

Physical demands in worklife

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Developments in industrialized countries have resulted in a decreasing number of industrial occupations that are physically strenuous in the traditional sense of the word. Many heavy work tasks have been fully or partially mechanized. At the same time, however, many workplaces have been created with work tasks imposing static, asymmetric loads on muscle groups of the arm. Work is often performed in a sitting position. It requires a relatively modest total energy expenditure. However, this expenditure is often large in relation to the size of the working muscles (6). Jobs such as these are highly fatiguing. Local loads on muscles, tendons, tendon attachments, and joints can be considerable.

The scope of the service sector has also increased during the aforementioned developments in industry. Many people in the public sector, eg, fire fighters and policemen, sometimes have extremely heavy work involving the lifting and carrying of an injured person or someone in need of assistance. In addition waste collection is one of the most strenuous trades in our time.

Specialization has also increased. A butcher cuts up carcasses throughout the workday. This activity imposes very heavy, asymmetric loads on his dominant arm and shoulder in particular.

Many occupations requiring workers to walk, stand, and lift or carry loads still exist, eg, in the construction industry.

These examples show that replacement of physically heavy work tasks by lighter work has not really simplified matters. The situation is highly complex. However, it is known that the capacity for strenuous work is still an important factor. About half of the gainfully employed people in Sweden have jobs in which physical work capacity is important to successful work performance.

Physical work capacity and muscular strength — Individual differences

Maximal oxygen uptake is the parameter displaying the best correlation with long-term work capacity in both sports and physically demanding occupations. This parameter is often referred to as "physical work capacity." The decline in physical work capacity from the age of 20 to 65 years is about 30 %, calculated in terms of mean values. The mean value for a 65-year-

old man is of the same magnitude as the value for a 20-year-old woman. On the average, the physical work capacity (measured in terms of maximal oxygen uptake) of women is about 30 % less than that of men the same age (3) (figure 1). The standard deviation is 10–15 % of the mean value for both men and women, irrespective of age.

These figures indicate that less than 2 % of the women in any given age group are capable of producing the average work of men. In other words, there is some overlapping in the values for men and women, but the number of women achieving the normal performance levels of men is very small.

The same average sexual difference prevails for muscular strength, with the exception of muscle groups in the arms and shoulders, where the differences are even more pronounced (3).

Women have an average lifting and carrying capacity which is 50–70 % of the capacity of men. The weight which is tolerable for 75 % of male industrial workers for long-term duties is only tolerable for about 10 % of female industrial workers (10).

Physical demands in different occupations

It is known that physical demands vary considerably in different occupations. There is therefore a need for some kind of classification. The heaviest tasks are the most interesting ones in many respects. They are often determinative in the recruitment to and success in an occupation. If tasks making occasional demands are taken into account, it will be found that many occupations still impose severe demands on oxygen uptake and muscular strength. According to an old model, work tasks can be roughly classified on the basis of energy requirements for the heaviest tasks (2) (table 1).

The introduction of different ergonomic measures causes continuous changes in strenuous tasks. These changes reduce physical demands. But experience has shown that this is a slow process. Some mechanization efforts have adverse effects caused by the intrusion of occasional tasks demanding great physical strength. Certain service and emergency occupations will probably always be physically demanding.

Optional work pace

Experimental work in the laboratory has shown that continuous work can be sustained for a long period

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of time if the work pace is equivalent to about half the worker's aerobic capacity. During work at this pace, there is no accumulation of lactic acid and only a modest increase in heart rate (1).

Many studies have shown that an optional choice of work pace in physically demanding occupational work results in an adaptation of pace or intensity until the worker is utilizing 40–45 % of her or his capacity (2, 5). This intensity is probably regulated “automatically” so that it never becomes too great for the individual. Basal physiology suggests that this is probably the case. At intensities exceeding 50 %, carbohydrate metabolism increases, and therefore the degree of exertion gradually increases. Heart rate and pulmonary ventilation per liter of oxygen uptake increase, and body temperature rises above 38°C. In other contexts studies of work performed in high ambient temperatures arrived at the conclusion that 38°C is an upper limit for body temperature (2).

An example of this type of adaptation can be found among construction workers. An equal number of construction workers (bricklayers, carpenters, and unskilled laborers) in each of the age groups 30–39, 40–49, 50–59, and 60–69 years was studied. The men were all experienced construction workers employed for the construction of a new building. The capacity for oxygen uptake in the 65-year-old workers averaged 30 % less than in the 35-year-old workers. The average heart rate during work was 20 beats/min slower in the typical 65-year-old than in the 35-year-old, but both employed about 40 % of their total capacity during a workday. Therefore the degree of exertion was the same, irrespective of age. However, the intensity of work performed by older subjects was 30 % lower (2). Since an older person does not utilize energy differently than a younger person, an older worker must be less productive.

In the construction trade the pace of work is not fixed, and there is some possibility for individual selection of work pace. In this kind of work, biological

demands are manifested through the worker's automatic selection of a given proportion of her or his individual capacity, namely, about 40 %. This intensity probably makes it possible for the worker to work at an optimum level in relation to her or his capability. As previously noted, this circumstance has an impact on productivity. In the construction trade, the problem has been solved to some extent by the successive transfer of older workers from heavy construction work to lighter repair and maintenance duties. But many older workers are still unable to cope.

As in other kinds of work, household work is intermittent, i.e., duties of varying intensity are interspersed. Ten women were found to utilize an average of 40–45 % of their maximal oxygen uptake in a workday spent on housework (e.g., cleaning, washing and similar strenuous tasks). This percentage was of the

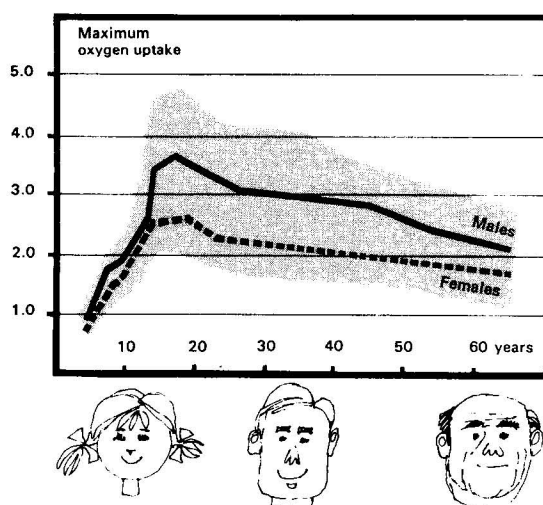


Figure 1. Maximal oxygen uptake in relation to age. The figure is based upon results from 350 normal persons (3). The shadowed area represents two standard deviations for the men and women.

Table 1. Classification of occupational tasks based upon oxygen uptake. The corresponding heart rate and exercise intensity on a bicycle ergometer are also given. The classification can only be used as an aid for a rough grouping. It should be noted that the individual's aerobic work capacity is often of decisive importance to intensity.

Classification	Oxygen uptake (l/min)	Heart rate, young person (beats/min)	Cycle ergometer (W)	Occupation
Extremely heavy work	> 1.75	> 150	> 125	{ Peak loads in fishing, dock labor, forestry, fire fighting
Heavy work	1.5–1.75	130–150	100–125	{ Peak loads in manual loading, iron and steel industry, building, farming, gardening
Moderately heavy work	1.0–1.5	100–130	50–100	{ Heavy hospital work, serving and cleaning (hotels and restaurants), heavy engineering work, tractor driving (forestry)
Light work	0.75–1.0	80–100	40–50	{ House work, light industry, laboratory work, light hospital work, retail and distribution trade
Very light work	0.5–0.75 < 0.5	70–80 < 70	20–40 < 20	Office work, car driving Sitting work (reading and writing)

same magnitude as for other occupations requiring movement of the body's mass. The group's aerobic capacity ranged from 1.5 to 2.3 l/min. The results suggest that a person automatically adjusts to a given level of exertion, even during this kind of work (2).

This adaptation principle suggests that the degree of exertion is always the same, irrespective of age, sex, and even work capacity. The consequence is that the intensity of work performance is generally less for an older worker than for a younger one of the same sex, and generally less for a woman than for a man of the same age.

At a relative work intensity of 40 %, heart rate is about 125 beats/min for people 20–29 years of age and about 95 beats/min for people 60–69 years of age (2) (figure 2).

Constrained work rate

From the medical and physiological point of view, however, the problems at workplaces with relatively constrained work rates are much greater than the problems previously discussed. If performance of a given work task, performed with the arms, requires the expenditure of five units of energy, a worker's capacity must be at least 12.5 units to keep expenditure from exceeding 40 % of his or her capacity. If three workers with capacities equivalent to 6, 12.5, and 25 units perform the same work and the work rate corresponds to five energy units, then the worker with the lowest capacity will be incapable of sustaining the work pace.

The work of airline hostesses entails a great deal of walking and a work pace which is constrained to some degree. Food serving and other duties must be performed within a given period of time, and hostesses have limited opportunities for determining their work rate. One study of a small group of hostesses found a significant correlation between median heart rate during work and maximal oxygen uptake expressed in milliliters of oxygen per kilogram of body weight. The results showed that the lower the work capacity, the

higher the heart rate (2). When workers are unable to select their own work pace, the relative work load varies inversely with work capacity. Signs of work-related problems in the form of fatigue, aching legs, etc, were especially pronounced in people with low work capacities.

The exertion to which fishermen are exposed is governed by the size of the catch and the weather. With a big catch, the work involved in hauling in and emptying nets is obviously heavier than with a small catch. In poor weather with a rough sea, other tasks in the form of the static work required to hold on are added to the basic work. On the other hand, the work rate is optional except for some tasks which must be performed quickly. On the average, a group of fishermen utilized about 43 % of their aerobic capacity during work at sea (2).

Some vocations encompass relatively brief phases of high intensity plus external heat loading. An example is the work of firemen. Work by firemen wearing respirators, often entailing life-saving measures in hot, smoke-filled rooms, imposes a heavy load on the blood circulation. For this reason a minimum oxygen uptake capacity has been set for firemen in Sweden (7). Heavy work performed in extreme heat for limited periods of time is also found in, eg, the steel industry. These tasks, even if brief in duration, impose demands governing recruitment to such work.

Musculoskeletal disorders

The fact that physically heavy work has a wearing effect on the body is reflected in the high incidence of symptoms from the musculoskeletal system and from sickness data for people with heavy vocations (11). Women regularly performing this kind of work run the risk of losing their jobs or being afflicted by musculoskeletal injury (8). A typical occupation of this kind is the work of medical orderlies in nursing homes. Physical work capacity should be taken into consideration when people are recruited for this kind of work.

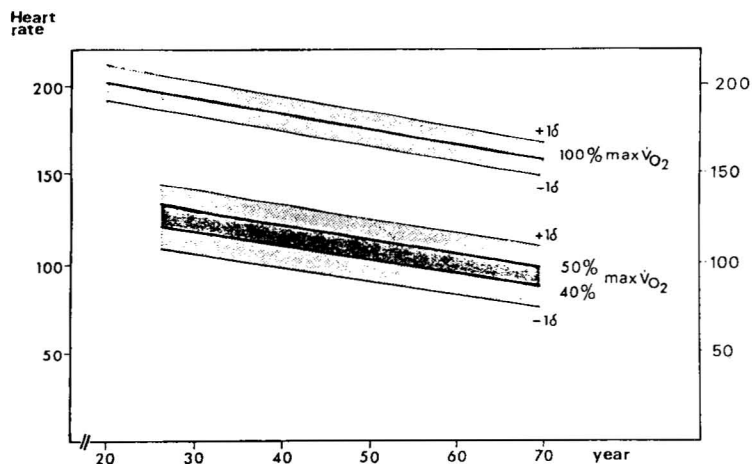


Figure 2. Heart rate in relation to age. Shown are the ± 1 SD limits: (max $\dot{V}O_2$ = maximal oxygen uptake)

An ordinary fitness test can be employed in assessing oxygen uptake and the capacity of the circulatory organs. The point of the test should be to ensure that the capacity is great enough to enable utilization of only 40 % of that capacity during occupational work. However, no simple tests are available for assessing muscular strength and the capacity of the musculoskeletal system. A long-term forecast is only possible after actual performance of the relevant work for a suitable length of time.

Each workplace should be adapted to the worker's ability to meet the simplest ergonomic demands. Adaptation to the employee's body size is one example. Women frequently encounter workplaces designed for men. The acceptance of poor ergonomics, and possibly even illness, is the wrong way to achieve sexual equality in the workplace. Few tools have been designed for an ordinary woman's hand. This lack impairs a female worker's ability to utilize the levers incorporated in the tool. Add to this situation a woman's lesser initial muscular strength, and the result may be reduced work productivity which may also be accompanied by symptoms of overloading.

Good technique is obviously very important to the performance of work. But good technique cannot compensate for a worker's lack of minimum strength.

Musculoskeletal disorders may appear even if the most common ergonomic requirements are satisfied. In recent years, the incidence of these disorders has been increasing, especially at workplaces in which work is physically light (4, 9). In many instances, workplaces are designed with the idea that each work step should be light and that the possibilities for the worker to remain sitting the whole time should be enhanced. However, as a consequence, there is an inevitable risk for monotonous work. Work is often performed with slightly elevated arms, and each work step is repeated very often. The development of disorders caused by physical overloading of the arms and shoulders is an unforeseen consequence of this workplace design. It is not known which individual factors are important to the development of these musculoskeletal disorders in individual workers (4, 9). More research is needed.

The disadvantages accompanying mechanization are now readily discernible. The natural variations in work movements and work positions which automatically resulted in dynamic, symmetrical work operations have disappeared. But the advantages offered by easier work undoubtedly outweigh the disadvantages, at least for older workers. Easier work also opens up many occupations for women and people with physical disabilities. A great deal could undoubtedly be done to reduce the adverse impact of mechanization, however.

The old, heavy occupations not only demanded large energy expenditures, in many instances, they also entailed walking. Workers were mobile and mainly per-

formed dynamic work. The only disadvantage of these occupations was the fact that they were physically strenuous.

Summary

Industrial occupations which are physically strenuous in the traditional sense of the word have decreased in number. They have partly been replaced by "light," repetitive, monotonous work tasks performed in a sitting position. The number of heavy work tasks within the service sector has increased. Specialization has been intensified. The individual's capacity for strenuous work is still of importance to successful work performance. Many studies show that an optional choice of work pace in physically demanding occupational work results in an adaptation of pace or intensity until the worker is utilizing 40–50 % of her or his capacity. When the work rate is constrained, the relative strain of the individual varies inversely with the physical work capacity. The frequency of musculoskeletal disorders has concurrently increased with the implementation of industrial mechanization. New, wise, ergonomic moves are needed to stop this development.

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