerry's contribution to the development of chronic disease epidemiology. In Zhang and colleagues' assessment of the evolution of epidemiological methodology presented in textbooks across the twentieth century, *Uses of Epidemiology* rides high (11), as clearly distinguishing between retrospective and prospective studies, elaborating a nuanced model of multiple levels and multiple agents of causation, and discussing, within the context of particular examples, confounding and bias. In *Uses of Epidemiology* we can see precursors of discussions of the population versus high-risk approach to disease prevention, elaborated later by Geoffrey Rose (16), the necessity of large-scale randomized trials in evaluating primary prevention of disease, and the ecological thinking now popular within epidemiology (7, 8, 15, 17, 18). Life course epidemiology was foreshadowed, for example, when Jerry wrote, "On all counts, the notion of hypertension, atherosclerosis and coronary heart disease as 'pediatric problems' represents a hopeful advance" (13); that disease of later life may be laid down in childhood; that "the 'physiological' failures reflected in perinatal mortality reflect the lifetime experience of the mother; and even that there was 'the programming of adult disease in childhood' (13). The style of epidemiological thinking revealed by close readings of *Uses of Epidemiology* and Jerry's other works will have much to contribute to the education of epidemiologists well into the twenty-first century.

### **Influence on Exercise and Public Health in the United Kingdom**

Through his insightful application of epidemiology to the effects of occupational and leisure physical activity on the risk of coronary heart disease, Jerry provided the foundation

for the field of exercise and public health to emerge, not only in the UK but worldwide. Prior to the 1950s, exercise in the UK was largely viewed as the necessary means of achieving and maintaining fitness for work, military action, or sport performance. Because of Jerry's early work, the scientific and medical communities awoke to the prospect of physical activity as a potent tool for combating disease and infirmity. Thus, he provided the impetus for a new multidisciplinary field of physical activity and health.

Jerry continued to inspire the emerging field of physical activity and health throughout the following decades. His own work continued with his research on civil servants in the 1970s (19, 20). His work provided a stimulus for the Harvard alumni and San Francisco longshoreman studies by Paffenbarger and colleagues in the 1970s and 1980s and the physical fitness research of Blair and colleagues with the Aerobics Center Longitudinal Study in Dallas from the late 1980s to the present. Other studies in the UK also addressed physical activity and health (21, 22). Outside epidemiology, the first indication that a new field related to public health was emerging in the UK came from the English Sports Council, which began to realize its responsibility for promoting sport and everyday activity for health benefits in the general public. On its behalf, Basse and Fentem (23) produced the first comprehensive appraisal of the influence of exercise on health in a small but insightful text entitled *Exercise: The Facts*, which featured Jerry's studies prominently. The authors' concluding statement, "Exercise can enhance normal health, prevent disease, and ameliorate the effects of disease" (p. 93) would not be misplaced today. It was not long before innovative physical education teachers in the UK realized the importance of activity for health in children and started to apply the principles of health-enhancing physical activity to the physical education curriculum (24). However, as with physical activity epidemiology, exercise science as a field was slow to develop in the UK. The emphasis remained on sports science, with a focus on the physiology of training, biomechanics of movement, and psychology of sport and its performance. Not until 1993 did the British Association of Sport Sciences add "Exercise" to its title to become BASES. The British Association of Sports Medicine took a little longer to become BASEM in 2000.

Although he officially retired in 1975, Jerry continued to contribute to physical activity and public health for three more decades, and one of his most critical, yet probably least known, contributions came in the late 1980s. In 1988 Jerry was asked to chair the Activity and Health Research Board, a charitable company set up to conduct and promote research into exercise, fitness, and health. As its first task, the Board conducted the ambitious English National Fitness Survey, a large-scale study of physical activity and fitness in

a random sample of adults in England, in 1990 (25). The survey included a detailed interview-administered questionnaire in the participants' homes, followed by a physical appraisal carried out in mobile units located at regional sites around the country. The interviews and fitness measures were comprehensive and at a level of rigor that was largely lacking in other measures being used around the world. The interview covered current, habitual, and past physical activity, attitudes and beliefs about physical activity, motives and barriers to physical activity, quality of life, other lifestyle behaviors, sociodemographic characteristics, and health status. The physical appraisal consisted of a battery of tests, including anthropometry, blood pressure, muscle function and joint flexibility, lung function, and a treadmill test of cardio-respiratory fitness. Many of the measures used in the survey were created specifically for it, including the treadmill test. Characteristic of Jerry, he insisted that the results of the treadmill test of cardio-respiratory fitness should be presented in a way that had meaning to the public health and wider community. Consequently, the results were expressed as the proportion of an individual's maximal oxygen uptake required to walk at 4.7 km/hr (~3 mph) on the level and up a 5% slope, an estimate of fitness for walking. A total of 4,316 adults (a 75.8% response rate) completed the in-home interview, and 2,768 completed the physical appraisal. The study produced some remarkable results, influenced opinion and policy regarding the significance of physical activity for public health until the present day, and shaped the nature of physical activity and public health activities.

The survey revealed for the first time that approximately 70% of adults in England were not active at a level that would benefit their health. Perhaps more striking were the reported levels of fitness for walking. Thirty percent of men and 49% of women aged 55 years and older exceeded 70% of their estimated maximal heart rate when walking at 4.7 km/hr on the level. The proportions increased to 70% and 91% for men and women, respectively, when walking at 4.7 km/hr up a 5% gradient. The results revealed that a large proportion of middle-aged and older adults were not even fit enough to perform activities of daily living.

Jerry and his team knew that understanding perceptions and barriers to physical activity was important for promoting it effectively, so their objective measures of fitness were set alongside perceptual data. They noted that many who were low in physical fitness regarded themselves as very active. Furthermore, 52% of men and 58% of women who reported no moderate or vigorous physical activity in the previous four weeks stated that they did enough exercise to keep fit. While this revealed the flaws in self-reported activity, it also indicated the need for public health awareness campaigns to increase understanding of the meaning of health-related exercise. One of the barriers to



activity for health stated most frequently was ‘Because I am not the sporty type,’ indicating a confounding in the minds of the public of ‘exercise’ with ‘athletic ability’. This form of data helped reorient many sport psychologists in the UK toward the emerging subfield of exercise psychology, which deals with motivational and mental health issues regarding physical activity. Additionally, not satisfied with a cross-sectional study, Jerry and his colleagues raised funds to track all of the study participants for subsequent mortality, thus creating a new cohort, now with 20 years of follow up.

The survey findings led to a series of important events. First, in 1993 the government established a task force to develop a national strategy for promoting physical activity. In 1994 it convened an international symposium with experts from around the world to create health promotion messages that could be used to promote physical activity for health and identify strategies to achieve increases in physical activity. The subsequent report (26), which preceded the Centers for Disease Control and Prevention/American College of Sports Medicine consensus statement published in 1995 (to which Jerry also contributed as a coauthor) (27), announced the following physical activity recommendation for adults:

“Take 30 minutes of moderate intensity physical activity, such as a sustained brisk walk, on at least five days of the week. Ideally, these 30 minutes should be one period of sustained activity, but shorter bouts of 15 minutes are also beneficial.”

Second, the report of the National Fitness Survey also recommended a series of actions including more monitoring of physical activity in the future and better evidence about what interventions work to promote physical activity. In 1991, the first annual Health Survey for England was conducted to provide regular information on various aspects of the nation’s health. Every few years the Health Survey asks people about their physical activity, using an instrument that remains remarkably similar to the one developed by Jerry for the National Fitness Survey (28). In 1996, a mass media campaign—Active for Life—was launched to educate the population about the health benefits of physical activity and to promote the new moderate-intensity public health message (29).

Jerry’s record demonstrates that he, like many great scientists, was deeply driven to improve human welfare. It simply was not enough to produce the evidence. It had to be implemented and it had to make a difference, something Jerry called ‘public health activism’. He frequently used his great writing and communication talents to this end. A prime example of his ability to convert complex phenomena into powerful messages is demonstrated in his often-quoted paper, ‘Exercise in the prevention of coronary heart disease: Today’s best buy in public health’ (30), published in 1994.

However, he continued to express dissatisfaction with his colleagues in medicine, health care, and government for the limited degree to which they were translating the burgeoning evidence for the effects of exercise on health into meaningful clinical practice and public programs. In a foreword to *Physical Activity and Health* he could not resist stating:

“In the half-century since the Second World War, there has been an explosion of research and thinking on the need for, and benefits of, physical activity/exercise across the lifespan and bodily systems. This knowledge is widely not being applied in practice. In consequence, there is an epochal waste of human potential for health, functional capacities, and well-being” (31) (p. xix).

In his later years, Jerry fought for greater recognition of the benefits of activity for older adults, an area of increasing interest and momentum. In 2003 he expressed his frustrations in his typically emotive style:

“When history comes to be written, society’s failure to apply modern knowledge of normal ageing processes, in particular, the loss of muscle, and the remedial possibilities, is likely to shame us” (32) (p. xix).

Jerry continued to inspire, suggest, support, cajole, prod, nag, ruffle feathers, or whatever it took to stimulate action on promoting physical activity, right up to the time of his passing. Even in his 90s, he was happy to be a founding trustee of Move4Health, which was established to lobby for physical activity for health, and he continued to advise and support other physical activity organizations in the UK.

His efforts have paid handsome dividends, and he saw many positive outcomes before he died. In 2001, 10 years after the results of the National Fitness Survey were published, Jerry met with officials of the Department of Health in an attempt to persuade them to measure fitness in the population again. Following a series of meetings, Jerry was commissioned to investigate the feasibility of including a measure of cardio-respiratory fitness in a future Health Survey for England. In addition, the Department asked Jerry to develop a simple measure of physical activity that all general practitioners could use in routine primary care to screen people for physical inactivity. Jerry undertook both projects with his usual vigor and attention to detail and both came to fruition in the period 2008 to 2010. The General Practice Physical Activity Questionnaire is now firmly embedded in the National Health Service Plan for 2010–2015 (33), and in 2008 the Health Survey for England measured cardio-respiratory fitness in a representative sample of adults, the results being published earlier this year (28).

So, it has taken a while in the UK, but the field of physical activity and public health is now well established. We have a national strategy for physical activity in both the UK and the United States (34), and physical activity contributes to the national obesity strategy (35). Physical activity and public health is a growing and maturing multidisciplinary area of study in universities, which are having an increasingly powerful influence on governmental as well as regional and local policy.

Fortunately, the UK has recognized Jerry’s significant contributions to public health. In 2002 he was awarded the second Edwin Chadwick Medal for services to public health. That year he also received an honorary Doctor of Science degree from the University of Loughborough, which houses one of the leading sports science schools in the UK. In 2006, the Department of Exercise, Nutrition and Health Sciences at the University of Bristol launched a prestigious annual public Jerry Morris Lecture, which Jerry attended in person. Sadly, he could not see the 2010 lecture, in what would be his 100th year, which focused on physical activity and physical function in older adults, his pet theme in his later years.

### What Was, Is (or, How We’ve Become Interested in Occupational Physical Activity Again)

Just as fashion trends appear cyclical—witness the expansion and contraction of gentlemen’s tie widths over time, apparently directly correlated with financial conditions (36)—so too our emphasis on the kinds of physical activities that “count” for health appears to have come full circle since Jerry’s pioneering studies published in the early 1950’s.

Beginning in 1949, he embarked on a series of studies, investigating coronary heart disease rates and sudden death among men in different occupations. In the classic investigation of London transport workers, Jerry and colleagues observed approximately 31,000 men, 35 to 64 years of age, between 1949 and 1950 (37). They made the novel—for that time—observation that bus drivers, sedentary during working hours, faced a distinct disadvantage for coronary heart disease compared with bus conductors, who were constantly moving while collecting fares from passengers riding the London double-decker buses. Not only did the conductors have a lower incidence rate of coronary heart disease (approximately 30% lower), they also were older when they developed the disease, had less severe disease, and experienced lower case fatality rates.

Subsequent research involving workers from a different service industry, the London postal service, yielded essentially similar findings (38): less heart disease and less severe disease among the postmen (who walked to deliver letters) than the postal service telephonists (who likely sat during most of their working hours).

A summary of these studies, taken from one of his last published articles (in this journal in April 2009) is presented in Table 1 (39).

These early studies provided the impetus for a wide range of studies, over the next half century, investigating potential health benefits associated with physical activity (40, 41). While many of the early studies examined physical activity on the job in relation to the development of chronic diseases (42, 43), these gradually evolved to studies of leisure-time physical activity (41). Such studies included, notably, the cohort studies of British civil servants by Jerry and colleagues (19, 44, 45) and of Harvard University alumni (46–48) by Professor Ralph Paffenbarger, a good friend and colleague of Jerry. The reason for this shift in focus to leisure-time physical activity was that occupational activity was decreasing as a result of increased mechanization; the British civil servants and Harvard alumni, typically white-collar workers, had scant opportunity to break a sweat while working. Additionally, many of the studies providing data on the association between physical activity and better health were large-scale prospective cohort studies, in which information on physical activity was obtained primarily from self-report on questionnaires. These questionnaires tend to be more accurate in assessing physical activities that are moderate to vigorous in intensity (i.e., those typically occurring as part of structured exercise during leisure-time) than activities that are light in intensity, such as those performed as part of household duties (49).

In recent years, the pendulum appears to have swung back again to embrace interest in physical activities that occur outside of leisure time (41). These include activities that occur as part of one’s job, household chores, and commuting. Several reasons may explain this more inclusive focus. One is that the cumulative body of research to date suggests that, for many chronic diseases, the total amount of energy expended appears to be the important variable

**TABLE 1.** Incidence\* of coronary heart disease per 1,000 men per year, 1949–1952: Age-standardized rates (4)

	Sudden death <sup>†</sup>	Total incidence
London: Double-decker busmen		
Ages 35–64		
Conductors	0.5	1.9
Drivers	1.1	2.7
National: Government service		
Ages 35–59		
Postmen	0.4	1.8
Telephonists <sup>‡</sup>	0.8	2.4

(Original published in Blair SN, Morris JN. Healthy hearts—and the universal benefits of being physically active: physical activity and health. *Ann Epidemiol.* 2009;19:253–256.)

\*Incidence: First clinical appearance of the disease.

<sup>†</sup>First appearance of the disease, no preceding sickness reported.

<sup>‡</sup>Men working mainly in Security and Foreign Office.

contributing to reduced risks of these diseases (41). In today’s increasingly sedentary society, leisure-time physical activity contributes only a small proportion of energy expenditure; a recent estimate using data from the United States indicated that only 5% of total energy expenditure is derived from leisure-time activities (50). Men are more likely than women to participate in leisure-time physical activity, whereas women are more likely to expend energy in household activities (50, 51). Thus, not taking into account household activities—despite the imprecision with which physical activity questionnaires capture these activities—may obscure any associations between physical activity and reduced risk for chronic diseases in women. For example, in a Canadian study, an inverse relation was observed between household activity and breast cancer risk, but no relation was seen with leisure-time, recreational activity (52).

Additionally, exercise scientists now agree that short bouts of physical activity ( $\geq 10$  minutes) of at least moderate intensity can improve fitness and cardiovascular risk factors (41, 53). This model is congruent with the sporadic physical activity of bus conductors observed by Jerry to have lower rates of coronary heart disease, compared with bus drivers, in his early studies. However, the notion of short bouts contrasted with assumptions widely held between the 1970’s and 1990’s that physical activity had to be vigorous and sustained in duration for health benefits, a view reflected in physical activity recommendations made prior to 1995 (27). As for very short bouts of physical activity, few data exist on the potential benefits of bouts lasting fewer than 10 minutes (53), with one study suggesting that even brief bouts of stair climbing (akin to what Jerry’s bus conductors were apt to do on the double-decker buses), lasting only 2 minutes, five times a day, was sufficient to improve cardio-respiratory fitness in young women (54). Such short bouts of stair climbing are easily incorporated into one’s routine, even for white-collar workers, potentially providing health benefits.

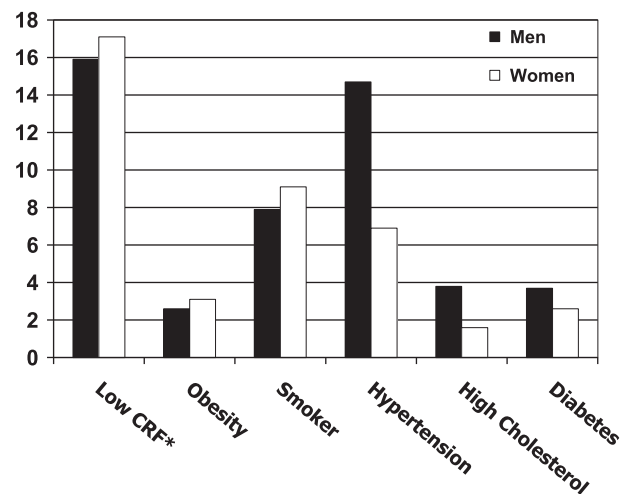
With the current low levels of physical activity during leisure time (55), activity undertaken as part of commuting has become an area of interest with regard to health (in addition to its appeal as an environmentally friendly form of transportation). The available data indicate that active commuting, which can involve short bouts of walking or cycling at least twice a workday (i.e., to and from work), may reduce the risk of cardiovascular disease and cancer (56, 57).

Recent data suggest that sedentary behavior—such as sitting for prolonged periods as occurred in Jerry’s bus driver subjects, and probably the postal service clerks and telephonists—is an independent risk factor for an adverse metabolic profile (58). A recent study found a graded increase in all-cause mortality rates among men and women who spent more time sitting (59), even among individuals who met

physical activity recommendations through leisure-time physical activity. These data further emphasize the importance of considering physical activities beyond leisure-time physical activity, which occupies only a small fraction of our waking hours, including attention toward decreasing sedentary behaviors.

Finally, another observation arising from Jerry’s early research, which has resurfaced as a point of current interest, is the “fit versus fat” issue, a colloquial phrasing of the questions: “Which is worse for health: low physical activity or fitness, or high levels of adiposity?” and “Does physical activity or fitness ameliorate the adverse health effects of increased adiposity?” Following his publication of the observation that London bus drivers experienced higher rates of coronary heart disease and more severe disease than bus conductors, a question arose regarding whether differences in physical activity were truly responsible, or whether “body shape” variation accounted for the contrasting rates of coronary heart disease, a phenomenon we now refer to as confounding (60).

Jerry and colleagues thus embarked on a study of the uniforms issued to workers, tallying uniforms by trouser and jacket sizes, in a publication titled “Physique of London busmen: Epidemiology of uniforms” (60). (Aside: Jerry disliked the subtitle; he indicated in a conversation to I. M. L. that this was inaccurate—it was not an epidemiologic study of uniforms!) The study did reveal that drivers had larger waist and chest sizes than conductors, so it was unclear whether the lack of activity or the larger size contributed to



**FIGURE 2.** Attributable fractions (%) for all-cause deaths in 40,842 men (3,333 deaths) and 12,943 women (491 deaths) in the Aerobics Center Longitudinal Study. The attributable fractions are adjusted for age and each other item shown in the figure. CRF\* = cardiorespiratory fitness determined by a maximal exercise test on a treadmill. (First published in Blair SN. Physical inactivity: the biggest public health problem of the 21st century. *Br J Sports Med* 2009; 43:1–2 [65].)

worse outcomes for coronary heart disease. However, investigators were able, in later studies, to confirm that regardless of size, physical activity was associated with lower rates of heart disease (19, 45).

Today, with obesity rates increasing worldwide, we continue to debate the relative contributions of physical inactivity or fitness versus adiposity to increased rates of cardio-metabolic diseases and to question whether increased

activity or fitness can partially—or even completely—mitigate the higher rates of such diseases associated with obesity. From a public health perspective, this is important because, while effective strategies do exist for weight loss, the majority of people who lose weight do not maintain their weight loss over time (61, 62). The available evidence suggests that for all-cause and cardiovascular disease mortality, higher levels of physical activity or fitness can

### Personal Reflections about Jerry by Michael Marmot

In an interview with George Davey Smith, Jerry refers to the fox and the hedgehog. (Jerry had, of course, read Isaiah Berlin's essay on the topic). Jerry says disarmingly: "I am a two-headed hedgehog if such a thing is conceivable. Exercise on one hand and equality on the other."

Jerry is justly famous for establishing the importance of exercise. But he was indeed a two-headed hedgehog. For those of us who, figuratively, sat at his knee—I sat there on and off from 1973 to my last conversation with him in 2009—it was he who taught how the social becomes biological. Exercise, diet, plasma lipids and hypertension may all be important in coronary heart disease, but must be put in a social context. Here, in extenso, is Jerry in the 1975 edition of *Uses* (p. 54):

The whole mode and style of life evidently are implicated in social class: income and wealth, financial security; physical environment; size of family and birth spacing; how children are reared; mean IQ levels, educational opportunity, parental interest and ambitions for children; language codes and ways of speaking; the self-image, horizons and long term goals; expectations of health and attitudes to illness, the utilisation of services. It is not surprising that compendium though it is, and withering at the edges as subsistence poverty is eliminated, jobs are upgraded, professions unionise, status deference declines, and some patterns of consumption converge – TV, home ownership, Marks & Spencer, women's mags, the motor-car, holidays abroad, youth and culture – this distinction by "social class" continues a powerful tool for the exploration of the levels of health that people enjoy, the troubles they suffer, and how they cope with these.

This is vintage Jerry, in style and content. Two sentences, between them, contain 143 words and almost as many ideas. The ideas have set a research agenda. Although absolute poverty in Britain has diminished, living and working conditions have improved, social differences in patterns of consumption are attenuated, there are still substantial social class differences in health. I would add that the 'troubles people suffer, and how they cope with these' are important for health.

Jerry's deep abiding concern was with how the social environment led to health and illness. Social class was both a manifestation of social influences on health, hence a way to study these influences, and also a concern in and of itself. In Jerry's formulation, we should understand why people of lower social position should have worse health, and then engage in advocacy and activism to change the situation.

To that end, Jerry was involved in setting up the Black Committee on Health Inequalities in 1978 and was a key member of it. Famously, Mrs Thatcher's government wanted no part of the Black Committee's Report or its recommendations. Black was not lost, however, and had a huge influence on the field of research into inequalities in health. Some of the debate following Black was on the importance of absolute material conditions of life as against issues associated with relative differences. Jerry would have none of that debate about priority. "Two issues we have to confront, those of poverty and inequality: they overlap but are not the same...skilled workers are less healthy but it is meaningless to think of them as poor except relatively". This emphasis both on absolute poverty and on relative differences associated with inequality are hardly surprising given the extensive quote above about how Jerry saw social class differences.

Jerry's inspiration continued to the last. After his 90th birthday he was publishing papers on minimum income for healthy living (MIHL). In a tradition stretching from Adam Smith to Amartya Sen, Jerry saw MIHL as encompassing not only enough money for healthy eating, for example, but participating in society with dignity, which includes reading a newspaper and buying presents for the grandchildren.

As Chair of the Commission on Social Determinants of Health I drew on Jerry's work on MIHL. When he rang me one Saturday afternoon to congratulate me on the Commission's report, I quickly flicked through the report. "We quoted you on p 90", I said. "And on page 79", said Jerry. Inspiring, and human! That was Jerry.



offset some of the increased risk associated with obesity (and vice versa; i.e., lower levels of adiposity can offset some of the increased risk associated with low levels of activity or fitness) (63). But for type 2 diabetes, adiposity is a far stronger risk factor, and high levels of activity or fitness do little to damp the excess risk associated with high levels of body fat (63).

It is a testament to the importance of the research questions initially raised by Jerry in the 1950's that these issues continue to occupy physical activity researchers today and that they continue to have public health relevance.

## SUMMARY

The research initiated by Jerry Morris nearly 60 years ago has grown to an impressive body of evidence linking physical inactivity to a long list of health outcomes. A comprehensive review of these studies was published in 2008 by an advisory committee to the U.S. Department of Health and Human Services (41). This report was the foundation of the first official U.S. government recommendations on physical activity, the 2008 Physical Activity Guidelines for Americans ([www.health.gov/paguidelines](http://www.health.gov/paguidelines)) (64). Similar recommendations have been released in recent years by many other countries, including the U.K. (34).

It is clear that low levels of physical activity and low cardio-respiratory fitness are major determinants of loss of function, chronic disease morbidity, and lower longevity. Professor Paffenbarger was one of the first to show shorter longevity in sedentary Harvard alumni when compared with their more active counterparts, and also a high population attributable risk for inactivity (47). Low cardio-respiratory fitness is the strongest predictor of mortality in the Aerobics Center Longitudinal Study (65). Fig. 2 shows that low levels of fitness, determined by an objective maximal exercise test on a treadmill, accounts for a greater proportion of deaths in the cohort than any of the other exposures. Hypertension in men is the only exposure that even approaches low fitness. Of course, population attributable risk is dependent on the strength of a risk factor and its prevalence in the population, so these data may not apply in other populations. However, these data do substantiate the hypothesis that physical inactivity is one of the major health problems facing modern societies, a point that Jerry spent a very productive lifetime studying and working to address.

Jerry set the foundation for research and public health initiatives around the world and continued to be a passionate supporter of both until the time of his death. He inspired several generations of scientists with his knowledge, enthusiasm, and sheer humility. Jerry was a wonderfully generous and humble human being and his spirit will continue to energize and inspire those working in the field around the

world. We all miss him and his guidance and enthusiasm for the field of physical activity and public health.

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