WHO Technical Report Series
835

AGING AND WORKING CAPACITY

Report of a
WHO Study Group

World Health Organization
Geneva

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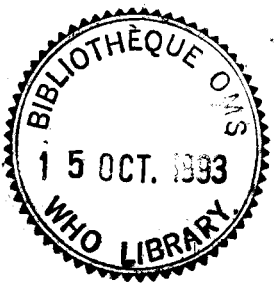

World Health Organization

Geneva 1993

WHO Library Cataloguing in Publication Data

WHO Study Group on Aging and Working Capacity
Aging and working capacity : report of a WHO study group.

(WHO technical report series ; 835)

1. Aging 2. Geriatrics 3. Work capacity evaluation I. Title II. Series

ISBN 92 4 120835 X (NLM Classification: WT 100)
ISSN 0512-3054

Printed in Switzerland
93/9633 - Benteli - 7500

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WHO Study Group on Aging and Working Capacity

Helsinki, 11–13 December 1991

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1. Introduction

A WHO Study Group on Aging and Working Capacity met at the Finnish Institute of Occupational Health in Helsinki, Finland, from 11 to 13 December 1991. The meeting, which was organized jointly by WHO's Office of Occupational Health and Programme on Health of the Elderly, was opened by Dr M.I.Mikheev, Chief, Office of Occupational Health, who welcomed the participants on behalf of the Director-General of the World Health Organization.

The problem of aging and work capacity is increasing in importance because of global demographic trends. The number of old people is constantly growing, and the proportion of aging people in various occupations is increasing. Their work capacity is often incompatible with work demands, which can lead to stress, health problems and high mortality, for example from cardiovascular diseases, suicide and accidents.

The objectives of the Study Group were:

1. To analyse changes in work capacity due to aging in relation to employment policy and sustained development in all Member States.
2. To study the biological background of aging, leading to changes in the physical and mental capacity for adapting to work requirements.
3. To identify health problems related to changes in work capacity among the aging workforce.
4. To define areas for health promotion in aging working populations.
5. To define a strategy and develop recommendations to help Member States to overcome the health problems related to aging working populations and the changes in their work capacity.
6. To identify gaps in knowledge and areas for further research.

1.1 Background

One of the greatest achievements of all time is the increase in human life expectancy that has been achieved over the past 100 years. In the 20th century, the mean life expectancy in developed countries has increased from about 47 years to more than 75 years. This, coupled with the decline in the birth rate, has brought marked changes in the demographic characteristics of the population. The mean age of the population in developed countries is increasing at an unprecedented rate, and it is estimated that in Europe it will approach 60 years by the year 2050. This trend is to be found in most of the developing world as well, although it has begun later.

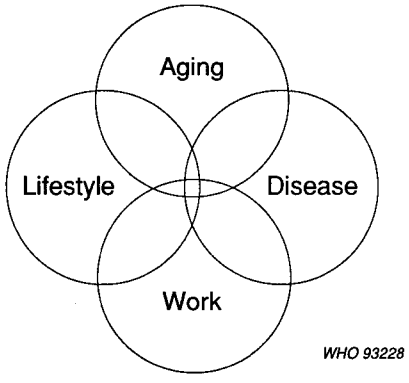
The mean age of the worker will almost certainly continue to increase rapidly. For centuries it did not vary significantly and there was, accordingly, no need to adapt the workplace to suit older workers. This is no longer the case. Most, if not all, societies will need to consider the interaction of the aging worker with the workplace and work environment.

Aspects which require further research include: (1) the work capacity (both physical and mental) of older workers as compared with younger ones; (2) the potential effect of various working conditions on older workers; (3) work satisfaction and the psychological characteristics of older workers as compared with younger ones; (4) the needs and the quality of life of older workers; (5) policy issues related to a change in the average age of workers; and (6) ways of maximizing both workers' health and economic efficiency and productivity.

It should be stated at the outset that there is a difference between aging and the accumulation of disease over time. Although for years it was thought that many physiological changes were due to aging, it has become increasingly clear that many decrements in function can be more appropriately attributed to disease, lifestyle (e.g. lack of exercise) or both. The aged population of today reflects all these factors. As the aging phenomenon is better understood, improvements in lifestyle enhance health and vigour and diseases are cured or better controlled, the differences between "old" and "young" will diminish. There will be changes not only in the characteristics of the older worker and the needs of the individual, but in the parameters of the workplace required (or perhaps no longer required) to achieve maximal health maintenance and productivity. Furthermore, since social and environmental factors vary considerably from country to country, programmes designed for older workers will need to vary accordingly. In addition, because of the rapidly changing demographic patterns in many countries, the programmes will need to be constantly revised.

Figure 1

Interaction of lifestyle, disease, work and true biological aging[a]



[a] At least three factors should be taken into consideration besides true biological aging: lifestyle, disease and work. Lifestyle, work and aging influence the severity of disease. In the absence of disease, lifestyle and work affect the rate of aging. The presence of disease modulates lifestyle and work, and may influence aging as well, and both disease and aging modify lifestyle. This comprehensive model emphasizes that action to help the situation of older workers should be multifactorial. (Figure adapted from reference 27, with the permission of the publisher).

Much of the literature in the field of geriatrics and gerontology must be read in light of the distinction between the phenomenon of aging and the accumulation of diseases over time. Indeed, because of the difficulty of distinguishing the true biological aging process from the consequences of long-term lifestyles and working conditions, there are those who have advocated paying special attention to and studying people who "age successfully". This is likely to be especially important for a better understanding of the interrelationship of the older worker and the workplace and for identifying those whose work will need to be adapted as they age (Fig.1). Furthermore, since there is a marked variability in many (if not most) functions with age, regardless of the cause, it is necessary to consider how workplaces can be designed to meet most effectively the needs of the wide range of capacities to be expected in older workers.

1.2 Definitions

1.2.1 *The aging worker*

Over 10 theories of aging have been proposed (*1*), but no single model can satisfactorily explain human aging, since the process is inherently multidimensional (*2*). Nor can a definition of "the elderly" be applied consistently; biological, social, economic and chronological criteria vary from country to country. In 1980, the United Nations recommended 60 years as the age of transition to the elderly segment of the population (*3*). However, from the viewpoint of occupational health, indications of age-related problems appear earlier. Certain functional capacities necessary for some kinds of work have been reported to decrease by 45 years of age (*4*), and the capacities for some, but not all, jobs have been reported to diminish by 50 to 55 years of age (*5-7*). Therefore, the definition of an "aging worker" could be considered to apply from 45 years. This definition is in harmony with earlier definitions proposed by the International Labour Organisation (ILO) and the United Nations, and includes people from the "elderly" segment of the population who have not yet retired and remain part of the working population.

The ILO, in its Older Workers Recommendation, 1980 (No.162), has defined older workers as "all workers who are liable to encounter difficulties in employment and occupation because of advancement in age" (*8*).

For the purposes of its report, the Study Group considered the terms "aging" and "older" to be synonymous and to apply to workers over 45 years of age.

1.2.2 *Work capacity*

"Work capacity" can be considered a comprehensive term covering all the capacities necessary to perform a given type of work, and can be used as a synonym for "work ability" with respect to a specific class of work. The term "work capacity" therefore includes physical, mental and social

functional capacities (see Annex). The degree to which work capacity corresponds to work demands will affect productivity, and difficulties in this regard can lead to stress and work-related diseases and disabilities. It is therefore important for governments, social agencies, employers and employees to understand what is currently known about these issues, and for new research to address specific aspects of aging in the context of the aging worker and the workplace.

1.3 Scope of the Study Group's discussions

Much of the available information on aging and work capacity has been obtained from studies carried out in a few industrialized countries. The Study Group was therefore restricted in its discussions, especially by the lack of relevant data on developing countries. However, it stressed that, although social, cultural and economic factors varied considerably from country to country, current demographic trends were making aging working populations a growing concern throughout the world. The Group therefore considered that its general conclusions and recommendations should be of relevance to developed and developing countries alike.

2. Aging population demographics

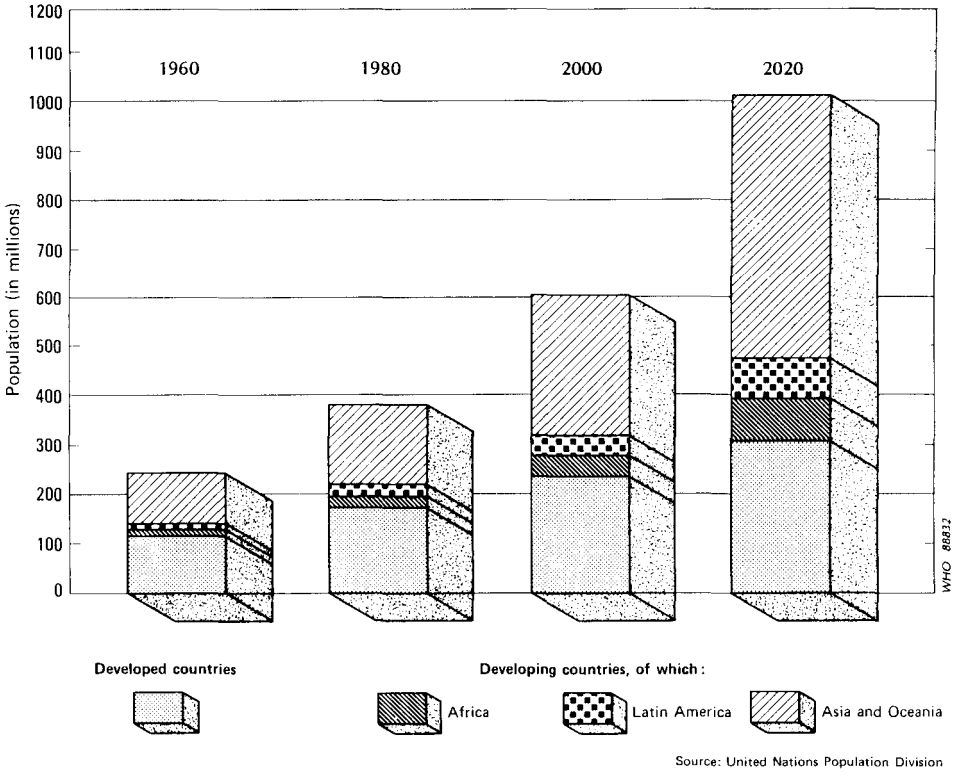
2.1 Aging population trends in developed and developing countries

As reported by a WHO Expert Committee on Health of the Elderly, which met in 1987: "By the year 2000, roughly two out of three of the world's 600 million elderly people (i.e., those aged 60 years or more) will be living in the developing countries, compared with about 50% in 1960 [Fig. 2]. The increase in the elderly population will be particularly marked in Asia, primarily as a result of the rapid growth expected in the number of the aged in China and India. This trend is illustrated in [Fig. 3], which shows, for the 20 countries with the largest elderly populations in 1980, the expected growth of the elderly population by the year 2020. In China and India alone, there will be a further 270 million elderly citizens by this date. The size of the aged population is expected to rise by more than 20 million in both Brazil and Indonesia, and by roughly half that number in Mexico, Nigeria, and Pakistan.

"On the other hand, much smaller absolute increases in elderly populations are anticipated for the European countries, where the process of population aging began much earlier. As a result, these developing countries will gradually replace the European nations in the ranking of countries with the largest elderly populations. Indonesia, for example, is expected to move from tenth place in 1980 to sixth in 2020, just ahead of Brazil, which had the eleventh largest elderly population in 1980. By the year 2020, Mexico is expected to have the ninth largest elderly population, ahead of Italy (tenth), France (eleventh) and the United Kingdom (thirteenth).

Figure 2

Population aged 60 years and over, by major world regions, 1960–2020



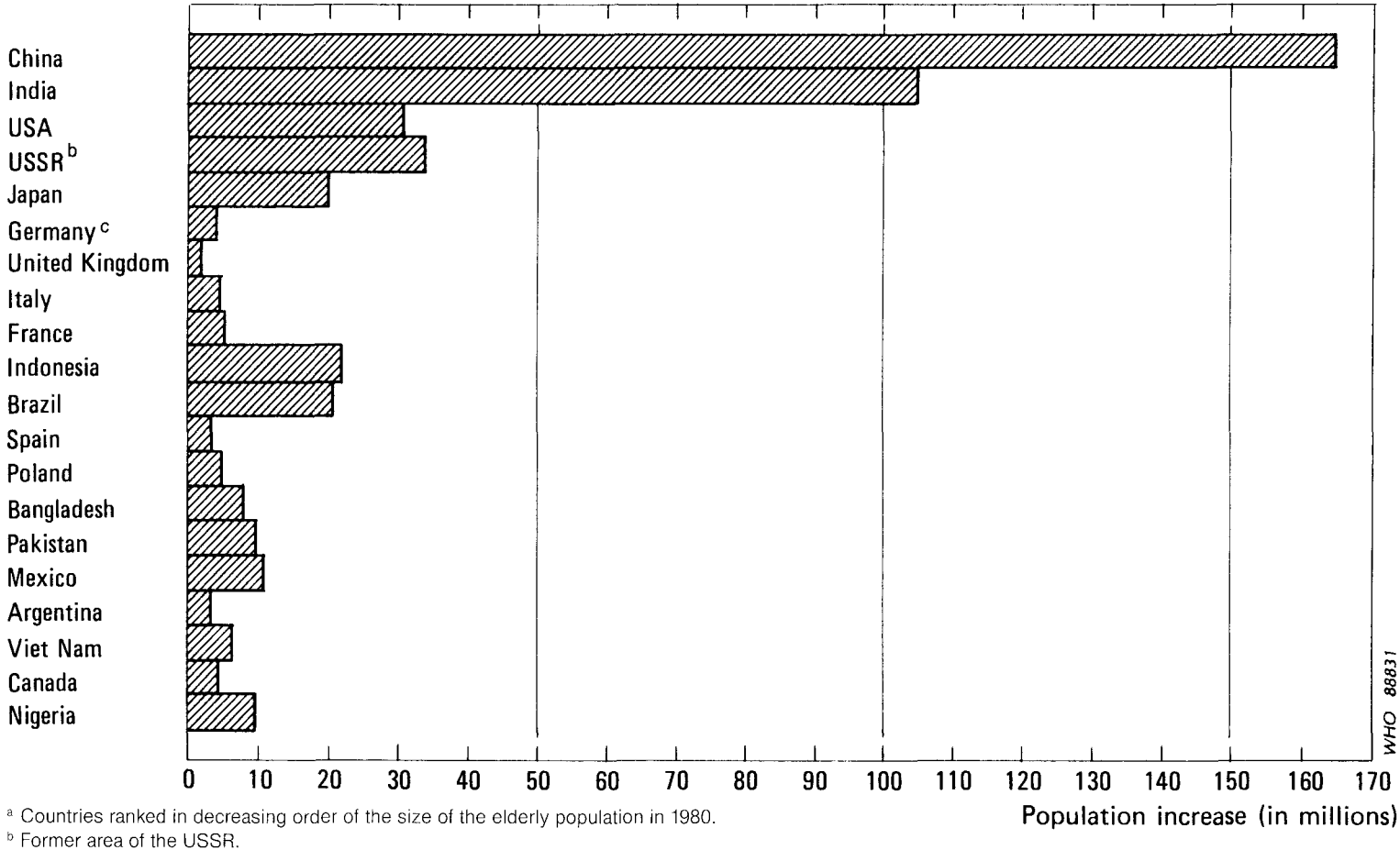
Reproduced from reference 9.

"In several developing countries, the population aged 60 years and over is increasing at a faster rate than the population as a whole. Thus between 1980 and 2020, the total population of the developing world is expected to increase by 95%, whereas the elderly population will probably rise by almost 240%. This will have a number of implications for the social and economic support of the elderly by the working-age population. Moreover, not only is the aged population increasing, but the elderly population is itself getting older as more and more people survive longer. In fact, the 'older' elderly place the greatest demand on health and social services.

"The 'greying' world population is a new phenomenon to which even the technically most advanced countries are still trying to adapt. A longer life used to be the privilege of comparatively few, until as recently as the first decades of this century, but is now a prospect for more and more people throughout the world. Desirable as it is, the aging of populations brings

Figure 3

Projected increase in the elderly population between 1980 and 2020 for the 20 countries with the largest elderly population in 1980[a]



[a] Countries ranked in decreasing order of the size of the elderly population in 1980.
[b] Former area of the USSR.
[c] Former area of the Federal Republic of Germany only.

with it new challenges and new demands that have particularly important implications in the context of the goal of health for all by the year 2000" (*3*).

2.2 An increasingly aged workforce

The 45-64-year-old part of the whole working population (aged 15-64 years) is also changing (see Table 1). In 1980, on average, 32% of the whole working population were older than 45 years in the countries of the Organisation for Economic Co-operation and Development (OECD). This proportion is expected to increase to 35.5% in the year 2000 and 41.3% in the year 2025. There are, however, marked differences between individual OECD countries: the oldest workforces in the year 2000 will be in Finland, Japan, Luxembourg, Sweden and Switzerland, where more than 40% of the working population will be older than 45 years, and the youngest in Ireland and Turkey, where well under 30% will be older than 45 years. Other "young" countries are Iceland, New Zealand and Portugal (*11*).

As an example of changes in the age structure of the workforce from 1985 to 2000, trends among the Finnish workforce are illustrated in Fig. 4 (*12*). The age structure of the workforce is favourable at present, but the balance between the various age groups will develop unfavourably when the large age cohorts born after the Second World War move into late middle age at the end of the 1990s. The problems associated with the rapid change in age structure will be further aggravated by the shortage of young workers at the end of the decade, due to the low birth rates over the past 20 years.

2.3 Ratio of retired people to the working population

At present, in Australia, Canada, Japan and New Zealand, the ratio of workers to pensioners is about 6 to 1; in most other OECD countries, there are between four and six workers for every retired person (see Table 2).

Table 1

Proportion of the workforce[a] aged 45–64 years in the OECD countries, Finland and the USA in 1980, and predictions for 2000 and 2025

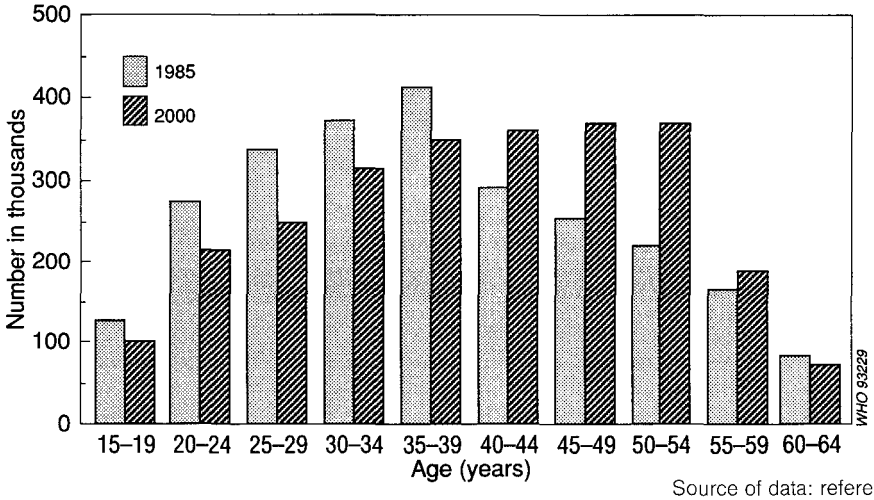
Year	OECD (n=24)	Finland	USA
1980	32.0%	31.1%	29.8%
2000	35.5%	40.1%	33.9%
2025	41.3%	42.6%	36.7%

[a] 15–64 years.

Adapted from reference *10*, with the permission of the publisher.

Figure 4

Age structure of the workforce in Finland in 1985 and predictions for 2000



Source of data: reference *12*.

Table 2

Number of people of working age[a] in relation to the number of retired people in 22 OECD countries in 1990, and predictions for 2010 and 2030[b]

Country	1990	2010	2030
Switzerland	4.6	3.2	2.1
Germany[c]	4.5	3.3	2.3
Finland	5.2	4.0	2.5
Austria	4.6	3.7	2.6
Netherlands	5.4	4.5	2.6
Canada	6.0	4.7	2.7
Denmark	4.4	4.1	2.7
Luxembourg	4.7	3.6	2.7
France	4.8	4.1	2.8
Italy	5.0	3.9	2.8
Sweden	3.7	3.7	2.8
Belgium	4.7	4.2	3.0
Norway	4.0	4.5	3.0
Japan	6.2	3.4	3.1
Greece	5.5	3.9	3.2
Spain	5.2	4.4	3.2
United Kingdom	4.4	4.5	3.2
USA	5.4	5.3	3.2
New Zealand	6.2	5.7	3.3
Australia	6.0	5.4	3.4
Portugal	5.6	4.7	3.5
Ireland	5.4	6.1	4.4

[a] 15–64 years.
[b] Countries ranked in ascending order of the 2030 estimate.
[c] Former area of the Federal Republic of Germany only.

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Table 3
Workforce participation rates for men aged 55–59 in 10 industrialized countries, 1960–1988/89

	1960	1970	1980	1988	1989
Belgium	85.1[a]	–	74.0[b]	–	–
Finland	90.4	76.6	67.6	59.1	59.7
France	82.4[c]	–	80.9	67.3[d]	70.2
Germany[e]	88.7[a]	89.2	82.3	79.8	78.6
Italy	83.7[a]	81.0	74.8	–	67.8
Japan	91.2[f]	–	–	91.3	91.6
Netherlands	–	86.9[g]	74.2	66.6	65.3
Sweden	–	90.9[g]	87.7	–	87.0
United Kingdom	–	93.1	90.1	80.3[h]	–
USA	88.9	89.5	81.9	78.9	78.8
Average	87.2	86.7	79.3	–	75.5[i]

[a] 1961; [b] 1979; [c] 1968; [d] 1987; [e] former area of the Federal Republic of Germany only; [f] 1965; [g] 1971; [h] 1986; [i] simple arithmetic average of rates for 9 countries, including the United Kingdom figure for 1986.

Data from: ILO *Year book of labour statistics*, copyright © International Labour Organisation (1962, 1970, 1989–90); and from Mirkin BA. Early retirement as a labor force policy: an international overview. *Monthly labor review*, 1987, March:19–33.

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In the future, there will be fewer workers to support the cost of an increasing number of retired people. The number of people aged 15-64 years as compared with the number of people over 65 years indicates that, for example, in 2030 Switzerland will have only 2.1 workers for every pensioner (see Table 2). There will be 11 OECD countries where fewer than three workers will support the pension costs for one pensioner. Ireland is an exception; in 2030 there are predicted to be over four workers for each pensioner.

2.4 Decreased workforce participation rates in developed and developing countries

In industrialized countries, the proportion of men aged 55-59 years (see Table 3) and 60-64 years (see Table 4) who were still in the workforce fell significantly from 1960 to 1989 (*13*).

In developing countries, the workforce participation rates for older men tend to be much higher than in industrialized countries (see Table 5). The workforce participation rates for women aged 55-59 over the period 1970-88/89 in some industrialized countries (see Table 6) are lower than those for men in the same age range, but the average participation rate rose for women from 1970 to 1988/89, while falling for men (*13*).

Table 4

Workforce participation rates for men aged 60–64 in 10 industrialized countries, 1960–1988/89

	1960	1970	1980	1988	1989
Belgium	70.8[a]	–	40.1[b]	–	–
Finland	79.1	65.0	43.0	29.5	27.8
France	–	68.0	47.6	25.7[c]	23.1
Germany[d]	–	74.9	44.2	34.5	34.2
Italy	53.6[a]	–	39.6	–	35.2
Japan	83.7[e]	–	–	71.1	71.4
Netherlands	–	73.9[f]	50.1	26.8	24.5
Sweden	–	78.7[f]	69.0	–	62.9
United Kingdom	–	87.0	71.2	53.4[g]	–
USA	77.1	71.7	61.0	53.6	54.1
Average	72.9	74.2	51.7	–	43.0[h]

[a] 1961; [b] 1979; [c] 1987; [d] former area of the Federal Republic of Germany only; [e] 1965; [f] 1971; [g] 1986; [h] simple arithmetic average of rates for 9 countries, including the United Kingdom figure for 1986.

Data from: Davies DR, Sparrow PR. Age and work behaviour. In: Charness N, ed. *Aging and human performance*. Chichester, Wiley, 1985; from Mirkin BA. Early retirement as a labor force policy: an international overview. *Monthly labor review*, 1987, March:19–33; and from ILO *Year book of labour statistics*, copyright © International Labour Organisation (1989–90).

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Table 5

Workforce participation rates for men aged 55–59, 60–64 and 65 and over in 10 developing countries (various years)

	Year	55–59	60–64	65+
China	1982	83.0	63.7	30.1
Costa Rica	1984	83.0	69.6	38.9
Guatemala	1981	90.3	85.8	66.9
Indonesia	1980	84.6	76.7	53.4
Mexico	1980	91.4	85.6	68.6
Morocco	1982	89.5	68.9	42.1
Peru	1981	94.9	88.5	63.2
Republic of Korea	1980	82.6	68.9	40.6
Thailand	1980	84.4	67.8	39.3
Tunisia	1984	82.1	59.2	38.5
Average		86.6	73.5	48.2

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Table 6

Workforce participation rates for women aged 55–59, 60–64 and 65 and over in 10 industrialized countries 1970–1988/89

	55–59				60–64				65+			
	1970	1980	1988[a]	1989[a]	1970	1980	1988[a]	1989[a]	1970	1980	1988[a]	1989[a]
Belgium	21.3[b]	19.1[c]	–	–	–	6.4[c]	–	–	–	1.7[d, e]	–	–
Finland	56.1	57.0	55.5	58.6	35.9	27.4	22.6	22.1	4.4	6.0	3.9[f]	3.4[f]
France	43.5[b]	47.3	–	45.1	–	27.3	–	18.1	–	6.8[e]	–	1.7
Germany[g]	37.2	38.7	41.1	40.9	22.5[d]	13.0	11.1	11.2	10.7[e]	3.0	1.8	1.6
Italy	18.2	21.4	–	20.2	10.6	11.0	–	9.8	2.6	3.5	–	2.2
Japan	–	–	50.9	52.2	–	–	38.6	39.2	–	–	15.6	15.7
Netherlands[h]	17.7[d]	18.2	24.0	24.0	11.9[d]	9.8	7.6	8.9	2.2[d]	0.9	–	–
Sweden	54.6[d]	68.8	–	78.5	34.5[d]	41.0	–	50.7	8.7[d]	3.7	–	–
United Kingdom	50.9	53.6	51.5[i]	–	28.8	22.4	18.8[i]	–	6.3[d, e]	3.6[e]	2.7[i]	–
USA	49.0	48.6	53.0	54.5	36.1	33.3	33.5	35.2	9.7	8.1	7.4	7.8
Average	38.7	41.4	–	46.2[j]	25.7	21.3	–	23.8[j]	6.4	4.1	–	5.0[k]

[a] Source: Mirkin BA. Early retirement as a labor force policy: an international overview. *Monthly labor review*, 1987, March: 19–33; and ILO *Year book of labour statistics, 1989/90* (Chapter I, Table I), copyright ©International Labour Organisation; [b] 1975; [c] 1979; [d] 1971; [e] data relate to 65–69-year-olds; [f] persons 65–74 years old; [g] former area of the Federal Republic of Germany only; [h]persons 15–64 years old; [i] 1986; [j] simple arithmetic average of rates for 9 countries, including the United Kingdom figure for 1986; [k] simple arithmetic average of rates for 7 countries, including the United Kingdom figure for 1986.

3. Aging workers and young workers

3.1 Physiological changes with age

The performance expected of older workers must make allowances for a number of physical and mental changes associated with aging (*15, 16*). The extent to which these changes reflect biological aging, as opposed to the impact of disease, environment and lifestyle, has been a topic of recent interest and research. It is becoming increasingly clear that physical training, at any age, can ameliorate or reverse some of the changes. It is also clear that the older population is heterogeneous and has a wide range of physical and mental capabilities. None the less, when populations of older and younger individuals are compared, or the same population is followed over a period of time, some consistent differences can be found.

The physical composition of the body changes with age. Lean body mass decreases significantly; total body fat as a proportion of body composition doubles between the ages of 25 and 70, while muscle weight declines, which leads to decreases in muscle strength, endurance and bulk. These changes are associated histologically with a decrease in the number of type II muscle fibres and decreased activity of muscle enzymes related to energy supply, including lactate dehydrogenase, triosephosphate dehydrogenase and glycerol-3-phosphate dehydrogenase. Bone loss appears to be inevitable with aging, and is accelerated in women during the postmenopausal period. There is a greater reduction in osteoblastic than in osteoclastic activity with age.

It is unclear how many of the substantial cardiovascular changes which occur with aging are related to disease. These changes include age-related declines in intrinsic myocardial contractile function associated with prolonged contraction time, decreased responsiveness to catecholamines and increased refractoriness to electrical stimulation. The sinus rhythm and other related electrical activities of the heart become slower. Blood vessel walls become less distensible and compliant. The vessels respond less to sympathetic stimulation.

There is a 50% decline in ventricular filling between the ages of 20 and 80. The time between aortic valve closure and mitral valve opening – the relaxation time – increases with age, and the maximum heart rate decreases. These cardiovascular and other associated changes lead to reduced physical capacity.

There are also substantial changes in the respiratory system with aging, including enlargement of the alveolar ducts with decreased surface area of the lung, decreased lung elasticity and an increase in residual lung volume. Residual volume increases from 20% of total lung capacity at age 20 to 35% at age 60. The rib articulations calcify with age and the thoracic spine often produces osteoarthritic changes, leading to stiffening of the thoracic cage. Respiratory muscle strength itself begins to decline at about the age of 50, and the endurance of these muscles lessens. The functional reserve

of the lung also diminishes. There is an average decline in vital capacity of 26 ml per year for men and 22 ml per year for women from age 20 to age 80. The arterial partial pressure of oxygen declines with age, while there are no significant changes in the partial pressure of carbon dioxide. As a result of these changes, there is a progressive decline in maximal oxygen consumption ($\dot{V}o_2max$), a good measure of overall cardiopulmonary function. However, these age-related declines vary greatly with physical condition, many fit older individuals outperforming more sedentary younger people.

As a result of these changes in muscular, cardiovascular and respiratory function, the ability of an individual to perform stressful activities declines with age. Maximum physical performance declines by approximately 1.5% per year. The most significant declines occur in activities which are of short duration, but require "explosive" effort from a large muscle mass, or prolonged activities that require high transmission of force to the environment, such as running (see Annex).

Alterations in the sensory organs have a substantial impact on the older individual's work capacity. The eye undergoes a number of age-related changes. Atrophic changes in the eyelid and decreased lacrimal gland function increase the incidence of conjunctivitis. Changes in the lens and ciliary body produce presbyopia (loss of accommodation), which can be corrected with appropriate lenses. Changes in pupil diameter, loss of the refractory power of the lens and increased scattering of light cause a gradual but steady decrease in static visual acuity. Dynamic visual acuity – the ability to discriminate details in a moving target – decreases even more rapidly with age. One of the most predictable changes with aging is the loss of ability to adapt from a light environment to a dark one. One standard measurement of vision that reflects changes with aging is the critical flicker frequency (CFF), which measures the point at which an alternating sequence of dark and light periods is perceived as a steady rather than a flashing light. Persistence, the continuation of a sensation after the physical stimulus has ceased, increases with age and contributes to age-related changes in CFF.

Glare is a major problem for older individuals. They require 50-70% more light than younger individuals to recognize a target near a source of glare. In addition, there is an increased need for contrast between a target and its background if older individuals are to identify the target, especially in dim light.

Anatomical changes in the external auditory canal, tympanic membrane, ossicular joints and inner ear produce presbycusis, a bilateral hearing loss for pure tones. Auditory changes associated with aging and perhaps with chronic noise exposure, include not only high-frequency hearing loss, but significant and linear losses in pitch discrimination, especially in the very high and very low frequencies. These losses in hearing and pitch discrimination often produce a major deterioration in the ability to make out speech.

A variety of age-related changes in the nervous system can affect work capacity and hence the adjustments in the pace of work necessary if the older worker is to be as productive as possible.

The speed at which information is processed usually slows substantially in older individuals. Peripheral slowing (due to changes in sensory organs and the peripheral nervous system) contributes only slightly to the overall changes. Difficulty in distinguishing two or more elements divided in time, exemplified by the critical flicker frequency (CFF) test in vision, is also manifested in hearing and touch discrimination. Most of the age-related slowness in responding to stimuli is due to slowness in the premotor time (time from stimulus presentation to motor activity) with only minor changes in motor time (time from muscle activation to actual movement).

Most of this slowness is due to alterations in central nervous system mechanisms, including changes in the interpretation of input and processing to produce correct (or incorrect) responses. For the more complex cognitive tasks, processing by older individuals is even slower. However, although older subjects are slower to respond, they are more likely to respond correctly.

Older individuals have more difficulty with the development of concepts and abstract thinking than younger ones. There are also age-related changes in the acquisition, storage and retrieval of information. Older people require more time and effort to encode (enter) information in the nervous system. However, when information has been encoded equally well by young and older people, the extent of memory storage is also similar. In memory tasks, recall (search for and retrieval of information from storage) declines more with age than recognition (matching stored information with information in the environment). Older individuals have more difficulty with recognition tasks when there are a number of responses to choose from. The role of education in this phenomenon is not clear.

Primary or short-term memory, which lasts only a few seconds, declines with age. Changes in secondary or long-term memory occur less often with age, and older individuals can usually adapt successfully to them.

Classic tests of intelligence do show some changes with aging. The results of verbal tests, which measure such features as retention of information, vocabulary and comprehension, change relatively little, but an age-related deterioration is observed in performance tests, which include speed of copying and logical ability.

3.2 Age and job performance

The physical and mental changes described in section 3.1 are reflected in a number of studies of job performance (*16-18*), which have concluded that performance deteriorates with age in a variety of situations that place heavy demands on mental functioning, such as sensory and perceptual

activities, selective attention, working memory and swift information processing. None the less, older workers have a similar productivity rate to young individuals in tasks requiring sustained attention and tasks in which the older workers are highly experienced.

A number of methodological problems make comparisons between older and younger workers difficult. For example, older workers who show a marked deterioration in productivity and performance are apt to be transferred or dismissed, and highly productive workers tend to be promoted to supervisory or management positions as they age. Nevertheless, a number of studies have shown fairly consistent patterns of productivity and job performance with age. Studies of skilled and semi-skilled workers, such as printing workers, knitwear workers, furniture makers and service engineers, have shown an inverted U-shaped performance curve, in which performance peaks in the late 30s and early 40s, with a gradual decline in performance in the 50s and 60s. This decline in performance is gradual, however, so that the productivity of workers in their late 50s often still exceeds that of workers in their teens and early 20s.

There is a tendency for workers to transfer from heavy manual labour to lighter tasks after the age of 45. Older workers are also less likely to be involved in occupations involving time stress, where the rate of work is maintained by external pacing or by the time pressure resulting from a piece-rate payment system, or in positions that require continuous body movement and activity. In a number of studies carried out in the United Kingdom, the median age of workers in occupations involving physical activity but minimal time stress, such as storekeepers, packers, labourers and factory service workers (responsible for cleaning and maintenance), was found to be higher than that of workers whose jobs made relatively high perceptual demands, such as pattern makers, electricians, millers and grinders.

A study of service engineers in the United Kingdom found that the quality-of-performance index for servicing simple machines peaked in the mid-20s and showed a substantial decline by age 50. The same tests of performance for more complex machines peaked in the early 40s and declined more slowly. Workers in their mid-50s performed better on these complex machines than workers in their early 20s. The results of this and other studies demonstrate that, when a substantial amount of training and experience is involved, older workers can maintain high levels of performance well into their 50s and 60s. Studies of clerical and sales workers have shown no significant difference between the performance of older and younger workers, and a United States Department of Labor study found no age differences in output per person per hour among office workers (*19*). Although mail sorters showed a gradual decline in performance after the age of 25, the performance results of those aged 65 and older were only 8% below those of workers under 25.

In several studies of performance ratings by supervisors (*20, 21*), older workers were rated at least as highly as younger workers. While

supervisors rated the speed of work and ability to learn of older workers lower than those of younger workers, overall efficiency was not considered to decline with aging. Steadiness and the ability to work without supervision were rated more highly for older workers.

The relative effectiveness of older workers in professional and managerial positions is more difficult to evaluate. In positions that require a great deal of up-to-date technical information, such as professional engineering jobs, the rate of performance peaks in the mid-30s, the performance of workers aged 55 and older reaching only 75% of this peak. Supervisors have a tendency to assign the more complex technical and engineering tasks to younger professionals.

The performance of older managers, however, is more positive. While older managers take more time to reach decisions, they use more information for these decisions, are more flexible, and appear to be as competent as younger managers in overall decision-making.

Studies of age and occupational accidents have found a generally lower incidence of accidents with age, but the severity of injuries increases, as does the time required for recovery. Job satisfaction and job involvement have been found to increase consistently with age. Avoidable absenteeism also decreases with age, although unavoidable absences such as sick leave do increase in older workers. In addition, job turnover significantly decreases with age.

While these studies of physiological changes and job performance show some areas in which older individuals do not perform as well as their younger cohorts, they demonstrate other areas in which older workers can contribute substantially to a productive society. In order to make full use of the capabilities of older workers, the workplace must be adjusted for the changes in vision, hearing and muscle strength that occur with aging. In addition, the assignment of responsibilities and job tasks in the workplace should take into account those areas in which older workers continue to perform at a very high level.

4. Health of the aging worker

4.1 Mortality

The public health aspects of population aging have recently been discussed (*3*), although assessments of age-related changes in health status are limited because there is a lack of comprehensive data for mortality and especially for morbidity. Roughly 50% of all deaths at ages 65–74 years, in the developed countries at least, are attributable to cardiovascular diseases; cancer accounts for one-quarter of deaths and about 7% of deaths are due to respiratory diseases (*3*). There is a considerable variation in mortality levels, even among the industrialized countries.

Age-standardized mortality rates calculated for men and women aged 30–69 years indicate that in Bulgaria, Czechoslovakia, Denmark, Hungary, Poland and Romania there was an increasing trend in mortality (all causes) among men over the 10-year period 1975–1985. Among women, an increasing trend was seen in Denmark, Hungary and Poland. Mortality rates for all cardiovascular diseases tended to increase among men and women over the period 1975–1985 in east European countries, but also among men in Greece (*22*).

4.2 Morbidity

There is a lack of comprehensive morbidity statistics, and it is therefore difficult to determine morbidity trends in various populations. A recent study in the United States of America indicates that morbidity from leading causes of ill-health (cancer, heart disease, diabetes, hypertension and arteriosclerosis) has increased, while a decline in morbidity among the elderly was found for skin diseases, visual and hearing problems and multiple orthopaedic problems (*23*).

In Finland, in parallel with the aging of the workforce, the incidence of chronic diseases is increasing, and most of these diseases have a negative impact on working capacity (*24*, *25*; see also Table 7).

It should be noted here that older people are more likely to be receiving various forms of long-term medication. Some drugs and medicines may affect people's ability to respond to work demands.

4.3 Disability and poor work ability

4.3.1 *Relative risk of work disability and mortality by occupation*

A high prevalence of chronic diseases causes a relatively high rate of

Table 7
Numbers of individuals suffering from various chronic diseases and occupation-related outcomes among the Finnish population aged 30–64 years (statistical data for the year 1980 and predictions for 2000)

Disease/outcome	Number 1980 (in thousands)	Number 2000 (in thousands)	Change (%)
Cardiovascular diseases	408	519	+ 27
Respiratory diseases	324	403	+ 24
Musculoskeletal disorders	746	924	+ 24
Cancer	28	56	+100
Mental diseases	362	441	+ 22
Occupational accidents	200	150	− 25
Occupational diseases	4.6	12	+161
Work disability	243	303	+ 25

premature work disability; on the basis of statistical data, it has been shown that such disability correlates strongly with premature mortality as well. In a national survey in Finland, the relative risk of work disability was found to be highest in lumbering, mining and construction work, and lowest among lawyers, administrators and educators (*26*).

4.3.2 *Poor work ability by occupation*

In a study in Finland, it was shown that, in men aged 55, poor work ability, as assessed by questionnaire, was most often experienced in occupations with mixed physical and mental work (*6*). Men and women whose jobs involved mostly mental work reported the best work ability. On average, 12.4% of women at the age of 55 years reported poor work ability, while the corresponding figure among the men was 15.8%. Among the women, the highest rates of poor work ability were 20% in home care occupations (for example domestic helpers, housekeepers) and 21% in auxiliary work (cleaners, kitchen helpers, construction workers, street-sweepers, etc.) (see Fig. 5).

Among men the highest rates of poor work ability reported were 24% in auxiliary jobs (park workers, labourers, carpenters, painters, etc.) and 19% in transport work (bus drivers, etc.) (see Fig. 6). Poor work ability was often associated with high disease prevalence at the age of 55 years (*6*). The importance of reports of poor work ability was seen in a study that included a follow-up period from 51 to 55 years of age. Of those women and men who at the age of 51 years had had poor work ability, about one-third became too disabled to work during the four-year follow-up period (see Table 8) (*28*).

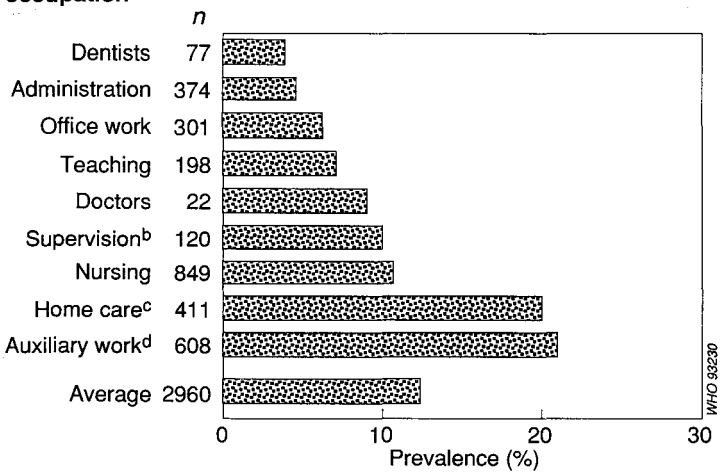
5. Working conditions of the aging worker

Aging workers can be found in all types of jobs. Work tasks and work equipment are not necessarily different for aging and young workers. The working environment may be the same and the mental demands of work (information intake and processing) as well as the physical demands (work postures, static work, dynamic work, repetitive work) are often similar, regardless of the age of the worker.

A study of 13 occupational groups with a mean age of 51 years (age range 45–58 years) identified a wide variety of stress factors in work (*29*). These can include environmental factors (lighting, climate, vibration, noise, danger, organization of work time, responsibility, conflicts, human contact), excessive demands on the sensory organs (visual, auditory, tactile, proprioceptive) and complexity and time pressure in decision-making. The data suggest that the older worker is often exposed at work to more than 10 stress factors at levels that exceed 50% of the maximal theoretical duration, frequency or significance.

Figure 5

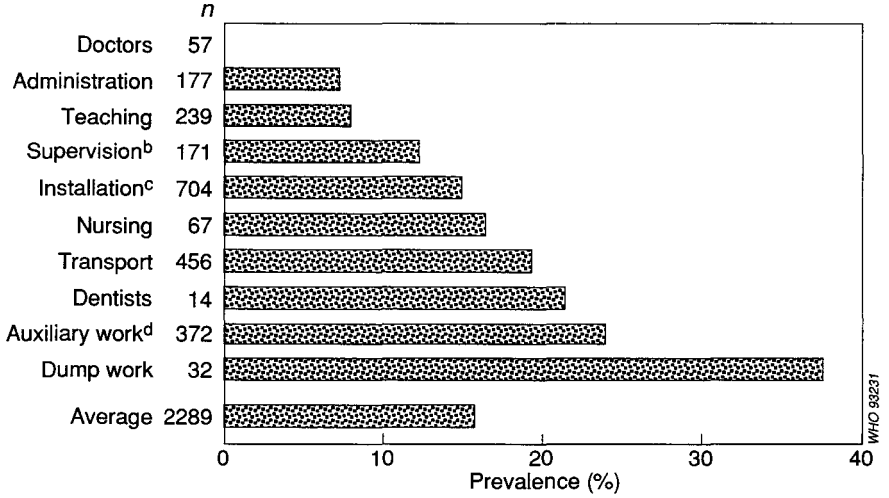
Prevalence of poor work ability among women in Finland at age 55 years, by occupation[a]



[a] Poor work ability is assessed by work ability index in a questionnaire survey (*6*). Figure adapted from reference *27*, with the permission of the publisher.
[b] Supervision: kitchen supervisors (cooks).
[c] Home care: domestic helpers and housekeepers looking after elderly people and their homes.
[d] Auxiliary work: cleaners, hospital aides, kitchen helpers, construction workers, street-sweepers, park workers.

Figure 6

Prevalence of poor work ability among men in Finland at age 55 years, by occupation[a]



[a] Poor work ability is assessed by work ability index in a questionnaire survey (*6*). Figure adapted from reference *27*, with the permission of the publisher.
[b] Supervision: technical supervision (fire chiefs, supervisors at construction sites).
[c] Installation: firemen, janitors, mechanics, pipe-fitters, car mechanics, carpenters, electricians.
[d] Auxiliary work: unskilled assistants, construction workers, street-sweepers, park workers, labourers, painters.

Table 8
Work ability of 51-year-old men and women in municipal jobs in Finland and proportion receiving a disability pension during a four-year follow-up period (1981–1985)

Work ability at 51 years of age	Total no. followed up[a]	Received a work disability pension between 51 and 55 years of age	
		Number	Percentage
Men			
Information lacking	450	56	12.4
Rating on work ability index:			
Poor	315	119	37.8
Average	1432	120	8.4
Good	359	3	0.8
All	2106	242	11.5
Women			
Information lacking	453	45	9.9
Rating on work ability index:			
Poor	325	109	33.5
Average	1913	85	4.4
Good	455	7	1.5
All	2693	201	7.5

[a] Numbers exclude those who died or received an old-age pension during the follow-up period.

Several aspects of working conditions should be given special attention in the case of aging workers:

- work organization
- psychological factors
- ergonomic factors
- physical factors
- chemical factors.

There is a lack of research data on the age-specific aspects of several of these factors, but some recommendations and general information emerged during the Study Group's discussions.

5.1 Work organization

Aging workers need more flexibility in the following areas:

Pace of work – the pace must be set by the worker, not by machines or by group demands.

Working hours – aging workers cannot tolerate long working hours as well as young workers. The optimal working day depends on the work demands; if the physical or cognitive demands are high, the day should not exceed 6-8 hours. Breaks are also more necessary for older than for younger workers.

Variety – aging workers need variety in the physical and cognitive demands placed on them, because their capacity for performing each task may be lower and they need time to recover after each type of work.

5.2 Psychological factors

Work roles – uncertainty about the aging worker's role in the workplace affects performance and self-confidence.

Job future – worries about the future (e.g. retirement, promotion, unemployment during a recession) will affect both performance and health.

Participation/control – the aging worker tends to be more loyal to the goals of the organization, provided that the worker feels that the work is under his or her control.

5.3 Ergonomic factors

Repetitive jobs – repetitive jobs lead to musculoskeletal disorders more easily in older workers. Repetitive jobs also imply less job variety and less control (see above).

Posture – because of lower muscle strength and endurance, prolonged periods in an awkward posture are less well tolerated by older workers. In addition, because of aging, long periods in the same posture may accelerate alterations in joint tissue.

Handling of heavy materials – because of lower muscle strength and degenerative joint disease, handling of heavy materials is less well tolerated by older workers and may lead to injury (arthrosis, low back pain) and accidents.

Speed – the body movements required for certain specific tasks are not so well performed by older workers, partly because they have fewer fast muscle fibres and partly because of less efficient neuromuscular coordination.

Precision – manual precision requires static loading as well as very good lighting conditions, in particular for older workers.

High aerobic demands – maximal aerobic power declines with age. High demands on older workers will introduce the risk of fatigue and accidents.

Anthropometric changes – changes in body composition occur with age. Body weight should be taken into account in workplace design.

5.4 Physical factors

Noise – noise will probably disturb the aging worker more than the young one. This may be because of a slight hearing loss, but also because the aging worker is more easily disturbed in concentration-demanding jobs.

Vibration – whole-body and local vibration may be more hazardous for aging than for younger workers, because of lower stress tolerance in older tissues and lower muscular capacity with age.

Heat – heat tolerance is lower in aging workers, partly because they are often less physically fit (see Annex).

Pressure – hyperbaric conditions are less well tolerated and can also expose the older worker to the risk of accident.

Lighting – the aging eye adapts more slowly to changes in lighting and is less sensitive to light. Therefore, lighting conditions are crucial.

The combined effects of poor lighting, noise, heat and vibration will reduce the work ability of the aging worker more than that of the young worker. The effects of these physical factors are probably not additive but, to some extent, multiplicative, and can severely reduce the aging worker's ability to concentrate and perform work.

5.5 Chemical factors

Elderly workers will have been exposed to chemicals for longer than younger ones, other things being equal. The cumulative effect of the exposure may result in clinical manifestations in later life.

Structural and functional changes with aging are of a degenerative nature and render aging people more vulnerable to toxic chemicals encountered in the workplace. Sensitivity to the carcinogenic effect of chemicals may also change with age.

There have been attempts to explain increased sensitivity to chemicals by age-related changes in pharmacokinetics and pharmacodynamics. For example, dermal absorption of chemicals increases with age (*30*). Physiological changes, such as decreased blood flow to the kidneys and liver in aging people, may lead to changes in the distribution and excretion of chemicals.

Studies of the metabolism of toxic chemicals in relation to age have focused on the microsomal mixed function oxidases. The results are contradictory and inconclusive. The metabolism of a given toxic chemical either increases or decreases with age, leading to either enhancement or reduction of its effect. Age-related changes in susceptibility to chemicals cannot be easily explained by pharmacokinetic alterations. Changes in receptor affinity, cellular responsiveness, intracellular signal transmission pathways, etc. may all play an important role in the increased sensitivity of aging workers to toxic industrial chemicals. Occupational exposure limits for toxic chemicals in the work environment do not allow for the generally higher vulnerability of aging workers.

6. The aging worker in special work environments

6.1 Working in the heat

One important determinant of ability to live and work in any harsh environment is the individual's physical work capacity, i.e. the ability to perform muscular work satisfactorily. The International Biological Programme (IBP) evaluation of work capacity (*31*) included data on anthropometric variables, muscle strength, lung volumes, aerobic and anaerobic capacity and power. The results for various tropical populations provided no evidence for the emergence of physiologically well adapted variants, either within tropical regions or relative to other populations that have exploited a temperate or cold environment. The body mass of individuals in tropical societies was generally low in relation to that of the sedentary white population elsewhere. Muscle strength and anaerobic power reached only about 75% of the levels found in Europeans but, partly because of low body mass, most tropical populations had a relative anaerobic power at least as large as that of their European counterparts. Extreme heat may, however, impair muscle strength and transport of oxygen by discouraging physical activity. A high ambient temperature gives some advantage but, as activity continues, high temperatures increase oxygen costs for a number of reasons, leading to fatigue and exhaustion. However, little information is available about possible differences between elderly and younger men and women in the capacity for everyday activities in the tropics. There is some evidence for a slight impairment of the thermoregulatory system, at least during the fifth decade, in physically fit middle-aged men (*32*).

Hot work environments can also be found in non-tropical countries. Heat is still a common problem in "western" societies in certain industries. There is evidence that old age is associated with heat intolerance. It is not known, however, whether this is due to disease, a less active lifestyle leading to lower physical fitness or the true aging process. In a study of middle-aged men, impaired work performance in the heat seemed to be mainly related to circulatory instability caused by the increased peripheral circulation necessary for heat dissipation (*33*).

6.2 Working in the cold

Biological protective mechanisms against cold in humans are much poorer than those against heat, and biological adaptation to a cold environment has been very limited. It is only with appropriate protection by means of clothing, housing and heating that humans can survive in very cold environments.

Several factors affect tolerance of cold: body size and shape, sex, subcutaneous fat, physical work capacity, aging, alcohol and drugs (*34*). The effects of aging on haemodynamic responses in cold air have not been sufficiently studied. Cold can induce either a stronger vasoconstriction or a

less efficient reaction of the peripheral circulation in older than in younger people. The reaction of blood pressure to cold is stronger in older than in younger people.

Tolerance to cold is thought to be lower in children and older people than in adults of 20-30 years of age. Generally, subjects over 50 years seem to have different haemodynamic responses to cold than younger ones. For outdoor workers in occupations such as fishing, dock work, construction and forestry the combination of a heavy physical workload, cold and changes due to aging can have a considerable effect on the cardiovascular system. In cold conditions, the wearing of protective clothing also increases the energy needed for strenuous work. A recent study covering 40 different occupations in Finland revealed that the most stressful factor in the work environment for men and women aged between 45 and 62 years was the climate – heat, cold and, in particular, changes in environmental conditions during the working day. Heat and cold were often accompanied by wet and dirty environments where the risk of work accidents was increased (*28, 29*).

6.3 Shiftwork

Shiftwork disturbs normal circadian rhythms and causes fatigue and disturbances of the sleep-wakefulness cycle. Gastrointestinal problems have been found to increase the adverse health effects of shiftwork, the critical age for these problems being about 40-45 years (*35*).

Age brings changes in the sleep-wakefulness and other circadian rhythms, reduces the delta-wave amplitude in electroencephalograms, increases the number and duration of arousals from sleep and increases daytime napping. Older people have longer mean sleep latency than younger volunteers, when studied in controlled conditions. In general, aging has been found to decrease the amplitude of many circadian rhythms and to increase the tendency to internal desynchronization.

The effect of age on physiological adjustment to phase shift or shiftwork has been investigated in only a few studies (*36-38*). Webb et al. (*36*) reported that the sleep of older people in experimental shiftwork was more disrupted than that of younger volunteers, but the increase in sleep disruption on changing from day to night work was even greater in younger people. In another study (*37*) the sleep of older shift workers (railway engineers aged 50-59) was found to be more frequently interrupted and the secretion of norepinephrine during shiftwork higher than in 25-37-year-olds. It has been suggested that the observed phase advance of the body-temperature circadian rhythm in older shift workers (male guards) increases the difficulty of day sleep following night duty (*38*). Intolerance of shiftwork is frequently associated with internal de-synchronization (*39*).

In a recent study of healthy 22-49-year-old female nurses, the physiological adjustment to night work was not influenced by age (*35*).

Controlled longitudinal studies are needed to clarify the effect of age on the adjustment to shiftwork. Since the need for attention and alertness in working life increases the effects of age on work capacity, the abilities of shift workers at different ages should be fully investigated. The new concept of more individual and more flexible working hours being introduced in many countries should take account of older people's prospects of adjusting to new work schedules.

6.4 Aging and work accidents

Studies examining accident frequency in relation to age have reported mixed results. The most common finding is that accident rates are lower in older workers than in young workers (aged 24 and below) and equal to accident rates in prime-age workers (25-44 years of age) (*40*). Different occupations have different ambient risk levels associated with them (*41*) and accident rates vary by occupation (*42*). Lack of experience could be an important determinant of accidents among new recruits to a job, but experience becomes less important later (*43*). However, in one study age and job experience were found to show a positive correlation with accident risk, which suggests that older, more experienced workers are more likely to be assigned to jobs involving greater risk (*44*). There was also a slight tendency for older workers to have higher accident rates than younger workers, but when accident risk was controlled this relationship became negligible (*44*). The conclusion of this study was that greater exposure to risk caused accidents and that accident risk modified any relationship between age, job experience and accident rates.

In a study of serious occupational accidents in southern Finland, older people were found to be less willing than younger ones to return to work after an accident, which delayed their rehabilitation. The older workers felt more often than the younger ones that pressure from a supervisor was the reason for the accident, and were less able to regulate their working pace. In most cases, older workers were injured by a collision with a moving vehicle (*45*). When accidents occur, they seem to be more serious in older than in younger workers.

Age-related changes in the senses of sight and hearing and the speed of reflex and movement may also increase the risk of accidents in older people. Osteoporosis is likely to increase the risk of bone fracture in older women doing physical work. Aging also increases the risk of falling (*46*).

7. Health promotion

7.1 Definition

Health promotion has been defined in the Ottawa Charter for Health Promotion as "the process of enabling people to increase control over, and

to improve, their health. To reach a stage of complete physical, mental and social well-being, an individual or group must be able to identify and to realize aspirations, to satisfy needs, and to change or cope with the environment.... Therefore, health promotion is not just the responsibility of the health sector, but goes beyond healthy life-styles to well-being" (*47*).

A WHO Expert Committee on Health Promotion in the Work Setting (*48*) emphasized that "health promotion is a continuum ranging from the treatment of disease, to the prevention of disease including protection against specific risks, to the promotion of optimal health. Achieving optimal health includes improving physical abilities in relation to sex and age, improving mental ability, developing reserve capacities and adaptability to changing circumstances of work and life, and reaching new levels of individual achievement in creative and other work."

7.2 Health promotion for aging workers

In many respects, health promotion is the same whatever the age of the target group. Aging workers, however, have several special features which should be taken into consideration in planning strategies.

Firstly, the health status of aging workers is lower than that of young workers. The presence of chronic symptoms and diseases can limit the possibilities for health promotion activities.

Secondly, the aging worker's functional capacities, or at least physical capacities, have often declined. Tolerance to external stress is lowered. Health promotion activities should make allowances for this lower starting point in order to avoid the risk of injury, excessive stress, etc.

Thirdly, ingrained habits make it more difficult to alter lifestyle factors such as diet. Special motivation is needed and more time should be allowed for adapting to new lifestyles.

Fourthly, frequent monitoring of progress is needed, both for safety reasons and so that the intensity of exercise can be gradually increased under medical control.

Fifthly, an individual approach in health promotion is important; results must be regularly evaluated and activities adjusted to take into account the changing needs of people as they age.

7.3 Lifestyle factors

Health promotion is essentially concerned with modifiable lifestyle factors, which are more or less the same for the whole working population. The report of the WHO Expert Committee on Health Promotion in the Work Setting (*48*) deals extensively with this issue, so only a brief description is given here. Parts of sections 7.3.1, 7.3.3 and 7.3.4 have been drawn from the Expert Committee's report.

7.3.1 *Tobacco smoking*

Smoking is a risk factor for cardiovascular disease, lung cancer and respiratory diseases; in working populations, it is associated with an increase in accidents and sick leave (*48*). In industrialized nations, for the majority of workers who smoke, cigarette smoking is a much greater cause of death and disability than the work environment (*49*). Workers who smoke are about 1.5 times as likely as non-smokers to be hospitalized. Smoking is more common in people suffering from tension and anxiety and most frequent of all among employees exposed to occupational stress (*50*). Inability to stop smoking has been reported to be related to job stress and a high workload, when a cigarette may be thought to provide relief from tension (*48*).

Most of the aspects mentioned above are highly relevant for older workers. Smoking was found to be a risk factor for work disability among municipal employees with musculoskeletal disease (*7*). In another study, people aged 53–58 years who smoked and were dissatisfied with life had the highest rate of disability (38.3%), whereas those in the age group 44–48 years who did not smoke and were satisfied with life had the lowest disability rate (5.8%) (*6*).

Smoking also predicts the decline experienced in work ability, together with other factors such as age and obesity. Cigarette smoking is a more significant factor in the decline experienced in physical work capacity than in the decrease in mental work capacity (*5*).

7.3.2 *Physical activity*

Maximal cardiorespiratory capacity can decline significantly after the age of 45 years if no regular physical exercise has been taken (*51*, also see Annex). The same is true for musculoskeletal capacity. In women, overall musculoskeletal ability decreases between 51 and 55 years of age. In men, the decline is seen most clearly in the isometric strength of the trunk muscles (*52*).

The trend of decline in physical work capacity is equally valid for workers performing either physical or mental work. This indicates strongly that physical work by itself does not maintain cardiorespiratory or musculoskeletal capacity. Therefore, in order to maintain sufficient capacity with age, specific physical exercise is needed, at least in professions where the physical demands are moderate or high.

Physical exercise also has a positive influence on productivity, absenteeism and turnover rate. Employee fitness programmes have brought promising results (*53*, *54*). The savings or definite benefits from health promotion programmes help to ensure the employer's support (*55*). Experiences in different professional groups and a company promotion programme in the USA also indicate that physical exercise increases the well-being of workers (*56*).

Physical exercise is more likely to be undertaken by those with a good basic education. It is clear that physical exercise is important for physical work capacity, but it is also significantly linked with good work ability whatever the type of work (*5, 7*) – physical or mental – together with enjoyment of life. Benefits can be obtained from physical exercise even at advanced age (*28*), and provide new possibilities for the aging worker.

Recently, health promotion programmes have been evaluated with the aim of reducing the "rate of aging". Regular physical activity, for example, may bring physiological improvements which in turn might reduce this rate. In a Japanese study, a small group of elderly men who had maintained a regular exercise programme appeared biologically to be considerably younger than they actually were (*57*). Older people should be encouraged to take appropriate exercise; the optimum duration and intensity of each type of exercise are being investigated.

Given the various positive effects of physical exercise on aging workers, employers and employees are strongly recommended to support health promotion action on physical exercise. Sports facilities for the weekly training needed to maintain an adequate cardiorespiratory and musculoskeletal capacity have been provided by employers in some countries for use during the working day and in leisure time. Such facilities can prevent negative behaviour such as excessive drinking and eating as well as smoking.

7.3.3 *Nutrition*

Factors related to overeating are associated with several of the leading causes of death in most developed nations: heart disease, arteriosclerosis and diabetes (*48*). Reducing obesity can decrease blood pressure, which can in turn reduce the risk of some of the diseases mentioned above.

Because cardiovascular diseases and musculoskeletal diseases are prevalent among aging workers, there is great potential for improving the health of workers by means of weight-loss programmes. The prevalence of obesity increases with age in industrialized countries.

Malnutrition and undernutrition can also cause significant health problems and decrease the productivity of individual workers. Poor nutrition may be related to cultural patterns, poverty or unavailability of an adequate or balanced food supply (*48*).

Since weight control is a significant problem in industrialized countries, programmes to reduce workers' weight are becoming increasingly popular. The programmes evaluated so far appear quite promising. Efforts to reduce cholesterol levels in the blood through education and emphasis on a low-fat diet, exercise and weight loss have led to reductions of 9-17% (*48*).

The workplace has a significant influence on the dietary habits of workers, and this influence can extend to the family. On the other hand, family

members often select and prepare the worker's food. Therefore, the problems of unhealthy nutrition should be addressed both in the workplace and at home. Because older workers often control the family's finances, their belief in the value of a balanced diet is essential for nutrition-based health promotion.

7.3.4 *Alcohol*

Alcohol contributes to many serious accidents causing personal injury and disability in workers. Alcohol-related loss of productivity can be substantial. In industrialized countries, workers with alcohol problems have markedly higher absenteeism than the rest of the workforce and their health care costs are 3-11 times as high (*48*).

There are cultural, social and psychological reasons for alcohol use and abuse. Certain occupation-related factors can increase the risk of alcohol abuse and related health problems (*48*).

The workplace has great potential for the control and prevention of alcohol use and abuse, for several reasons. Evaluations of programmes to combat alcohol-related problems have shown a positive effect on work performance, absenteeism, health care costs and costs related to disabled employees (*48*).

More information is needed about the age-related aspects of alcohol use and abuse in different occupations. Work-related reasons for abuse must be identified before preventive measures can be taken. A recent problem in many industrialized countries is increasing unemployment, which often affects older workers. The worker's return to working life can be seriously affected by the lifestyle adopted during unemployment.

7.4 Ergonomics

In a four-year follow-up of 6257 employees, aged 45-58 years at the onset of the study and representing 40 different occupations, three groups of factors were identified that predicted the decline experienced in work capacity as well as the rate of retirement from working life on the grounds of disability over the four years (*7, 28, 29*). These factors can be presented as targets for various types of action in the workplace (redesign, training, education, etc.) aimed at preventing a premature decline in work capacity among aging workers.

The three groups of factors are:

1. Excessive physical demands:
   - static muscular work
   - use of muscular strength
   - lifting and carrying
   - sudden extreme effort
   - repetitive movements
   - simultaneously bent and twisted work postures

2. Stressful and dangerous work environment:
   - dirty and wet workplace
   - risk of work accidents
   - hot workplace
   - cold workplace
   - changes in temperature during the working day
   - poor lighting
3. Poor organization of work:
   - conflicts of responsibilities
   - unsatisfactory supervision and planning of work
   - fear of failure and mistakes
   - time pressure
   - lack of freedom of choice
   - lack of control over own work
   - lack of professional development
   - lack of acknowledgement and appreciation.

Each factor in the list increased the risk of a decline in work capacity during the four-year follow-up period. A combination of several factors (e.g. lifting, plus heat, plus time pressure) produced a linear increase in the risk of becoming too disabled to work by the end of the four years. Risk factors in the workplace were practically the same for aging men and women, but the most harmful combination differed slightly according to health status. People with cardiovascular disease differed from those with musculoskeletal disease or mental disorders with respect to the combination of risk factors associated with a premature decline in work ability (*5*, *7*).

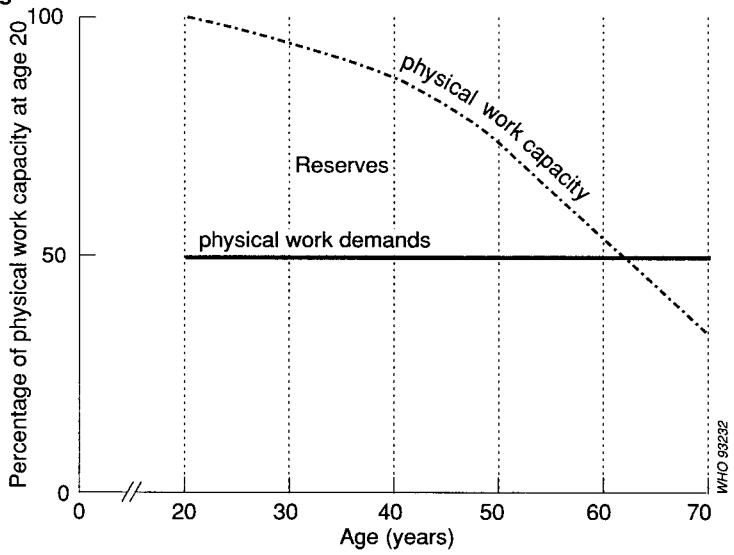
8. Supporting work capacity as workers age

The best way of supporting work capacity as workers age is a combination of health promotion and job redesign, taking into account individual needs and ensuring flexibility in the workplace. Fig. 7 illustrates the situation in physically demanding occupations before action has been taken. The physical demands of work (lifting, carrying, etc.) do not usually change as the worker ages, but physical work capacity declines with age, depending on the quality and quantity of physical exercise taken. The individual's reserves for recovering from work can decrease significantly with age if no physical exercise is taken; after the age of 50 years the reserves may become insufficient for full recovery. At this point, work induces chronic fatigue, which increases the risk of work-related diseases and work disability.

Fig. 8 provides a solution to this problem. Physical work demands (lifting, carrying, etc.) are reduced as the worker ages so that the reserves available to a 60-year-old worker are similar to those of a 30-year-old worker. If

Figure 7

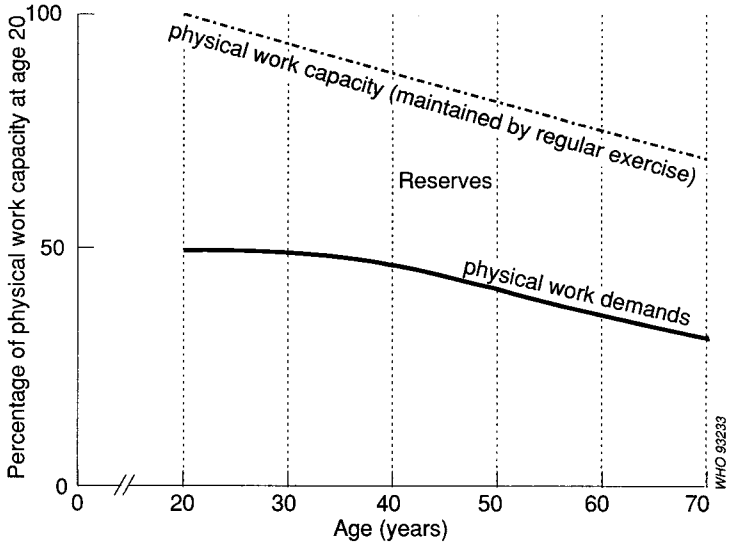
Theoretical relation between physical work capacity and physical work demands with aging



Adapted from reference *28*, with the permission of the publisher.

Figure 8

Suggested modifications to permit continued employment in physically demanding occupations[a]



[a] Physical work demands should decrease with age and the experience of the older worker should be taken more into consideration. The premature decline of physical work capacity is prevented by health promotion, e.g. encouraging physical exercise. Adapted from reference *28*, with the permission of the publisher.

health promotion activities, such as physical exercise, are undertaken, an accelerated decline of physical work capacity is prevented. Older workers can take on a higher proportion of mental and social tasks to replace the physical tasks they have given up. For example, they might train young workers or plan and develop improved working conditions to maintain their productivity at a satisfactory level. The trend towards multiple skills, competency-based training and retraining promotes better occupational flexibility, thus improving the employability of workers as they grow older. The successful application of this basic concept requires simultaneous job redesign and health promotion.

The concept introduced above focused on physically demanding work. Similar concepts can be drawn up for mentally demanding work. The main principle is that work demands should change, just as workers themselves change as they grow older. It should be emphasized that a number of mental and social abilities can undergo a positive change with increasing age: such new strengths should be respected and exploited in everyday work.

9. Conclusions

9.1 The older worker

1. Current demographic trends in industrialized countries indicate an increase in the average age of the workforce and thus an increase in the number of older workers (i.e. those over 45 years). In developing countries with large populations, the absolute number of older workers will increase, although they will remain only a small proportion of the total labour force.

2. Older workers constitute a special group in the labour force (notwithstanding the greater variation between individuals) with characteristics that require special attention from the occupational health point of view. Older workers' needs should always be considered in the design of occupational health and safety programmes. In the past, these needs have not been given due consideration either at the national level or in practice in the enterprise.

3. Changes in physical, psychological and psychomotor performance are found in older workers as a result of the biological process of aging as well as exposure to physical, environmental and organizational factors in the workplace. Such changes may imply limitations in work capacity in certain jobs and necessitate the adaptation of work to suit the individual worker.

4. Well established data from several countries demonstrate an increasing probability with age of chronic diseases, such as cardiovascular disorders, musculoskeletal disorders, respiratory

diseases and cancer, which implies that a high percentage of the older workforce experiences limitations in functional capacity, including work capacity, and cannot carry out all the tasks expected of the younger worker without some adaptation of the work environment. This does not mean that older people are less valuable workers, but it does indicate the need for job adjustment and special occupational health and safety arrangements for the protection and promotion of their health at work. To facilitate the implementation of such arrangements, some countries have created incentives for employers.

5. Older workers may have specific strengths (e.g. greater dedication to work, better routine skills as a result of long experience, a more stable character because of experience and age-related intellectual and personality development) that make them particularly suitable for certain demanding jobs. Society should make better use of these capacities, which are often lacking in younger workers.

9.2 The older worker and the workplace

6. Employers and fellow workers are often not aware of the strengths of older workers, and in many cases existing conditions of work or prejudice may lead to discrimination against older workers. In many countries, employers have pensioned off workers not only in old age, but also in later middle age, which brings considerable economic loss and wastes the experience, skills and capacities of older workers. In such circumstances, the worker is deprived of the benefits of working, which may affect his or her overall quality of life.

7. From the experience gained in certain industrialized countries, it appears that the adaptation of work to suit older workers can be facilitated both through action by governments, employers and trade unions and by increasing both workers' participation in decisions concerning their own work and the potential for self-regulation of work (e.g. deciding on objectives, setting the pace of work and choosing the working practices used).

8. Social security schemes and employment policies are not always conducive to continuing work at an older age. The benefits to the worker of continuing to work depend not only on the individual's health and work capacity, but also on the arrangements made for job adaptation and the existence of special incentives to continue work. Such incentives (e.g. a higher eventual rate of pension for people who continue to work beyond retirement age) have been successful in some industrialized countries (e.g. Canada).

9.3 Research and education needs

9. Many aspects of aging and work are still not understood and research data, in particular on the long-term effects of aging on work and of work on the aging process, are still needed. In many countries, the

information base relating to older workers' participation in the workforce and the problems they encounter is inadequate or unsystematic.

10. Besides the Office of Occupational Health and the Programme on Health of the Elderly, WHO has several programmes relevant to the protection and promotion of older workers' health (e.g. those concerned with cardiovascular diseases, cancer and certain other noncommunicable diseases). In the planning and implementation of such programmes, collaboration with the Office of Occupational Health and adoption of an occupational health approach, with due attention paid to the middle-aged and older working population, could be highly productive.

11. In all sectors of society and in all groups in working life, there is a need to improve information on, awareness of, and attitudes towards older workers. The necessary information may be produced and distributed by research and other expert institutions, governments, social partners and others.

10. Recommendations

10.1 Recommendations to Member States

1. National policies aimed at maintaining older workers in a socially and economically meaningful role should be adopted by governments and supported by appropriate legislation.

2. Public policy should support social partners in the establishment of working conditions and occupational health services that will enable workers to realize a full and productive working life into their old age.

3. In view of the increase in the ratio of retired people to those of working age, governments should consider incentives to encourage older workers to stay at work as long as their health permits.

4. Employers should be provided with specific and detailed guidelines so that they can adapt the work environment to suit the needs of aging workers.

5. Employers, managers, supervisors, planners and designers who make decisions and draw up plans for the work environment (machinery, processes, tools, etc.), work organization and job design should be provided with training, education and information about the need to adapt work and the work environment to the worker and on methods of putting this principle into practice. This would help to ensure that appropriate workplaces are provided for older workers and their skills and experience fully utilized.

6. Experts in occupational health and safety, such as occupational health physicians and nurses, industrial hygienists, ergonomists, psychologists, physiotherapists and safety engineers, should be taught

about aging and work as part of their professional training at the level of both basic education and postgraduate and continuing education.

7. More research needs to be done to determine both the strengths and the needs of older workers. Research in human factors related to occupation should include people from the full range of working ages. In order to identify and measure age-related effects associated with modifiable lifestyle and environmental factors, research should as far as possible incorporate designs that allow the separation of these effects from the effects of biological aging. Studies should be included to provide information about the elements that lead to successful aging in the work context. Research should cover not only theoretical aspects, but also the validation and evaluation of methods of adapting jobs to suit older workers.
8. In order to develop better tools for surveillance of age-specific health and employment issues, information should be regularly gathered on such occurrences as occupational injuries, sick leave and retirements due to disability, with reference to sex, job type and age. Databases and other information systems should be developed to provide a complete and systematic picture of the participation of older workers in the workforce and the problems they encounter.
9. Periodic health examinations should be carried out for all workers aged 45 or older. These are intended to identify:
   (a) deficits in such areas as muscular strength and performance and cardiorespiratory status, which could be improved by exercise programmes;
   (b) age-related changes in such functions as vision, hearing and the musculoskeletal system, which would call for appropriate adaptation of the work environment and the provision of appropriate aids;
   (c) physical and mental risk factors for morbidity and mortality, which should be reported to the worker and his or her physician for appropriate treatment or adjustments in lifestyle.

   These examinations should be carried out using standardized methods and the results should be systematically recorded for practical and research purposes.
10. Employers and workers should be encouraged to support long-term workplace health promotion programmes and similar public health initiatives concerned with lifestyle (smoking, alcohol abuse, nutrition, physical exercise, etc.), which are known to encourage the maintenance of health and vigour with increasing age.

10.2 Recommendations to employers, trade unions and regulatory agencies

1. Work capability, not age, should be the criterion for hiring and retaining employees.

2. Employers should maintain sufficient flexibility in the design of jobs and the work environment to ensure appropriate working conditions for the markedly heterogeneous older population. Workers should be given the opportunity to participate in decisions or actions that affect their jobs.
3. Work arrangements should be flexible to allow for job sharing, part-time work and time off for family responsibilities. There should be incentives to encourage part-time work during the years traditionally dedicated to retirement in order to maximize older people's participation in the workforce.
4. Every worker should be provided with appropriate education and vocational training as a basic component of work. This education should anticipate technical changes in the workplace and the redesigning of work as workers age, and allow employees to maintain and increase their skills and achieve job satisfaction.

10.3 Recommendation to WHO

WHO is encouraged to give due attention to the health aspects of aging and work in all relevant programmes.

Acknowledgements

The Study Group acknowledges with special thanks the contributions made by Dr L. Cooney and Dr J. Ilmarinen to the finalization of this report. It also gratefully acknowledges the contributions made by the following: Dr R. Cremer, Department of Health Science, Faculty of Medicine, Academic Medical Centre, Coronel Laboratory, University of Amsterdam, Netherlands; Dr J. Hurrell, Division of Biomedical and Behavioral Science, National Institute for Occupational Safety and Health, Cincinnati, OH, USA; and Dr H. Hermanova, Regional Adviser for Elderly Disability and Rehabilitation, WHO Regional Office for Europe, Copenhagen, Denmark.

References

1. Masoro EJ. *Handbook of physiology in aging.* Boca Raton, FL, CRC Press, 1981.
2. Heikkinen E. Aging and functional capacity; theoretical and research models. In: Goedhard WJA, ed. *Aging and work.* The Hague, Pasmans, 1992:62–67.
3. *Health of the elderly. Report of a WHO Expert Committee.* Geneva, World Health Organization, 1989 (WHO Technical Report Series, No. 779).
4. Ilmarinen J. Physiological criteria for retirement age. *Scandinavian journal of work, environment and health,* 1988, 14(Suppl.1):88–89.
5. Tuomi K et al. Work load and individual factors affecting work ability among aging municipal employees. *Scandinavian journal of work, environment and health,* 1991, 17(Suppl.1):128–134.

6. **Tuomi K et al.** Prevalence and incidence rates of diseases and work ability in different work categories of municipal occupations. *Scandinavian journal of work, environment and health,* 1991, **17**(Suppl.1):67–74.

7. **Tuomi K et al.** Work load and individual factors affecting work disability among aging municipal employees. *Scandinavian journal of work, environment and health,* 1991, **17**(Suppl.1):94–98.

8. Recommendation No. 162. Recommendation concerning older workers. In: International Labour Organisation. *International Labour Conventions and Recommendations, 1919–1981 (arranged by subject-matter).* Geneva, International Labour Office, 1982:773–779.

9. *World health statistics annual, 1987.* Geneva, World Health Organization, 1987.

10. **Ilmarinen J et al.** Background and objectives of the Finnish research project on aging workers in municipal occupations. *Scandinavian journal of work, environment and health,* 1991, **17**(Suppl.1):7–11.

11. **Working party on social policy 29–31.10.1984.** *The social and labour market implications of aging populations. The changing population age structure.* Paris, Organisation for Economic Co-operation and Development, 1984.

12. *Labour market prognoses: labour supply up to 2000 and demand up to 1995.* Helsinki, Ministry of Labour, 1988:1–53 (Studies of labour policy, No. 73).

13. **Davies DR, Matthews G, Wong CSK.** Ageing and work. In: Cooper CL, Robertson IT, eds. *International review of industrial and organizational psychology, Vol. 6.* Chichester, John Wiley, 1991:151–159.

14. **Kinsella K.** *Aging in the Third World.* Washington, DC, US Bureau of the Census, 1988.

15. **Williams MD.** Age-related physiologic changes. In: Beck J, ed. *Geriatric review syllabus.* New York, American Geriatrics Society, 1991:11–35.

16. **Davies DR, Sparrow PD.** Age and work behaviour. In: Charness N, ed. *Aging and human performance.* Chichester, John Wiley, 1985:293–326.

17. **Corso JF.** Auditory perception and communication. In: Birren JE, Schaie KW, eds. *Handbook of the psychology of aging.* New York, Van Nostrand, 1977:535–550.

18. **Davies DR, Jones DM, Taylor A.** Selective and sustained attention tasks; individual and group difference. In: Parasuramen R, Davies DR, eds. *Varieties of attention.* New York, Academic Press, 1984:395–447.

19. *Comparative job performance by age; large plants in the men's footwear and household furniture industries.* Washington DC, Department of Labor, 1957 (Bulletin No. 1223).

20. **Smith MW.** Older workers' efficiency in jobs of various types. *Personnel journal,* 1953, **32**:19–23.

21. **Crook GH, Heinstein M.** *The older worker in industry.* University of California, Berkeley, CA, Institute of Industrial Relations, 1958.

22. **Pisa Z, Uemura K.** International differences in developing improvements in cardiovascular health. *Annals of medicine,* 1989, **21**(3):193–197.

23. **Verbrugge LM.** Longer life but worsening health? Trends in health and mortality of middle-aged and older persons. *Milbank Memorial Fund quarterly,* 1984, **62**:475–519.

24. **Aromaa A et al.** *Health, functional limitations and need for care in Finland. Basic results from the Mini-Finland Health Survey.* Helsinki/Turku, Social Insurance Institution, 1989.

25. **Rantanen J.** *Occupational health and safety of Finnish employees at the turn of the decades (1980/1989) and perspectives for the future.* Helsinki, Finnish Institute of Occupational Health, 1991 [in Finnish].

26. **Hytti H.** *Ammatilliset työkyvyttömyysriskit 1976–80.* [*Occupational work disability risks 1976–80.*] Helsinki, National Social Security Institute, 1988 (Series T9, publication 32).

27. **Ilmarinen J.** Job design guidelines for the aged with regard to decline in their maximal aerobic capacity. Part II — The scientific basis for the guide. *International journal of industrial ergonomics,* 1992, **10**:65–77.

28. **Ilmarinen J et al.** Summary and recommendations of a project involving cross-sectional and follow-up studies on the aging worker in Finnish municipal occupations (1981–1985). *Scandinavian journal of work, environment and health,* 1991, **17**(Suppl. 1):135–141.

29. **Ilmarinen J et al.** Classification of municipal occupations. *Scandinavian journal of work, environment and health,* 1991, **17**(Suppl. 1):12–29.

30. **Birnbaum LS.** Pharmacokinetic bases of age-related changes in sensitivity to toxicants. *Annual review of pharmacology and toxicology,* 1991, **31**:101–128.

31. **Shephard RJ.** Work capacity: methodology in a tropical environment. In: Collins KJ, Roberts DF, eds. *Capacity for work in the tropics.* Cambridge, Cambridge University Press, 1988:1–30 (Society for the Study of Human Biology Symposium Series, No. 26).

32. **Pandolf KB et al.** Thermoregulatory responses of middle-aged and young men during dry-heat acclimation. *Journal of applied physiology,* 1988, **65**(1):65–71.

33. **Smolander J et al.** Circulatory and thermal responses of men with different training status to prolonged physical work in dry and humid heat. *Scandinavian journal of work, environment and health,* 1987, **13**:37–46.

34. **Budd GM et al.** Effects of fitness, fatness and age on men's responses to whole body cooling in air. *Journal of applied physiology,* 1991, **71**(6):2387–2393.

35. **Harma M et al.** The relation of age to the adjustment of the circadian rhythms of oral temperature and sleepiness to shift work. *Chronobiology international,* 1991, 7:227–233.

36. **Webb WB, Agnew HW, Dreblow L.** Sleep of older subjects in shift work. In: Reinberg A, Vieux N, Andlauer P, eds. *Night and shiftwork. Biological and social aspects.* Oxford, Pergamon, 1981:375–390.

37. **Torsvall L, Åkerstedt T, Gillberg M.** Age, sleep and irregular workhours. A field study with electroencephalographic recording, catecholamine excretion and self-rating. *Scandinavian journal of work, environment and health,* 1981, 7:196–203.

38. **Matsumoto K, Morita Y.** Effects of night-time nap and age on sleep patterns of shiftworkers. *Sleep,* 1987, **10**:580–589.

39. **Reinberg A et al.** Alteration of period and amplitude of circadian rhythms in shift workers. With special reference to temperature, right and left hand grip strength. *European journal of applied physiology,* 1988, **57**:15–25.

40. **Dillingham AE.** Age and workplace injuries. *Aging and work,* 1981, 4:1–10.

41. **Hale AR, Hale M.** *A review of the industrial accident literature.* London, Her Majesty's Stationery Office, 1972.

42. **Dillingham AE.** *The injury risk structure of occupations and wages* [Dissertation]. Ithaca, NY, Cornell University, 1979.

43. **Surry J.** *Industrial accidents research.* Toronto, Labour Safety Council, 1977.

44. **Hansen CP.** A consul model of the relationships among accidents, biodata, personality and cognitive factors. *Journal of applied psychology,* 1989, 74:81–90.

45. **Salminen S et al.** Aging and serious occupational accidents. In: Lethinen S et al., eds. *Towards the 21st century. Work in the 1990s. International symposium on future trends in the changing working life, 13–15 August 1991, Helsinki, Finland.* Helsinki & Oitmäki, Institute of Occupational Health & Finnish Employers' Management Development Institute, 1991:250–255.

46. **Goedhard WJA.** Prevention of age-related diseases; the role of occupational health. In: Goedhard WJA, ed. *Aging and work.* The Hague, Pasmans, 1992:49–61.

47. Ottawa Charter for Health Promotion. *Health promotion,* 1986, 1(4):iii–v.

48. *Health promotion for working populations. Report of a WHO Expert Committee.* Geneva, World Health Organization, 1988 (WHO Technical Report Series, No. 765).

49. **United States Public Health Service, Office on Smoking and Health.** *The health consequences of smoking: cancer and chronic lung disease in the workplace. A report of the Surgeon General.* Washington, DC, US Government Printing Office, 1985.

50. **Selye H.** Stress without distress in working life. In: Levi L, ed. *Society, stress and disease, vol. 4. Working life.* Oxford, Oxford University Press, 1981:263–269.

51. **Ilmarinen J et al.** Changes in maximal cardiorespiratory capacity among aging municipal employees. *Scandinavian journal of work, environment and health,* 1991, 17(Suppl. 1):99–109.

52. **Nygård C-H, Lupopajärvi T, Ilmarinen J.** Musculoskeletal capacity and its changes among aging municipal employees in different work categories. *Scandinavian journal of work, environment and health,* 1991, 17(Suppl. 1):110–117.

53. **Cox M, Shephard RJ, Corey P.** Influence of an employee fitness programme upon fitness, productivity and absenteeism. *Ergonomics,* 1981, 24(10):795–806.

54. **Shephard RJ.** *Economic benefits of enhanced fitness.* Champaign, IL, Human Kinetics Publishers, 1986.

55. **Chenoweth D.** Health promotion: benefits versus costs. *Occupational health and safety,* 1983, 52:37–41.

56. **Blair SN et al.** A public health intervention model for worksite health promotion: impact of exercise and physical fitness in a health promotion plan after 24 months. *Journal of the American Medical Association,* 1986, 255:921–926.

57. **Nakamura E, Moritani T, Kanetaka A.** Biological age versus physical fitness age. *European journal of applied physiology,* 1989, 58:778–785.

Annex

Age and functional capacity

1. Concept of functional capacity

In empirical research, the concept of functional capacity is defined in various ways, for example as a structure consisting of physical, psychological and social functions which are categorized from simple to complex, or as the ability to cope with everyday activities (*1*). There are several models to describe age-related changes in functional capacity (decrement model, functional profile model, plasticity model, optimum level model, biological age model, cohort model). The level of functional capacity, both within a single individual and among individuals belonging to the same age group, is highly variable. Recent research suggests that many characteristics of the social environment vary in their effects on cohort members as they age, i.e. individuals may age differently from one another. It has been suggested that human beings can also, to some extent, age the way they want to, i.e. that age is not merely a passive product of biological and social influences (*2*).

2. Physical capacity for work

2.1 *Cardiorespiratory capacity*

In general, physical work capacity seems to decrease earlier than mental capacity. After the age of 45 years, cardiorespiratory capacity, measured as maximal oxygen consumption ($\dot{V}o_2max$), can decrease by more than 25% over four years, although such a large deterioration would be rare both among women (Fig. A1) and among men (Fig. A2) (*3*). The $\dot{V}o_2max$ may soon become inadequate if work demands do not decrease with age. For example, if the physical demands of work call for an oxygen uptake of 1.0 litre/min, as in the steel and building industry, the $\dot{V}o_2max$ of the worker should be at least 2.0 litres/min. Otherwise, the cardiorespiratory strain resulting from the work will exceed 50% of the worker's maximal capacity and the worker will be overloaded. At the age of 55 years, 63% of women studied in various municipal occupations did not have the physical capacity for physical work calling for 1.0 litre of oxygen/min if their relative aerobic strain was not to exceed 50% of $\dot{V}o_2max$ (Fig. A3) (*4, 5*). All the men studied at 55 years of age had sufficient capacity for this external stress (1.0 litre/min) and the relative aerobic strain was acceptable ($\leq$ 50% $\dot{V}o_2max$). However, if the work demands were higher, e.g. 1.5 litres of oxygen/min, the cardiorespiratory capacity of 75% of these men would be inadequate, and this could lead to a decrease in productivity.

There are many tasks for which the $\dot{V}o_2max$ exceeds 1.5 litres/min, as found in logging, handling waste containers, postal delivery on foot, delivery of dairy products, work in the building, steel and sawmill

Figure A1

Decline, over a four-year period, in maximal oxygen consumption ($\dot{V}o_2max$, l/min) of 23 women aged over 45 years working in municipal occupations in Finland

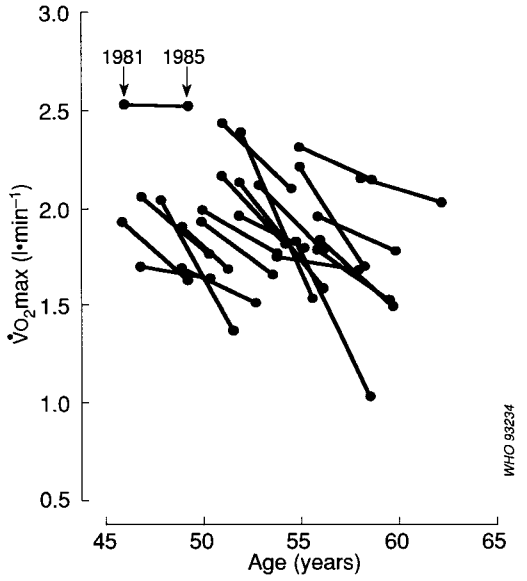


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Figure A2

Decline, over a four-year period, in maximal oxygen consumption ($\dot{V}o_2max$, l/min) of 12 men aged over 45 years working in municipal occupations in Finland

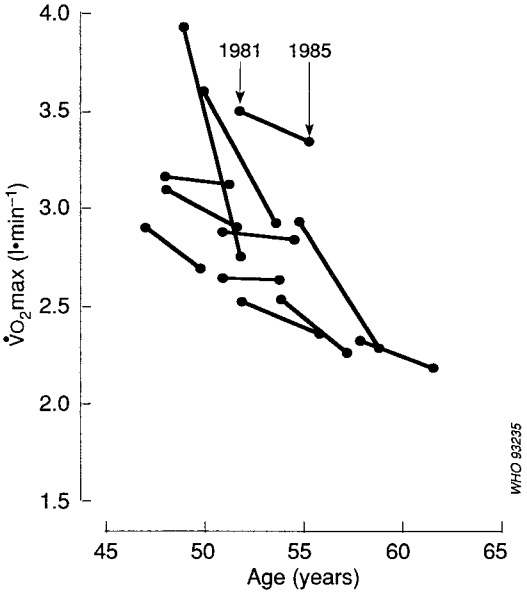

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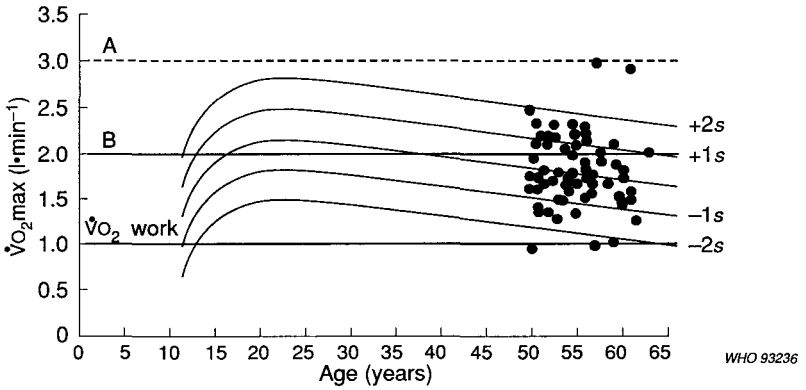
Figure A3

Maximal oxygen consumption ($\dot{V}o_2max$, l/min) of 68 women working in Finnish municipal occupations, in relation to age and standard curves (mean ± 2SD)[a]



[a] If the $\dot{V}o_2$ required for physical work is 1 l/min, maximal oxygen consumption should be 3 l/min (A) if relative aerobic strain is not to exceed 33% of $\dot{V}o_2$max, or 2 l/min (B) if relative aerobic strain is not to exceed 50% of $\dot{V}o_2$max. The results of the study show that $\dot{V}o_2$max is inadequate to meet the latter requirement in two-thirds of the women over 45 years of age. Adapted from reference 5, with the permission of the publisher.

industries and the work of auxiliary municipal employees (*6*, *7*).[1] Physical work today is still too heavy for most women and men over 55 years of age if the same demands are made of younger and older workers and the older workers have undergone the normal age-related decline in cardiorespiratory capacity.

2.2 *Musculoskeletal capacity*

Musculoskeletal capacity seems to decrease at least as quickly as cardiorespiratory capacity. In a study of municipal employees in various work categories, general musculoskeletal capacity, including 11 tests of muscle strength and endurance, joint mobility, etc., decreased by 26% between the ages of 51 and 55 years in women (*8*). Typical for men was the decrease in maximal trunk extension and flexion strength. Whatever the person's occupation, the decrease between 51 and 55 years was more than 20%. Hand-grip strength seemed to decrease by about 5% between 51 and 55 years for both women and men.

Recent data indicate that the decline in physical work capacity with age may be greater and start earlier than generally expected. If work demands

[1] Auxiliary workers include:
Women — cleaners, hospital aides, kitchen helpers, construction workers, street-sweepers, park workers.
Men — unskilled assistants, construction workers, street-sweepers, park workers, labourers, painters.

have not decreased correspondingly, the work will become physically too demanding in the age range 50–55 years, especially for women but also for unfit men.

2.3 *Exercise and aging*

The recent emphasis on lifestyle and preventive medicine has focused attention on the role of exercise as a means of slowing down the aging process and reducing the disability resulting from various diseases associated with aging (*9*).

The functional reserves in young adult life of organ systems such as the heart, lungs and kidneys are 4–10 times those required to maintain normal homoeostasis. There is an almost linear decline in all functional reserves after the age of 30. In normal men, between the ages of 30 and 80 years, nerve conduction velocity and the levels of many cellular enzymes decrease by about 15%, cardiac index at rest by up to 30%, vital capacity and renal blood flow by as much as 50%, maximal breathing capacity by as much as 60% and maximal work rate or maximal oxygen uptake ($\dot{V}o_2max$) in many individuals by almost 70%.

It is reasonable to assume that maintenance of physical fitness by an individual in the later years can reduce the expected decline in physiological reserves attributable to aging. In a Japanese study, a small group of elderly men who had maintained a regular exercise programme appeared biologically to be considerably younger than they actually were. These regular physiological improvements might, in turn, reduce the "rate of aging" (*10*).

In terms of the cardiovascular system, exercise such as cycling, swimming, running, jogging or even walking brings a range of physical and psychological benefits for the participant, regardless of age. Exercise increases red blood cell mass, the muscle capillary-fibre ratio, blood-flow in exercising muscle, muscle cell content of myoglobin and mitochondria, and levels of enzymes for aerobic glycolysis. All these changes promote more efficient production of adenosine triphosphate (ATP) for skeletal muscle work and facilitate oxygen delivery to tissues (*9*). Exercise also has metabolic effects which may reduce the risk of development of atherosclerosis. For example, exercise can increase the level of high-density lipoprotein cholesterol. Current evidence suggests a range of interactions between physical activity and the risk of coronary heart disease. Although strenuous exercise increases the risk of sudden death, there is evidence that maintaining aerobic or endurance fitness through regular exercise is beneficial.

Exercise may decrease the risk of cerebrovascular and peripheral vascular disease, although the evidence is less strong than for coronary heart disease. Regular exercise also has an effect on pulmonary function and on the musculoskeletal system. Activity seems to increase cortical bone density and protect against the loss of bone mineral in the aging skeletal system.

It has been suggested that there is a decline with age both in humoral immunity (i.e. antibody formation) and in the cellular response or delayed immunity. Imperfect or altered immunity may predispose an individual to a variety of illnesses in later years. At least theoretically, exercise can improve the immune system. The probability of developing cancer increases strongly with age, and this can be related to the failure of immune functions. Most studies show a lower cancer risk in physically active persons.

Regular exercise has a positive influence on a person's sense of well-being and self-esteem. Exercise can ameliorate depressive illness, and "running therapy" has been used alone or as a supplement to group or individual psychotherapy. Sleeping patterns, which change with age, can also be positively influenced by regular exercise. It should also be mentioned that sport can increase sexual vitality; in general, participation in sport and a meaningful sexual relationship are markers of positive emotional health and are inversely related to depression (*9*).

The trainability of aging workers is good. In a study of 25 men aged over 45 years, the improvement in the maximal oxygen consumption ($\dot{V}o_2max$ in litres/min) observed in the most of the group after four years of regular physical training was remarkable (Fig. A4). The improvements in $\dot{V}o_2max$ observed in 16 women over 45 years of age were not related to age, nor to the baseline level before training (Fig. A5). The differences in the effects of training on men and women are mostly due to the differences in the quality and quantity of exercise taken. Men trained more intensively (jogging, running, skiing, cycling, swimming, etc.) than women (walking). The results demonstrate, however, that brisk walking is also an effective form of physical training for older workers (*3*, *11*).

3. Motor performance

Changes in motor performance with age can be summarized as follows (*12*):

- Large movements made at maximum speed show substantial slowing with age, apparently because of muscular limitations. Most other movements are not limited by muscular factors, but by the speed of decisions required to guide the movements and the time taken to monitor them.
- Greater changes occur with age when the movements cannot be prepared in advance.
- Monitoring of movements appears to be an aspect of caution, and older people show greater caution than younger ones.
- Older people tend to be slower but more accurate than younger ones if means are available for them to monitor their own performance.
- Aging has a disproportionately large adverse effect on the performance of complex actions in terms of both speed and accuracy.
- Age-related changes in the performance of relatively simple

Figure A4

Improvement, over a four-year period of physical training, in the maximal oxygen consumption ($\dot{V}o_2max$, l/min) of 25 men aged over 45 years working in municipal occupations in Finland

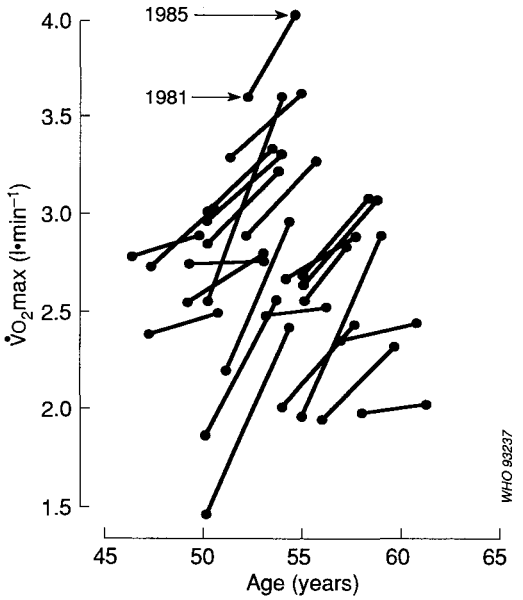


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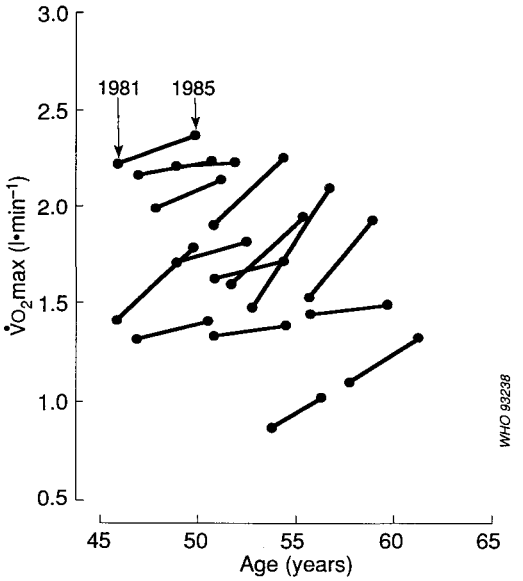
Figure A5

Improvement, over a four-year period of physical training, in the maximal oxygen consumption ($\dot{V}o_2max$, l/min) of 16 women aged over 45 years working in municipal occupations in Finland



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sensorimotor tasks show little consistent relation to sex, educational level or socioeconomic status.

- Sensorimotor performance correlates to some extent with intelligence, but also clearly shows a substantial degree of independence.
- Older people tend to avoid jobs that demand rapid decisions or continuous activity at a pace dictated by the machinery.
- Industrial and road accidents involving older people are attributable mainly to slowness in making decisions, rather than to any sensory or motor impairment.

4. Mental capacity for work

It has often been observed that slowing down of performance correlates with age. This slowing down is manifested not only in sensorimotor tasks, but also in perception, problem-solving and other situations in which the mental rather than the motor component is stressed (*13*). There are, however, large variations between individuals during aging, such that a substantial number of old people perform at a level at least equal to the average of a group of younger subjects. Changes in performance with age very commonly become disproportionately greater as the difficulty of the task increases.

Many studies have revealed that age trends in performance are due directly to age-related effects on the central nervous system. In many tasks, however, both young and old workers are working well within their capacities, and changes of capacity, even in old age, are less important. More significant is the identification of areas where age-related changes do affect performance and where some relatively trivial factor limits what can be done, so that comparatively small changes in the task may bring it back within the scope of an older person. An attempt to fit the job to the person is a far better approach for older workers than moving the person to another job (*13*).

4.1 *Motivation and activity*

Motivation and activity studies have revealed that for many persons complex social motivations are often more important determinants of everyday behaviour than basic physiological needs. Too much motivation, however, can be as bad as too little; overinvolvement or overarousal, resulting in a heightened drive state, may impair performance in the elderly as compared with the young. Age differences in a variety of human activities may be related to motivation rather than to intellectual or physiological competence (*14*).

4.2 *Intellectual ability and mental performance*

A decline in intellectual ability with age may not be seen before the age of 50 or 60 for many functions, and even then the decline may be small (*15*). Intellectual functions that require rapid use of non-verbal perceptual manipulative skills may decline earlier. Generally, age differences are more quantitative than qualitative.

Cross-sectional and longitudinal studies suggest that people who perform relatively well when young will also perform relatively well when old. However, the performance level when young does not indicate whether the age-related decline will be large, small or somewhere in between (*15*). In a study of 51-55-year-old municipal employees, mental performance was found to be better among those doing mental work than among those doing physical or mixed work, but the physical and mixed workers did not differ from one another (*15*). Visual search ability decreased significantly between the ages of 51 and 55 years in transport workers (bus-drivers); and short-term memory declined in nursing and administrative occupations (*16*). So the effect of aging on mental performance – as on physical performance – can be different from one job to another and occupational demands do not automatically prevent the decline of performance. In mental work, it is important to keep the information processing system optimally loaded. Work demands should therefore follow age-optimal patterns for the perceptual system, the motor system and the cognitive system, which includes memory, attention and effort (*17*).

4.3 *Problem-solving*

Problem-solving abilities peak at different ages (*18*). Elderly persons probably define their problems differently from the young. Older professionals also recognize that their goals have changed. They are therefore predisposed to show a degree of flexibility, as compared with younger people, rather than the rigidity conventionally attributed to the elderly. Elderly people also show a clear recognition of the need to ask others' advice. Older workers can conserve and exploit their intellectual resources more fully than the young and they have a more subtle perception of the point at which the complexity of the decision becomes too great for them; in this way, they are able to avoid unnecessary mistakes. Their adaptation to functional decrements helps older workers to maintain a relatively high level of performance (*18*). In addition, there are studies indicating that everyday problem-solving improves with age (*19*). For example, in a study of young, middle-aged and older adults living in New York, performance in the Everyday Problem-Solving Inventory and verbal ability test increased with age, whereas performance in a traditional problem-solving test declined after middle age.

5. Experience

An essential characteristic of older workers is that they have experience, which enables them to compensate for the other effects of age. While capacity diminishes with age, experience increases, and the sum of these two determines the ability of the worker (*20*).

References

1. **Heikkinen E et al.** Functional capacity of men born in 1906–10, 1926–30 and 1946–50: basic report. *Scandinavian journal of social medicine,* 1984, **Suppl. 33**:1–93.

2. **Heikkinen E.** Aging and functional capacity; theoretical and research models. In Goedhard WJA, ed. *Aging and work.* The Hague, Pasmans, 1992:62–67.

3. **Ilmarinen J et al.** Changes in maximal cardiorespiratory capacity among aging municipal employees. *Scandinavian journal of work, environment and health,* 1991, **17**(Suppl. 1):99–109.

4. **Ilmarinen J.** Physiological criteria for retirement age. *Scandinavian journal of work, environment and health,* 1988, **14**(Suppl. 1):88–89.

5. **Ilmarinen J.** Job design guidelines for the aged with regard to decline in their maximal aerobic capacity. Part II – The scientific basis for the guide. *International journal of industrial ergonomics,* 1992, **10**:65–77.

6. **Ilmarinen J.** Physical load on the cardiovascular system in different work tasks. *Scandinavian journal of work, environment and health,* 1984, **10**:403–408.

7. **Suurnäkki T, Nygård C-H, Ilmarinen J.** Stress and strain of elderly employees in municipal occupations. *Scandinavian journal of work, environment and health,* 1991, **17**(Suppl. 1):30–39.

8. **Nygård C-H.** *Work and musculoskeletal capacity: a field and laboratory study of 44–62-year-old women and men* [Dissertation]. Kuopio, Finland, University of Kuopio, 1988.

9. **Siegel AJ.** Exercise and aging. In: Strauss RH, ed. *Sports medicine.* Philadelphia, WB Saunders, 1984:270–285.

10. **Nakamura E, Moritani T, Kanetaka A.** Biological age versus physical fitness age. *European journal of applied physiology,* 1989, **58**:778–785.

11. **Ilmarinen J et al.** Summary and recommendations of a project involving cross-sectional and follow-up studies on the aging worker in Finnish municipal occupations (1981–1985). *Scandinavian journal of work, environment and health,* 1991, **17**(Suppl. 1):135–141.

12. **Welford AT.** Motor performance. In: Birren JE, Schaie KW, eds. *Handbook of the psychology of aging.* New York, Van Nostrand Reinhold, 1977:450–492.

13. **Welford AT.** *Aging and human skill.* London, Oxford University Press, 1958.

14. **Elias FM, Elias PK.** Motivation and activity. In: Birren JE, Schaie KW, eds. *Handbook of the psychology of aging.* New York, Van Nostrand Reinhold, 1977:357–381.

15. **Botwinick J.** Intellectual abilities. In: Birren JE, Schaie KW, eds. *Handbook of the psychology of aging.* New York, Van Nostrand Reinhold, 1977:580–604.

16. **Suvanto S et al.** Performance efficiency and its changes among aging municipal employees. *Scandinavian journal of work, environment and health,* 1991, **17**(Suppl. 1):118–121.

17. **Jackson J, Mulder G.** Aging and mental capacity to work. In: Goedhard JWA, ed. *Aging and work.* The Hague, Pasmans, 1992:49–61.

18. **Rabbit P.** Changes in problem solving ability in old age. In: Birren JE, Schaie KW, eds. *Handbook of the psychology of aging.* New York, Van Nostrand Reinhold, 1977:606–625.

19. **Cornelius SW, Gaspi A.** Everyday problem-solving in adulthood and old age. *Psychology and aging,* 1987, **2**(2):144–153.

20. **Edholm OG.** Age and work. In: Edholm OG, ed. *The biology of work.* New York, McGraw-Hill, 1967:218–226.

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In many industrialized and developing countries, the mean age of the working population is rising as a result of increasing life expectancy and other global demographic trends. The changing age structure of the workforce has focused attention on the abilities — both physical and mental — and work performance of older people, which have implications for national employment, health and social policies. This report of a WHO Study Group discusses the causes, environmental as well as physiological, of age-related changes in work capacity, in particular with respect to the influence of work organization and of physical and ergonomic factors on job performance. Stressing the need for flexibility in adapting work to suit the individual, the report identifies specific requirements for health promotion in an aging working population. Its recommendations take account of both lifestyle factors and working conditions, with the aim of optimizing the functional capacity and health of older workers, while promoting economic efficiency and productivity by ensuring that skills and experience are fully utilized.

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